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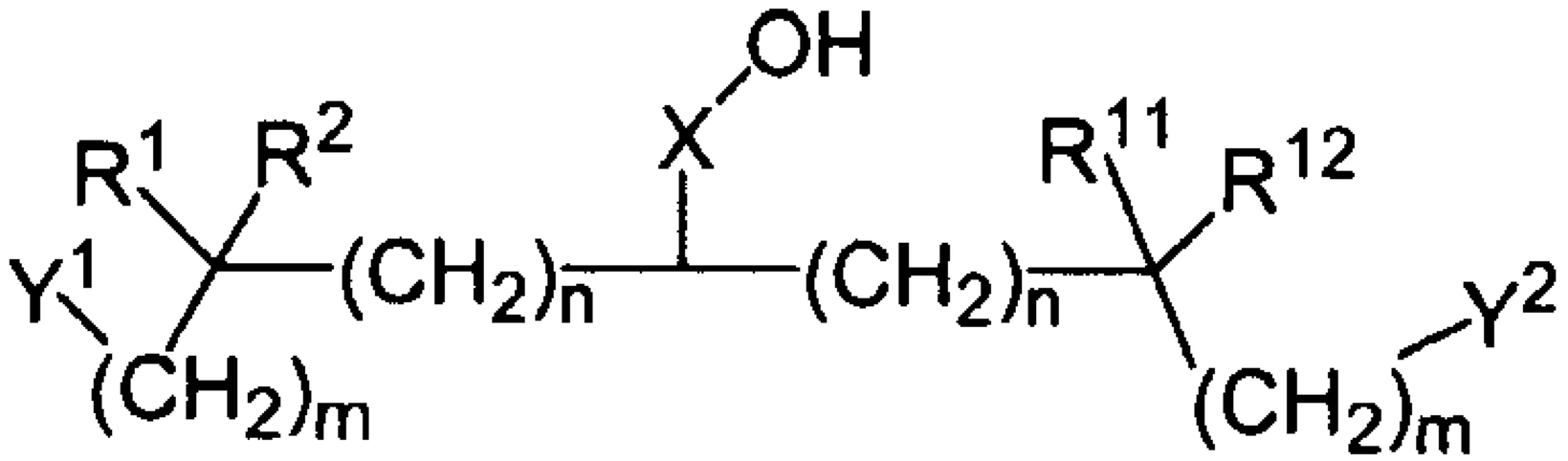

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(57) Abrégé/Abstract:
The present invention relates to a compound of formula I: (see formula I) wherein R^1, R^2, R^{11}, R^{12}, Y^1, Y^2, X, n and m are as defined in the claims, compositions comprising the compound, and methods useful for treating and preventing a variety of diseases and conditions. In certain embodiments, the compound, compositions, and methods of the invention are useful in combination therapy with other therapeutics, such as hypocholesterolemic and hypoglycemic agents.

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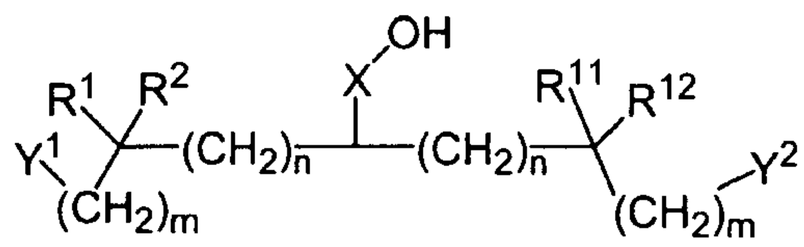
ABSTRACT

The present invention relates to a compound of formula I:



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wherein R^1, R^2, R^{11}, R^{12}, Y^1, Y^2, X, n and m are as defined in the claims, compositions comprising the compound, and methods useful for treating and preventing a variety of diseases and conditions. In certain embodiments, the compound, compositions, and methods of the invention are useful in combination therapy with other therapeutics, such as hypocholesterolemic and hypoglycemic agents.

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HYDROXYL COMPOUNDS AND COMPOSITIONS FOR CHOLESTEROL MANAGEMENT AND RELATED USES

1. FIELD OF THE INVENTION

The invention relates to hydroxyl compounds and pharmaceutically acceptable salts, hydrates, solvates, and mixtures thereof; compositions comprising a hydroxyl compound or a pharmaceutically acceptable salt, hydrate, solvate, or mixtures thereof; and methods for treating or preventing a disease or disorder such as, but not limited to, aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, enhancing bile production, enhancing reverse lipid transport, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, modulating C reactive protein, obesity, oxysterol elimination in bile, pancreatitis, Parkinson's disease, a peroxisome proliferator activated receptor-associated disorder, phospholipid elimination in bile, renal disease, septicemia, metabolic syndrome disorders (*e.g.*, Syndrome X), and a thrombotic disorder, which method comprise administering a hydroxyl compound or composition of the invention. The compounds of the invention can also treat or prevent inflammatory processes and diseases like gastrointestinal disease, irritable bowel syndrome (IBS), inflammatory bowel disease (*e.g.*, Crohn's Disease, ulcerative colitis), arthritis (*e.g.*, rheumatoid arthritis, osteoarthritis), autoimmune disease (*e.g.*, systemic lupus erythematosus), scleroderma, ankylosing spondylitis, gout and pseudogout, muscle pain: polymyositis/polymyalgia rheumatica/fibrositis; infection and arthritis, juvenile rheumatoid arthritis, tendonitis, bursitis and other soft tissue rheumatism.

2. BACKGROUND OF THE INVENTION

Obesity, hyperlipidemia, and diabetes have been shown to play a causal role in atherosclerotic cardiovascular diseases, which currently account for a considerable proportion of morbidity in Western society. Further, one human disease, termed "Syndrome X" or "Metabolic Syndrome", is manifested by defective glucose metabolism (insulin resistance), elevated blood pressure (hypertension), and a blood lipid imbalance (dyslipidemia). See *e.g.* Reaven, 1993, *Annu. Rev. Med.* 44:121-131.

The evidence linking elevated serum cholesterol to coronary heart disease is overwhelming. Circulating cholesterol is carried by plasma lipoproteins, which are particles of complex lipid and protein composition that transport lipids in the blood. Low density lipoprotein (LDL) and high density lipoprotein (HDL) are the major cholesterol-carrier proteins. LDL is believed to be responsible for the delivery of cholesterol from the liver, where it is synthesized or obtained from dietary sources, to extrahepatic tissues in the body. The term "reverse cholesterol transport" describes the transport of cholesterol from extrahepatic tissues to the liver, where it is catabolized and eliminated. It is believed that plasma HDL particles play a major role in the reverse transport process, acting as scavengers of tissue cholesterol. HDL is also responsible for the removal of non-cholesterol lipid, oxidized cholesterol and other oxidized products from the bloodstream.

Atherosclerosis, for example, is a slowly progressive disease characterized by the accumulation of cholesterol within the arterial wall. Compelling evidence supports the belief that lipids deposited in atherosclerotic lesions are derived primarily from plasma apolipoprotein B (apo B)-containing lipoproteins, which include chylomicrons, very low density lipoproteins (VLDL), intermediate-density lipoproteins (IDL), and LDL. The apo B-containing lipoprotein, and in particular LDL, has popularly become known as the "bad" cholesterol. In contrast, HDL serum levels correlate inversely with coronary heart disease. Indeed, high serum levels of HDL are regarded as a negative risk factor. It is hypothesized that high levels of plasma HDL are not only protective against coronary artery disease, but may actually induce regression of atherosclerotic plaque (*e.g.*, see Badimon *et al.*, 1992, *Circulation* 86:(Suppl. III)86-94; Dansky and Fisher, 1999, *Circulation* 100:1762 3.). Thus, HDL has popularly become known as the "good" cholesterol.

2.1 Cholesterol Transport

The fat-transport system can be divided into two pathways: an exogenous one for cholesterol and triglycerides absorbed from the intestine and an endogenous one for cholesterol and triglycerides entering the bloodstream from the liver and other non-hepatic tissue.

In the exogenous pathway, dietary fats are packaged into lipoprotein particles called chylomicrons, which enter the bloodstream and deliver their triglycerides to adipose tissue for storage and to muscle for oxidation to supply energy. The remnant of the chylomicron, which contains cholesteryl esters, is removed from the circulation by a specific receptor found only on liver cells. This cholesterol then becomes available again for cellular metabolism or for recycling to extrahepatic tissues as plasma lipoproteins.

In the endogenous pathway, the liver secretes a large, very-low-density lipoprotein particle (VLDL) into the bloodstream. The core of VLDL consists mostly of triglycerides synthesized in the liver, with a smaller amount of cholesteryl esters either synthesized in the liver or recycled from chylomicrons. Two predominant proteins are displayed on the surface of VLDL, apolipoprotein B-100 (apo B-100) and apolipoprotein E (apo E), although other apolipoproteins are present, such as apolipoprotein CIII (apo CIII) and apolipoprotein CII (apo CII). When VLDL reaches the capillaries of adipose tissue or of muscle, its triglyceride is extracted. This results in the formation of a new kind of particle called intermediate-density lipoprotein (IDL) or VLDL remnant, decreased in size and enriched in cholesteryl esters relative to a VLDL, but retaining its two apoproteins.

In human beings, about half of the IDL particles are removed from the circulation quickly, generally within two to six hours of their formation. This is because IDL particles bind tightly to liver cells, which extract IDL cholesterol to make new VLDL and bile acids. The IDL not taken up by the liver is catabolized by the hepatic lipase, an enzyme bound to the proteoglycan on liver cells. Apo E dissociates from IDL as it is transformed to LDL. Apo B-100 is the sole protein of LDL.

Primarily, the liver takes up and degrades circulating cholesterol to bile acids, which are the end products of cholesterol metabolism. The uptake of cholesterol-containing particles is mediated by LDL receptors, which are present in high concentrations on hepatocytes. The LDL receptor binds both apo E and apo B-100 and is responsible for binding and removing both IDL and LDL from the circulation. In addition, remnant receptors are responsible for clearing chylomicrons and VLDL remnants (*i.e.*, IDL). However, the affinity of apo E for the LDL receptor is greater than that of apo B-100. As a result, the LDL particles have a much longer circulating life span than IDL particles; LDL circulates for an average of two and a half days before binding to the LDL receptors in the liver and other tissues. High serum levels of LDL, the "bad" cholesterol, are positively associated with coronary heart disease. For example, in atherosclerosis, cholesterol derived from circulating LDL accumulates in the walls of arteries. This accumulation forms bulky plaques that inhibit the flow of blood until a clot eventually forms, obstructing an artery and causing a heart attack or stroke.

Ultimately, the amount of intracellular cholesterol liberated from the LDL controls cellular cholesterol metabolism. The accumulation of cellular cholesterol derived from VLDL and LDL controls three processes. First, it reduces the ability of the cell to make its own cholesterol by turning off the synthesis of HMGCoA reductase, a key enzyme

in the cholesterol biosynthetic pathway. Second, the incoming LDL-derived cholesterol promotes storage of cholesterol by the action of cholesterol acyltransferase ("ACAT"), the cellular enzyme that converts cholesterol into cholesteryl esters that are deposited in storage droplets. Third, the accumulation of cholesterol within the cell drives a feedback mechanism that inhibits cellular synthesis of new LDL receptors. Cells, therefore, adjust their complement of LDL receptors so that enough cholesterol is brought in to meet their metabolic needs, without overloading (for a review, see Brown & Goldstein, in *The Pharmacological Basis Of Therapeutics*, 8th Ed., Goodman & Gilman, Pergamon Press, New York, 1990, Ch. 36, pp. 874-896).

High levels of apo B-containing lipoproteins can be trapped in the subendothelial space of an artery and undergo oxidation. The oxidized lipoprotein is recognized by scavenger receptors on macrophages. Binding of oxidized lipoprotein to the scavenger receptors can enrich the macrophages with cholesterol and cholesteryl esters independently of the LDL receptor. Macrophages can also produce cholesteryl esters by the action of ACAT. LDL can also be complexed to a high molecular weight glycoprotein called apolipoprotein(a), also known as apo(a), through a disulfide bridge. The LDL-apo(a) complex is known as Lipoprotein(a) or Lp(a). Elevated levels of Lp(a) are detrimental, having been associated with atherosclerosis, coronary heart disease, myocardial infarction, stroke, cerebral infarction, and restenosis following angioplasty.

2.2 Reverse Cholesterol Transport

Peripheral (non-hepatic) cells predominantly obtain their cholesterol from a combination of local synthesis and uptake of preformed sterol from VLDL and LDL. Cells expressing scavenger receptors, such as macrophages and smooth muscle cells, can also obtain cholesterol from oxidized apo B-containing lipoproteins. In contrast, reverse cholesterol transport (RCT) is the pathway by which peripheral cell cholesterol can be returned to the liver for recycling to extrahepatic tissues, hepatic storage, or excretion into the intestine in bile. The RCT pathway represents the only means of eliminating cholesterol from most extrahepatic tissues and is crucial to the maintenance of the structure and function of most cells in the body.

The enzyme in blood involved in the RCT pathway, lecithin:cholesterol acyltransferase (LCAT), converts cell-derived cholesterol to cholesteryl esters, which are sequestered in HDL destined for removal. LCAT is produced mainly in the liver and circulates in plasma associated with the HDL fraction. Cholesterol ester transfer protein (CETP) and another lipid transfer protein, phospholipid transfer protein (PLTP), contribute

to further remodeling the circulating HDL population (see for example Bruce *et al.*, 1998, *Annu. Rev. Nutr.* 18:297 330). PLTP supplies lecithin to HDL, and CETP can move cholesteryl esters made by LCAT to other lipoproteins, particularly apoB-containing lipoproteins, such as VLDL. HDL triglycerides can be catabolized by the extracellular hepatic triglyceride lipase, and lipoprotein cholesterol is removed by the liver via several mechanisms.

Each HDL particle contains at least one molecule, and usually two to four molecules, of apolipoprotein A I (apo A I). Apo A I is synthesized by the liver and small intestine as preproapolipoprotein, which is secreted as a proprotein that is rapidly cleaved to generate a mature polypeptide having 243 amino acid residues. Apo A I consists mainly of a 22 amino acid repeating segment, spaced with helix-breaking proline residues. Apo A I forms three types of stable structures with lipids: small, lipid-poor complexes referred to as pre-beta-1 HDL; flattened discoidal particles, referred to as pre-beta-2 HDL, which contain only polar lipids (*e.g.*, phospholipid and cholesterol); and spherical particles containing both polar and nonpolar lipids, referred to as spherical or mature HDL (HDL3 and HDL2). Most HDL in the circulating population contains both apo A I and apo A II, a second major HDL protein. This apo A I- and apo A II-containing fraction is referred to herein as the AI/AII-HDL fraction of HDL. But the fraction of HDL containing only apo A I, referred to herein as the AI HDL fraction, appears to be more effective in RCT. Certain epidemiologic studies support the hypothesis that the AI-HDL fraction is antiartherogenic (Parra *et al.*, 1992, *Arterioscler. Thromb.* 12:701-707; Decossin *et al.*, 1997, *Eur. J. Clin. Invest.* 27:299-307).

Although the mechanism for cholesterol transfer from the cell surface is unknown, it is believed that the lipid-poor complex, pre-beta-1 HDL, is the preferred acceptor for cholesterol transferred from peripheral tissue involved in RCT. Cholesterol newly transferred to pre-beta-1 HDL from the cell surface rapidly appears in the discoidal pre-beta-2 HDL. PLTP may increase the rate of disc formation (Lagrost *et al.*, 1996, *J. Biol. Chem.* 271:19058-19065), but data indicating a role for PLTP in RCT is lacking. LCAT reacts preferentially with discoidal and spherical HDL, transferring the 2-acyl group of lecithin or phosphatidylethanolamine to the free hydroxyl residue of fatty alcohols, particularly cholesterol, to generate cholesteryl esters (retained in the HDL) and lysolecithin. The LCAT reaction requires an apolipoprotein such as apo A I or apo A-IV as an activator. ApoA-I is one of the natural cofactors for LCAT. The conversion of cholesterol to its HDL-sequestered ester prevents re-entry of cholesterol into the cell, resulting in the ultimate removal of cellular cholesterol. Cholesteryl esters in the mature

HDL particles of the AI-HDL fraction are removed by the liver and processed into bile more effectively than those derived from the AI/AII-HDL fraction. This may be due, in part, to the more effective binding of AI-HDL to the hepatocyte membrane. Several HDL receptors have been identified, the most well characterized of which is the scavenger receptor class B, type I (SR BI) (Acton *et al.*, 1996, *Science* 271:518-520). The SR-BI is expressed most abundantly in steroidogenic tissues (*e.g.*, the adrenals), and in the liver (Landshulz *et al.*, 1996, *J. Clin. Invest.* 98:984-995; Rigotti *et al.*, 1996, *J. Biol. Chem.* 271:33545-33549). Other proposed HDL receptors include HB1 and HB2 (Hidaka and Fidge, 1992, *Biochem J.* 15:161 7; Kurata *et al.*, 1998, *J. Atherosclerosis and Thrombosis* 4:112 7).

While there is a consensus that CETP is involved in the metabolism of VLDL- and LDL-derived lipids, its role in RCT remains controversial. However, changes in CETP activity or its acceptors, VLDL and LDL, play a role in "remodeling" the HDL population. For example, in the absence of CETP, the HDL becomes enlarged particles that are poorly removed from the circulation (for reviews on RCT and HDL, See Fielding & Fielding, 1995, *J. Lipid Res.* 36:211-228; Barrans *et al.*, 1996, *Biochem. Biophys. Acta.* 1300:73-85; Hirano *et al.*, 1997, *Arterioscler. Thromb. Vasc. Biol.* 17:1053-1059).

2.3 Reverse Transport of Other Lipids

HDL is not only involved in the reverse transport of cholesterol, but also plays a role in the reverse transport of other lipids, *i.e.*, the transport of lipids from cells, organs, and tissues to the liver for catabolism and excretion. Such lipids include sphingomyelin, oxidized lipids, and lysophophatidylcholine. For example, Robins and Fasulo (1997, *J. Clin. Invest.* 99:380 384) have shown that HDL stimulates the transport of plant sterol by the liver into bile secretions.

2.4 Peroxisome Proliferator Activated Receptor Pathway

Peroxisome proliferators are a structurally diverse group of compounds that, when administered to rodents, elicit dramatic increases in the size and number of hepatic and renal peroxisomes, as well as concomitant increases in the capacity of peroxisomes to metabolize fatty acids via increased expression of the enzymes required for the β-oxidation cycle (Lazarow and Fujiki, 1985, *Ann. Rev. Cell Biol.* 1:489 530; Vamecq and Draye, 1989, *Essays Biochem.* 24:1115 225; and Nelali *et al.*, 1988, *Cancer Res.* 48:5316 5324). Chemicals included in this group are the fibrate class of hypolipidemic drugs, herbicides, and phthalate plasticizers (Reddy and Lalwani, 1983, *Crit. Rev. Toxicol.* 12:1 58).

Peroxisome proliferation can also be elicited by dietary or physiological factors, such as a high fat diet and cold acclimatization.

Insight into the mechanism whereby peroxisome proliferators exert their pleiotropic effects was provided by the identification of a member of the nuclear hormone receptor superfamily activated by these chemicals (Isseman and Green, 1990, *Nature* 347:645 650). This receptor, termed peroxisome proliferator activated receptor α (PPARα), was subsequently shown to be activated by a variety of medium and long chain fatty acids. PPARα activates transcription by binding to DNA sequence elements, termed peroxisome proliferator response elements (PPRE), in the form of a heterodimer with the retinoid X receptor (RXR). RXR is activated by 9-cis retinoic acid (*see* Kliewer *et al.*, 1992, *Nature* 358:771 774; Gearing *et al.*, 1993, *Proc. Natl. Acad. Sci. USA* 90:1440 1444, Keller *et al.*, 1993, *Proc. Natl. Acad. Sci. USA* 90:2160 2164; Heyman *et al.*, 1992, *Cell* 68:397 406, and Levin *et al.*, 1992, *Nature* 355:359 361). Since the discovery of PPARα, additional isoforms of PPAR have been identified, *e.g.*, PPARβ, PPARγ and PPARδ, which have similar functions and are similarly regulated.

PPARs have been identified in the enhancers of a number of gene-encoding proteins that regulate lipid metabolism. These proteins include the three enzymes required for peroxisomal β-oxidation of fatty acids; apolipoprotein A-I; medium chain acyl-CoA dehydrogenase, a key enzyme in mitochondrial β-oxidation; and aP2, a lipid binding protein expressed exclusively in adipocytes (reviewed in Keller and Whali, 1993, *TEM*, 4:291 296; *see also* Staels and Auwerx, 1998, *Atherosclerosis* 137 Suppl:S19 23). The nature of the PPAR target genes coupled with the activation of PPARs by fatty acids and hypolipidemic drugs suggests a physiological role for the PPARs in lipid homeostasis.

Pioglitazone, an antidiabetic compound of the thiazolidinedione class, was reported to stimulate expression of a chimeric gene containing the enhancer/promoter of the lipid binding protein aP2 upstream of the chloroamphenicol acetyl transferase reporter gene (Harris and Kletzien, 1994, *Mol. Pharmacol.* 45:439 445). Deletion analysis led to the identification of an approximately 30 bp region accounting for pioglitazone responsiveness. In an independent study, this 30 bp fragment was shown to contain a PPRE (Tontonoz *et al.*,1994, *Nucleic Acids Res.* 22:5628 5634). Taken together, these studies suggested the possibility that the thiazolidinediones modulate gene expression at the transcriptional level through interactions with a PPAR and reinforce the concept of the interrelatedness of glucose and lipid metabolism.

2.5 Current Cholesterol Management Therapies

In the past two decades or so, the segregation of cholesterolemic compounds into HDL and LDL regulators and recognition of the desirability of decreasing blood levels of the latter has led to the development of a number of drugs. However, many of these drugs have undesirable side effects and/or are contraindicated in certain patients, particularly when administered in combination with other drugs.

Bile-acid-binding resins are a class of drugs that interrupt the recycling of bile acids from the intestine to the liver. Examples of bile-acid-binding resins are cholestyramine (QUESTRAN LIGHT, Bristol-Myers Squibb), and colestipol hydrochloride (COLESTID, Pharmacia & Upjohn Company). When taken orally, these positively charged resins bind to negatively charged bile acids in the intestine. Because the resins cannot be absorbed from the intestine, they are excreted, carrying the bile acids with them. The use of such resins, however, at best only lowers serum cholesterol levels by about 20%. Moreover, their use is associated with gastrointestinal side-effects, including constipation and certain vitamin deficiencies. Moreover, since the resins bind to drugs, other oral medications must be taken at least one hour before or four to six hours subsequent to ingestion of the resin, complicating heart patients' drug regimens.

The statins are inhibitors of cholesterol synthesis. Sometimes, the statins are used in combination therapy with bile-acid-binding resins. Lovastatin (MEVACOR, Merck & Co., Inc.), a natural product derived from a strain of *Aspergillus*; pravastatin (PRAVACHOL, Bristol-Myers Squibb Co.); and atorvastatin (LIPITOR, Warner Lambert) block cholesterol synthesis by inhibiting HMGCoA reductase, the key enzyme involved in the cholesterol biosynthetic pathway. Lovastatin significantly reduces serum cholesterol and LDL-serum levels. However, serum HDL levels are only slightly increased following lovastatin administration. The mechanism of the LDL-lowering effect may involve both reduction of VLDL concentration and induction of cellular expression of LDL-receptor, leading to reduced production and/or increased catabolism of LDL. Side effects, including liver and kidney dysfunction are associated with the use of these drugs.

Nicotinic acid, also known as niacin, is a water-soluble vitamin B-complex used as a dietary supplement and antihyperlipidemic agent. Niacin diminishes the production of VLDL and is effective at lowering LDL. It is used in combination with bile-acid-binding resins. Niacin can increase HDL when administered at therapeutically effective doses; however, its usefulness is limited by serious side effects.

Fibrates are a class of lipid-lowering drugs used to treat various forms of hyperlipidemia, elevated serum triglycerides, which may also be associated with hypercholesterolemia. Fibrates appear to reduce the VLDL fraction and modestly increase HDL; however, the effects of these drugs on serum cholesterol is variable. In the United States, fibrates have been approved for use as antilipidemic drugs, but have not received approval as hypercholesterolemia agents. For example, clofibrate (ATROMID-S, Wyeth-Ayerst Laboratories) is an antilipidemic agent that acts to lower serum triglycerides by reducing the VLDL fraction. Although ATROMID-S may reduce serum cholesterol levels in certain patient subpopulations, the biochemical response to the drug is variable, and is not always possible to predict which patients will obtain favorable results. ATROMID-S has not been shown to be effective for prevention of coronary heart disease. The chemically and pharmacologically related drug, gemfibrozil (LOPID, Parke-Davis), is a lipid regulating agent which moderately decreases serum triglycerides and VLDL cholesterol. LOPID also increases HDL cholesterol, particularly the HDL2 and HDL3 subfractions, as well as both the AI/AII-HDL fractions. However, the lipid response to LOPID is heterogeneous, especially among different patient populations. Moreover, while prevention of coronary heart disease was observed in male patients between the ages of 40 and 55 without history or symptoms of existing coronary heart disease, it is not clear to what extent these findings can be extrapolated to other patient populations (*e.g.*, women, older and younger males). Indeed, no efficacy was observed in patients with established coronary heart disease. Serious side-effects are associated with the use of fibrates, including toxicity; malignancy, particularly malignancy of gastrointestinal cancer; gallbladder disease; and an increased incidence in non-coronary mortality. These drugs are not indicated for the treatment of patients with high LDL or low HDL as their only lipid abnormality.

Oral estrogen replacement therapy may be considered for moderate hypercholesterolemia in post-menopausal women. However, increases in HDL may be accompanied with an increase in triglycerides. Estrogen treatment is, of course, limited to a specific patient population, postmenopausal women, and is associated with serious side effects, including induction of malignant neoplasms; gall bladder disease; thromboembolic disease; hepatic adenoma; elevated blood pressure; glucose intolerance; and hypercalcemia.

Long chain carboxylic acids, particularly long chain α,ω-dicarboxylic acids with distinctive substitution patterns, and their simple derivatives and salts, have been disclosed for treating atherosclerosis, obesity, and diabetes (*See, e.g.*, Bisgaier *et al.*, 1998, *J. Lipid Res.* 39:17-30, and references cited therein; International Patent Publication WO

98/30530; U.S. Patent No. 4,689,344; International Patent Publication WO 99/00116; and U.S. Patent No. 5,756,344). However, some of these compounds, for example the α,ω-dicarboxylic acids substituted at their α,α'-carbons (U.S. Patent No. 3,773,946), while having serum triglyceride and serum cholesterol-lowering activities, have no value for treatment of obesity and hypercholesterolemia (U.S. Patent No. 4,689,344).

U.S. Patent No. 4,689,344 discloses β,β,β',β'-tetrasubstituted-α,ω-alkanedioic acids that are optionally substituted at their α,α,α',α'-positions, and alleges that they are useful for treating obesity, hyperlipidemia, and diabetes. According to this reference, both triglycerides and cholesterol are lowered significantly by compounds such as 3,3,14,14-tetramethylhexadecane-1,16-dioic acid. U.S. Patent No. 4,689,344 further discloses that the β,β,β',β'-tetramethyl-alkanediols of U.S. Patent No. 3,930,024 also are not useful for treating hypercholesterolemia or obesity.

Other compounds are disclosed in U.S. Patent No. 4,711,896. In U.S. Patent No. 5,756,544, α,ω-dicarboxylic acid-terminated dialkane ethers are disclosed to have activity in lowering certain plasma lipids, including Lp(a), triglycerides, VLDL-cholesterol, and LDL-cholesterol, in animals, and elevating others, such as HDL-cholesterol. The compounds are also stated to increase insulin sensitivity. In U.S. Patent No. 4,613,593, phosphates of dolichol, a polyprenol isolated from swine liver, are stated to be useful in regenerating liver tissue, and in treating hyperuricuria, hyperlipemia, diabetes, and hepatic diseases in general.

U.S. Patent No. 4,287,200 discloses azolidinedione derivatives with anti-diabetic, hypolipidemic, and anti-hypertensive properties. However, the administration of these compounds to patients can produce side effects such as bone marrow depression, and both liver and cardiac cytotoxicity. Further, the compounds disclosed by U.S. Patent No. 4,287,200 stimulate weight gain in obese patients.

It is clear that none of the commercially available cholesterol management drugs has a general utility in regulating lipid, lipoprotein, insulin and glucose levels in the blood. Thus, compounds that have one or more of these utilities are clearly needed. Further, there is a clear need to develop safer drugs that are efficacious at lowering serum cholesterol, increasing HDL serum levels, preventing coronary heart disease, and/or treating existing disease such as atherosclerosis, obesity, diabetes, and other diseases that are affected by lipid metabolism and/or lipid levels. There is also a clear need to develop drugs that may be used with other lipid-altering treatment regimens in a synergistic manner.

There is still a further need to provide useful therapeutic agents whose solubility and Hydrophile/Lipophile Balance (HLB) can be readily varied.

Citation or identification of any reference in Section 2 of this application is not an admission that such reference is available as prior art to the present invention.

3. SUMMARY OF THE INVENTION

The invention encompasses hydroxyl compounds useful in treating various disorders.

The invention further encompasses pharmaceutical compositions comprising one or more compounds of the invention and a pharmaceutically acceptable vehicle, excipient, or diluent. A pharmaceutically acceptable vehicle can comprise a carrier, excipient, diluent, or a mixture thereof.

The invention encompasses a method for treating or preventing aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, enhancing bile production, enhancing reverse lipid transport, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, modulating C reactive protein, obesity, oxysterol elimination in bile, pancreatitis, Parkinson's disease, a peroxisome proliferator activated receptor-associated disorder, phospholipid elimination in bile, renal disease, septicemia, metabolic syndrome disorders (*e.g.*, Syndrome X), and a thrombotic disorder, comprising administering to a patient in need of such treatment or prevention a therapeutically effective amount of a compound of the invention or a pharmaceutical composition comprising a compound of the invention and a pharmaceutically acceptable vehicle, excipient, or diluent.

The invention also encompasses a method for inhibiting hepatic fatty acid and sterol synthesis comprising administering to a patient in need thereof a therapeutically effective amount of a compound of the invention or a pharmaceutical composition comprising a compound of the invention and a pharmaceutically acceptable vehicle, excipient, or diluent.

The invention also encompasses a method of treating or preventing a disease or disorder that is capable of being treated or prevented by increasing HDL levels, which comprises administering to a patient in need of such treatment or prevention a therapeutically effective amount of a compound of the invention and a pharmaceutically acceptable vehicle, excipient, or diluent.

The invention also encompasses a method of treating or preventing a disease or disorder that is capable of being treated or prevented by lowering LDL levels, which

comprises administering to such patient in need of such treatment or prevention a therapeutically effective amount of a compound of the invention and a pharmaceutically acceptable vehicle, excipient, or diluent.

The compounds of the invention favorably alter lipid metabolism in animal models of dyslipidemia at least in part by enhancing oxidation of fatty acids through the ACC/malonyl-CoA/CPT-I regulatory axis and therefore the invention also encompasses methods of treatment or prevention of metabolic syndrome disorders.

The invention further encompasses a method for reducing the fat content of meat in livestock comprising administering to livestock in need of such fat-content reduction a therapeutically effective amount of a compound of the invention or a pharmaceutical composition comprising a compound of the invention and a pharmaceutically acceptable vehicle, excipient, or diluent.

The invention provides a method for reducing the cholesterol content of a fowl egg comprising administering to a fowl species a therapeutically effective amount of a compound of the invention or a pharmaceutical composition comprising a compound of the invention and a pharmaceutically acceptable vehicle, excipient, or diluent.

The present invention may be understood more fully by reference to the detailed description and examples, which are intended to exemplify non-limiting embodiments of the invention.

4. DEFINITIONS AND ABBREVIATIONS

Apo(a): apolipoprotein(a)

Apo A-I: apolipoprotein A-I

Apo B: apolipoprotein B

Apo E: apolipoprotein E

FH: Familial hypercholesterolemia

FCH: Familial combined hyperlipidemia

GDM: Gestational diabetes mellitus

HDL: High density lipoprotein

IDL: Intermediate density lipoprotein

IDDM: Insulin dependent diabetes mellitus

LDH: Lactate dehdyrogenase

LDL: Low density lipoprotein

Lp(a): Lipoprotein (a)

MODY: Maturity onset diabetes of the young

NIDDM: Non-insulin dependent diabetes mellitus

PPAR: Peroxisome proliferator activated receptor

RXR: Retinoid X receptor

VLDL: Very low density lipoprotein

As used herein, the phrase "compounds of the invention" means compounds disclosed herein. Particular compounds of the invention are compounds of formulas **I-XXII** and pharmaceutically acceptable salts, hydrates, enantiomers, diastereomer, racemates or mixtures of stereoisomers thereof. Thus, "compound of the invention" collectively means compound of formulas **I-XXII** and pharmaceutically acceptable salts, hydrates, enantiomers, diastereomer, racemates or mixtures of stereoisomers thereof. The compounds of the invention are identified herein by their chemical structure and/or chemical name. Where a compound is referred to by both a chemical structure and a chemical name, and the chemical structure and chemical name conflict, the chemical structure is to be accorded more weight.

The compounds of the invention can contain one or more chiral centers and/or double bonds and, therefore, exist as stereoisomers, such as double-bond isomers (*i.e.*, geometric isomers), enantiomers, or diastereomers. According to the invention, the chemical structures depicted herein, and therefore the compounds of the invention, encompass all of the corresponding compounds' enantiomers and stereoisomers, that is, both the stereomerically pure form (*e.g.*, geometrically pure, enantiomerically pure, or diastereomerically pure) and enantiomeric and stereoisomeric mixtures.

As used herein, a composition that "substantially" comprises a compound means that the composition contains more than about 80% by weight, more preferably more than about 90% by weight, even more preferably more than about 95% by weight, and most preferably more than about 97% by weight of the compound.

As used herein, a reaction that is "substantially complete" means that the reaction contains more than about 80% by weight of the desired product, more preferably more than about 90% by weight of the desired product, even more preferably more than about 95% by weight of the desired product, and most preferably more than about 97% by weight of the desired product.

A compound of the invention is considered optically active or enantiomerically pure (*i.e.*, substantially the R-form or substantially the S-form) with respect to a chiral center when the compound is about 90% ee (enantiomeric excess) or greater, preferably, equal to or greater than 95% ee with respect to a particular chiral center.

A compound of the invention is considered to be in enantiomerically-enriched form when the compound has an enantiomeric excess of greater than about 1% ee, preferably greater than about 5% ee, more preferably, greater than about 10% ee with respect to a particular chiral center. A compound of the invention is considered diastereomerically pure with respect to multiple chiral centers when the compound is about 90% de (diastereomeric excess) or greater, preferably, equal to or greater than 95% de with respect to a particular chiral center. A compound of the invention is considered to be in diastereomerically-enriched form when the compound has an diastereomeric excess of greater than about 1% de, preferably greater than about 5% de, more preferably, greater than about 10% de with respect to a particular chiral center. As used herein, a racemic mixture means about 50% of one enantiomer and about 50% of is corresponding enantiomer relative to all chiral centers in the molecule. Thus, the invention encompasses all enantiomerically-pure, enantiomerically-enriched, diastereomerically pure, diastereomerically enriched, and racemic mixtures of compounds of Formulas **I** through **XXII**.

Enantiomeric and diastereomeric mixtures can be resolved into their component enantiomers or stereoisomers by well known methods, such as chiral-phase gas chromatography, chiral-phase high performance liquid chromatography, crystallizing the compound as a chiral salt complex, or crystallizing the compound in a chiral solvent. Enantiomers and diastereomers can also be obtained from diastereomerically- or enantiomerically-pure intermediates, reagents, and catalysts by well known asymmetric synthetic methods.

The compounds of the invention are defined herein by their chemical structures and/or chemical names. Where a compound is referred to by both a chemical structure and a chemical name, and the chemical structure and chemical name conflict, the chemical structure is determinative of the compound's identity.

When administered to a patient, *e.g.*, to an animal for veterinary use or for improvement of livestock, or to a human for clinical use, the compounds of the invention are administered in isolated form or as the isolated form in a pharmaceutical composition. As used herein, "isolated" means that the compounds of the invention are separated from other components of either (a) a natural source, such as a plant or cell, preferably bacterial culture, or (b) a synthetic organic chemical reaction mixture. Preferably, via conventional techniques, the compounds of the invention are purified. As used herein, "purified" means that when isolated, the isolate contains at least 95%, preferably at least 98%, of a single hydroxy compound of the invention by weight of the isolate.

The phrase "pharmaceutically acceptable salt(s)," as used herein includes, but is not limited to, salts of acidic or basic groups that may be present in the compounds of the invention. Compounds that are basic in nature are capable of forming a wide variety of salts with various inorganic and organic acids. The acids that may be used to prepare pharmaceutically acceptable acid addition salts of such basic compounds are those that form non-toxic acid addition salts, *i.e.*, salts containing pharmacologically acceptable anions, including but not limited to sulfuric, citric, maleic, acetic, oxalic, hydrochloride, hydrobromide, hydroiodide, nitrate, sulfate, bisulfate, phosphate, acid phosphate, isonicotinate, acetate, lactate, salicylate, citrate, acid citrate, tartrate, oleate, tannate, pantothenate, bitartrate, ascorbate, succinate, maleate, gentisinate, fumarate, gluconate, glucaronate, saccharate, formate, benzoate, glutamate, methanesulfonate, ethanesulfonate, benzenesulfonate, p-toluenesulfonate and pamoate (*i.e.*, 1,1'-methylene-bis-(2-hydroxy-3-naphthoate)) salts. Compounds of the invention that include an amino moiety also can form pharmaceutically acceptable salts with various amino acids, in addition to the acids mentioned above. Compounds of the invention that are acidic in nature are capable of forming base salts with various pharmacologically acceptable cations. Examples of such salts include alkali metal or alkaline earth metal salts and, particularly, calcium, magnesium, sodium lithium, zinc, potassium, and iron salts.

As used herein, the term "hydrate" means a compound of the invention or a salt thereof, that further includes a stoichiometric or non-stoichiometric amount of water bound by non-covalent intermolecular forces. The term hydrate includes solvates, which are stoichiometric or non-stoichiometric amounts of a solvent bound by non-covalent intermolecular forces. Preferred solvents are volatile, non-toxic, and/or acceptable for administration to humans in trace amounts.

As used herein, the term "altering lipid metabolism" indicates an observable (measurable) change in at least one aspect of lipid metabolism, including but not limited to total blood lipid content, blood HDL cholesterol, blood LDL cholesterol, blood VLDL cholesterol, blood triglyceride, blood Lp(a), blood apo A-I, blood apo E and blood non-esterified fatty acids.

As used herein, the term "altering glucose metabolism" indicates an observable (measurable) change in at least one aspect of glucose metabolism, including but not limited to total blood glucose content, blood insulin, the blood insulin to blood glucose ratio, insulin sensitivity, and oxygen consumption.

As used herein, the term "alkyl group" means a saturated, monovalent unbranched or branched hydrocarbon chain. Examples of alkyl groups include, but are not limited to, (C_1–C_6)alkyl groups, such as methyl, ethyl, propyl, isopropyl, 2-methyl-1-propyl, 2 methyl 2-propyl, 2-methyl-1-butyl, 3-methyl-1-butyl, 2 methyl-3-butyl, 2,2 dimethyl 1-propyl, 2-methyl-1-pentyl, 3 methyl-1-pentyl, 4 methyl-1-pentyl, 2-methyl-2-pentyl, 3-methyl-2-pentyl, 4 methyl 2 pentyl, 2,2 dimethyl 1 butyl, 3,3-dimethyl-1-butyl, 2-ethyl-1-butyl, butyl, isobutyl, t–butyl, pentyl, isopentyl, neopentyl, and hexyl, and longer alkyl groups, such as heptyl, and octyl. An alkyl group can be unsubstituted or substituted with one or two suitable substituents.

As used herein, the term an "alkenyl group" means a monovalent unbranched or branched hydrocarbon chain having one or more double bonds therein. The double bond of an alkenyl group can be unconjugated or conjugated to another unsaturated group. Suitable alkenyl groups include, but are not limited to (C_2–C_6)alkenyl groups, such as vinyl, allyl, butenyl, pentenyl, hexenyl, butadienyl, pentadienyl, hexadienyl, 2-ethylhexenyl, 2-propyl-2-butenyl, 4-(2-methyl-3-butene)-pentenyl. An alkenyl group can be unsubstituted or substituted with one or two suitable substituents.

As used herein, the term an "alkynyl group" means monovalent unbranched or branched hydrocarbon chain having one or more triple bonds therein. The triple bond of an alkynyl group can be unconjugated or conjugated to another unsaturated group. Suitable alkynyl groups include, but are not limited to, (C_2–C_6)alkynyl groups, such as ethynyl, propynyl, butynyl, pentynyl, hexynyl, methylpropynyl, 4-methyl-1-butynyl, 4-propyl-2-pentynyl, and 4-butyl-2-hexynyl. An alkynyl group can be unsubstituted or substituted with one or two suitable substituents.

As used herein, the term an "aryl group" means a monocyclic or polycyclic-aromatic radical comprising carbon and hydrogen atoms. Examples of suitable aryl groups include, but are not limited to, phenyl, tolyl, anthacenyl, fluorenyl, indenyl, azulenyl, and naphthyl, as well as benzo-fused carbocyclic moieties such as 5,6,7,8-tetrahydronaphthyl. An aryl group can be unsubstituted or substituted with one or two suitable substituents. Preferably, the aryl group is a monocyclic ring, wherein the ring comprises 6 carbon atoms, referred to herein as "(C_6)aryl".

As used herein, the term an "heteroaryl group" means a monocyclic- or polycyclic aromatic ring comprising carbon atoms, hydrogen atoms, and one or more heteroatoms, preferably 1 to 3 heteroatoms, independently selected from nitrogen, oxygen, and sulfur. Illustrative examples of heteroaryl groups include, but are not limited to,

pyridinyl, pyridazinyl, pyrimidinyl, pyrazyl, triazinyl, pyrrolyl, pyrazolyl, imidazolyl, (1,2,3)- and (1,2,4)-triazolyl, pyrazinyl, pyrimidinyl, tetrazolyl, furyl, thiophenyl, isoxazolyl, thiazolyl, furyl, phenyl, isoxazolyl, and oxazolyl. A heteroaryl group can be unsubstituted or substituted with one or two suitable substituents. Preferably, a heteroaryl group is a monocyclic ring, wherein the ring comprises 2 to 5 carbon atoms and 1 to 3 heteroatoms, referred to herein as "(C_2–C_5)heteroaryl".

As used herein, the term "cycloalkyl group" means a monocyclic or polycyclic saturated ring comprising carbon and hydrogen atoms and having no carbon-carbon multiple bonds. Examples of cycloalkyl groups include, but are not limited to, (C_3–C_7)cycloalkyl groups, such as cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, and cycloheptyl, and saturated cyclic and bicyclic terpenes. A cycloalkyl group can be unsubstituted or substituted by one or two suitable substituents. Preferably, the cycloalkyl group is a monocyclic ring or bicyclic ring.

As used herein, the term "heterocycloalkyl group" means a monocyclic or polycyclic ring comprising carbon and hydrogen atoms and at least one heteroatom, preferably, 1 to 3 heteroatoms selected from nitrogen, oxygen, and sulfur, and having no unsaturation. Examples of heterocycloalkyl groups include pyrrolidinyl, pyrrolidino, piperidinyl, piperidino, piperazinyl, piperazino, morpholinyl, morpholino, thiomorpholinyl, thiomorpholino, and pyranyl. A heterocycloalkyl group can be unsubstituted or substituted with one or two suitable substituents. Preferably, the heterocycloalkyl group is a monocyclic or bicyclic ring, more preferably, a monocyclic ring, wherein the ring comprises from 3 to 6 carbon atoms and form 1 to 3 heteroatoms, referred to herein as (C_1–C_6)heterocycloalkyl.

As used herein, the terms "heterocyclic radical" or "heterocyclic ring" mean a heterocycloalkyl group or a heteroaryl group.

As used herein, the term "alkoxy group"means an –O–alkyl group, wherein alkyl is as defined above. An alkoxy group can be unsubstituted or substituted with one or two suitable substituents. Preferably, the alkyl chain of an alkyloxy group is from 1 to 6 carbon atoms in length, referred to herein as "(C_1–C_6)alkoxy".

As used herein, the term "aryloxy group" means an –O–aryl group, wherein aryl is as defined above. An aryloxy group can be unsubstituted or substituted with one or two suitable substituents. Preferably, the aryl ring of an aryloxy group is a monocyclic ring, wherein the ring comprises 6 carbon atoms, referred to herein as "(C_6)aryloxy".

As used herein, the term "benzyl" means –CH_2–phenyl.

As used herein, the term "phenyl" means $-C_6H_5$. A phenyl group can be unsubstituted or substituted with one or two suitable substituents, wherein the subtituent replaces an H of the phenyl group. As used herein, "Ph," represents a phenyl group or a substituted phenyl group.

As used herein, the term "hydrocarbyl" group means a monovalent group selected from $(C_1–C_8)$alkyl, $(C_2–C_8)$alkenyl, and $(C_2–C_8)$alkynyl, optionally substituted with one or two suitable substituents. Preferably, the hydrocarbon chain of a hydrocarbyl group is from 1 to 6 carbon atoms in length, referred to herein as "$(C_1–C_6)$hydrocarbyl".

As used herein, a "carbonyl" group is a divalent group of the formula C(O).

As used herein, the term "alkoxycarbonyl" group means a monovalent group of the formula –C(O)–alkoxy. Preferably, the hydrocarbon chain of an alkoxycarbonyl group is from 1 to 8 carbon atoms in length, referred to herein as a "lower alkoxycarbonyl" group.

As used herein, a "carbamoyl" group means the radical $-C(O)N(R')_2$, wherein R' is chosen from the group consisting of hydrogen, alkyl, and aryl.

As used herein, "halogen" means fluorine, chlorine, bromine, or iodine. Accordingly, the meaning of the terms "halo" and "Hal"encompass fluoro, chloro, bromo, and iodo.

As used herein, a "suitable substituent" means a group that does not nullify the synthetic or pharmaceutical utility of the compounds of the invention or the intermediates useful for preparing them. Examples of suitable substituents include, but are not limited to: $(C_1–C_8)$alkyl; $(C_1–C_8)$alkenyl; $(C_1–C_8)$alkynyl; (C_6)aryl; $(C_2–C_5)$heteroaryl; $(C_3–C_7)$cycloalkyl; $(C_1–C_8)$alkoxy; (C_6)aryloxy; –CN; –OH; oxo; halo, $–CO_2H$; $–NH_2$; $–NH((C_1–C_8)alkyl)$; $–N((C_1–C_8)alkyl)_2$; $–NH((C_6)aryl)$; $–N((C_6)aryl)_2$; –CHO; $–CO((C_1–C_8)alkyl)$; $–CO((C_6)aryl)$; $–CO_2((C_1–C_8)alkyl)$; and $–CO_2((C_6)aryl)$. One of skill in the art can readily choose a suitable substituent based on the stability and pharmacological and synthetic activity of the compound of the invention.

As used herein, a composition that is "substantially free" of a compound means that the composition contains less than about 20% by weight, more preferably less than about 10% by weight, even more preferably less than about 5% by weight, and most preferably less than about 3% by weight of the compound.

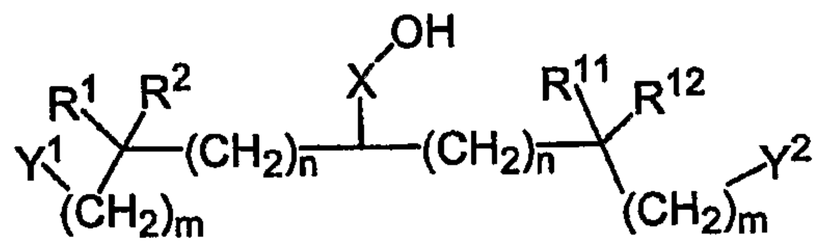
5. DETAILED DESCRIPTION OF THE INVENTION

The compounds of the invention are useful in medical applications for treating or preventing a variety of diseases and disorders such as, but not limited to, cardiovascular disease, stroke, and peripheral vascular disease; dyslipidemia; dyslipoproteinemia; a disorder of glucose metabolism; Alzheimer's Disease; Parkinson's Disease, diabetic nephropathy, diabetic retinopathy, insulin resistance, metabolic syndrome disorders (*e.g.*, Syndrome X); a peroxisome proliferator activated receptor-associated disorder; septicemia; a thrombotic disorder; obesity; pancreatitis; hypertension; renal disease; cancer; inflammation; inflammatory muscle diseases, such as polymylagia rheumatica, polymyositis, and fibrositis; impotence; gastrointestinal disease; irritable bowel syndrome; inflammatory bowel disease; inflammatory disorders, such as asthma, vasculitis, ulcerative colitis, Crohn's disease, Kawasaki disease, Wegener's granulomatosis, (RA), systemic lupus erythematosus (SLE), multiple sclerosis (MS), and autoimmune chronic hepatitis; arthritis, such as rheumatoid arthritis, juvenile rheumatoid arthritis, and osteoarthritis; osteoporosis, soft tissue rheumatism, such as tendonitis; bursitis; autoimmune disease, such as systemic lupus and erythematosus; scleroderma; ankylosing spondylitis; gout; pseudogout; non-insulin dependent diabetes mellitus; polycystic ovarian disease; hyperlipidemias, such as familial hypercholesterolemia (FH), familial combined hyperlipidemia (FCH); lipoprotein lipase deficiencies, such as hypertriglyceridemia, hypoalphalipoproteinemia, and hypercholesterolemia; lipoprotein abnormalities associated with diabetes; lipoprotein abnormalities associated with obesity; and lipoprotein abnormalities associated with Alzheimer's Disease. The compounds and compositions of the invention are useful for treatment or prevention of high levels of blood triglycerides, high levels of low density lipoprotein cholesterol, high levels of apolipoprotein B, high levels of lipoprotein Lp(a) cholesterol, high levels of very low density lipoprotein cholesterol, high levels of fibrinogen, high levels of insulin, high levels of glucose, and low levels of high density lipoprotein cholesterol. The compounds and compositions of the invention also have utility for treatment of NIDDM without increasing weight gain. The compounds of the invention may also be used to reduce the fat content of meat in livestock and reduce the cholesterol content of eggs.

The invention provides novel compounds particularly useful for treating or preventing a variety of diseases and conditions, which include, but are not limited to aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, enhancing

bile production, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, modulating C reactive protein, obesity, oxysterol elimination in bile, pancreatitis, pancreatitius, Parkinson's disease, a peroxisome proliferator activated receptor-associated disorder, phospholipid elimination in bile, renal disease, septicemia, Syndrome X, and a thrombotic disorder.

The invention encompasses compounds of formula **I**:



I

or a pharmaceutically acceptable salt, hydrate, solvate or mixture thereof, wherein:

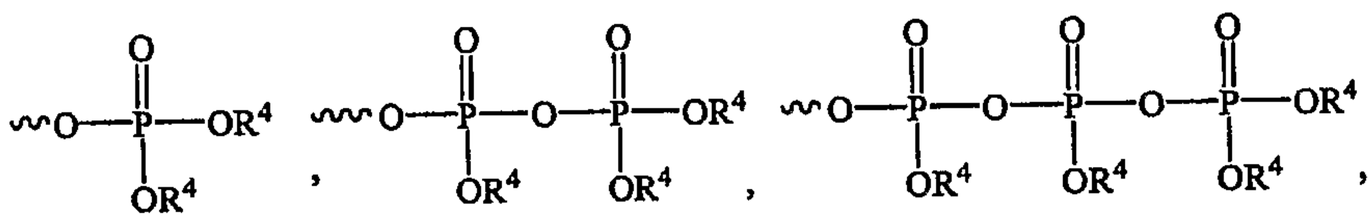
(a) each occurrence of m is independently an integer ranging from 0 to 5;

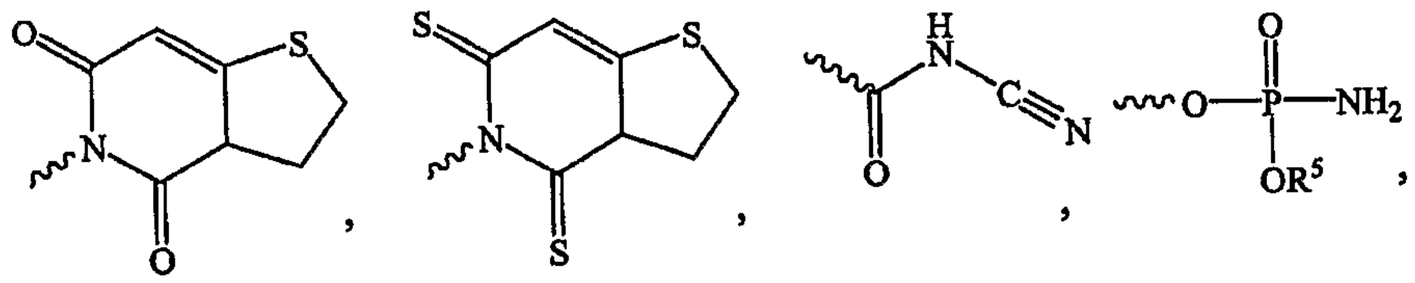
(b) each occurrence of n is independently an integer ranging from 3 to 7;

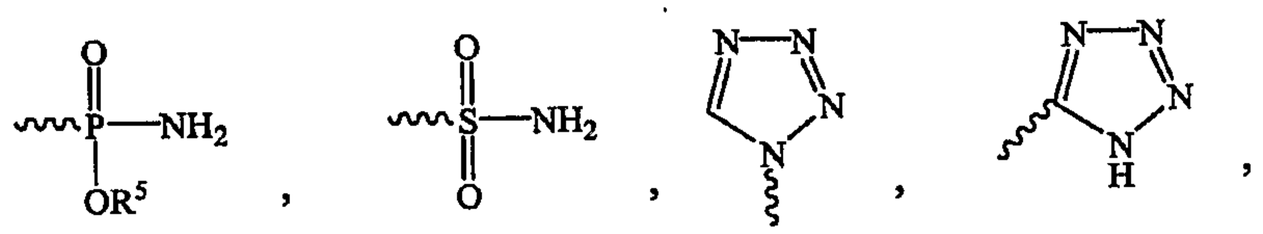
(c) X is $(CH_2)_z$ or PH, wherein z is an integer from 0 to 4;

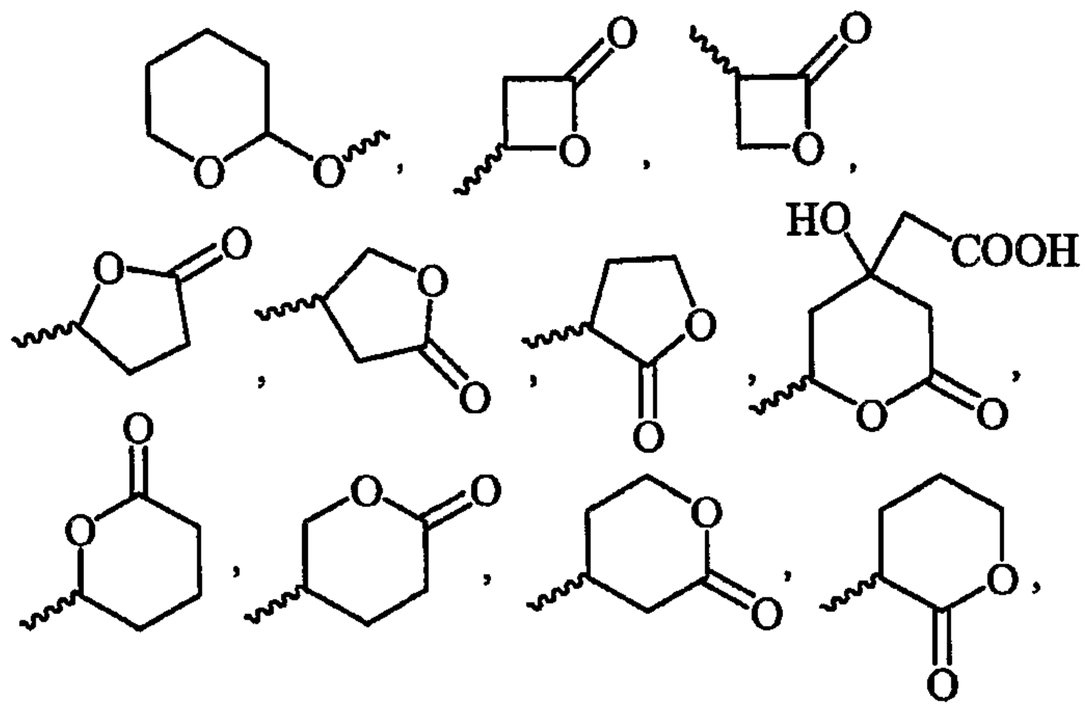
(d) each occurrence of R^1, R^2, R^{11}, and R^{12} is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl, wherein R^1, R^2, R^{11}, and R^{12} are not each simultaneously H; and

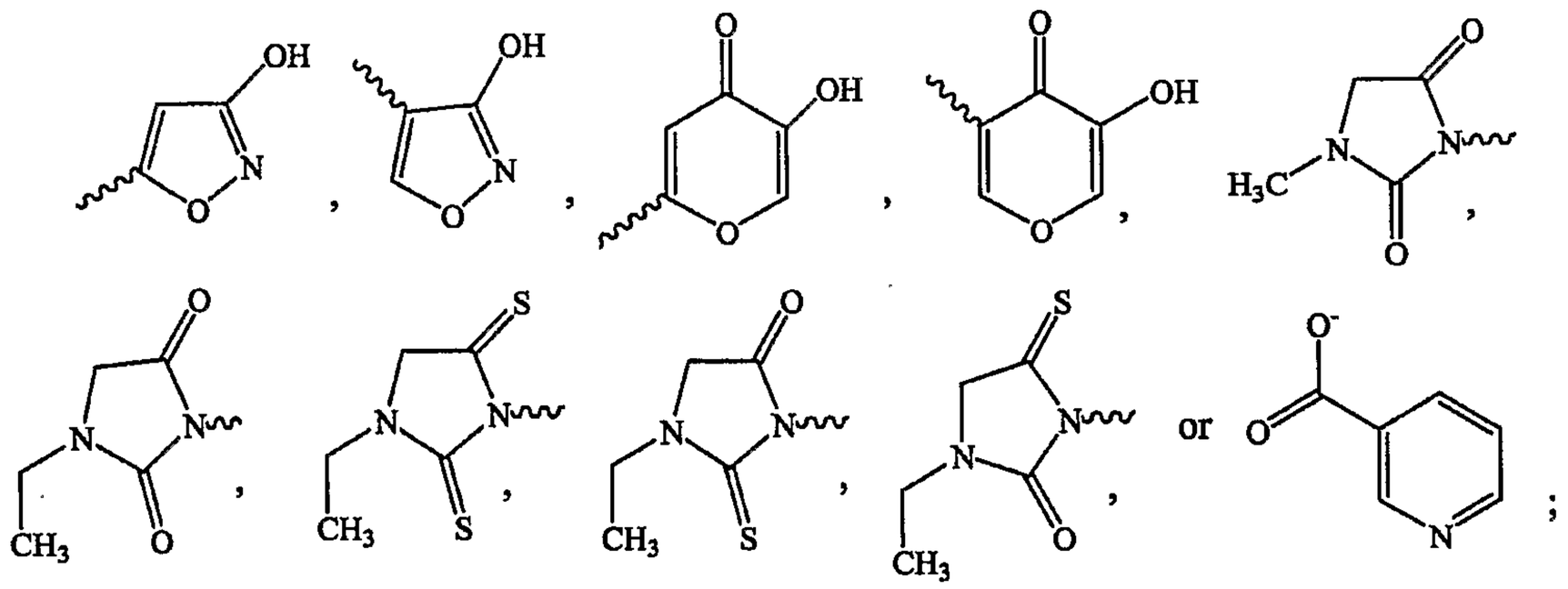
(e) each occurrence of Y^1 and Y^2 is independently $(C_1–C_6)$alkyl, OH, COOH, $COOR^3$, SO_3H,











wherein:

(i) Y^1 and Y^2 are not each simultaneously (C_1-C_6)alkyl;

(ii) R^3 is (C_1–C_6)alkyl, (C_2–C_6)alkenyl, (C_2–C_6)alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, (C_1–C_6)alkoxy, or phenyl groups,

(iii) each occurrence of R^4 is independently H, (C_1–C_6)alkyl, (C_2–C_6)alkenyl, or (C_2–C_6)alkynyl and is unsubstituted or substituted with one or two halo, OH, C_1–C_6 alkoxy, or phenyl groups; and

(iv) each occurrence of R^5 is independently H, (C_1–C_6)alkyl, (C_2–C_6)alkenyl, or (C_2–C_6)alkynyl.

Preferably in formula I, each occurrence of Y^1 and Y^2 is independently OH, $COOR^3$, or COOH.

Other preferred compounds of formula I are those wherein m is 0.

Other preferred compounds of formula I are those wherein m is 1.

Other preferred compounds of formula I are those wherein n is 4.

Other preferred compounds of formula **I** are those wherein n is 5.

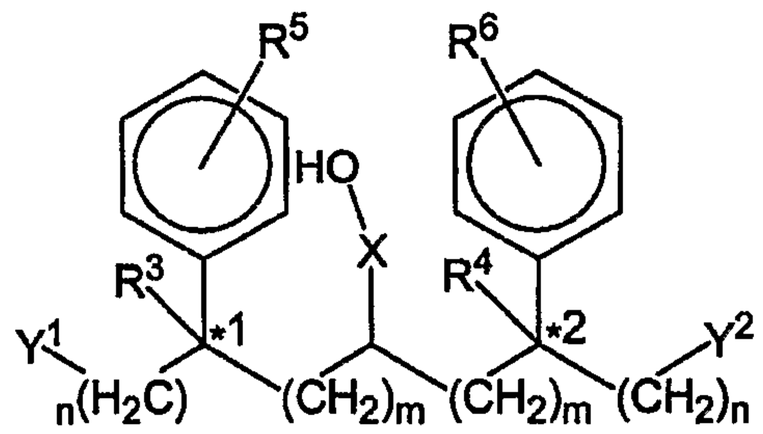
Other preferred compounds of formula **I** are those wherein z is 0.

Other preferred compounds of formula **I** are those wherein z is 1.

Other preferred compounds of formula **I** are those wherein Y^1 is (C_1–C_6)alkyl and Y^2 is OH.

Other preferred compounds of formula I are those wherein Y^1 is methyl and Y^2 is OH.

In another embodiment, the invention encompasses compounds of formula **II**:



II

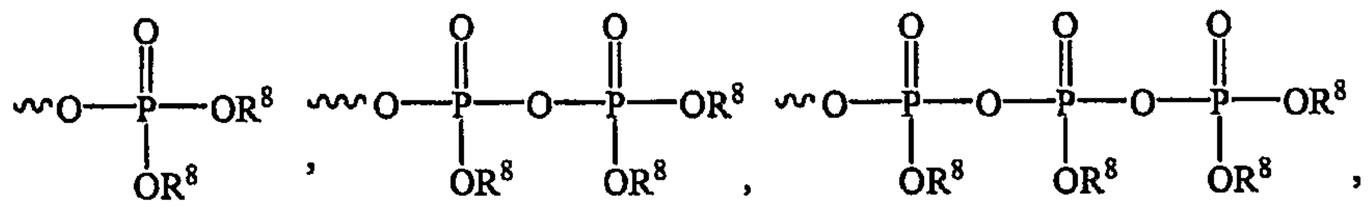
or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein:

(a) each occurrence of m is independently an integer ranging from 3 to 7;

(b) each occurrence of n is independently an integer ranging from 0 to 5;

(c) X is $(CH_2)_z$ or PH, wherein z is an integer from 0 to 4;

(d) each occurrence of Y^1 and Y^2 independently (C_1–C_6)alkyl, OH, COOH, $COOR^7$, SO_3H,



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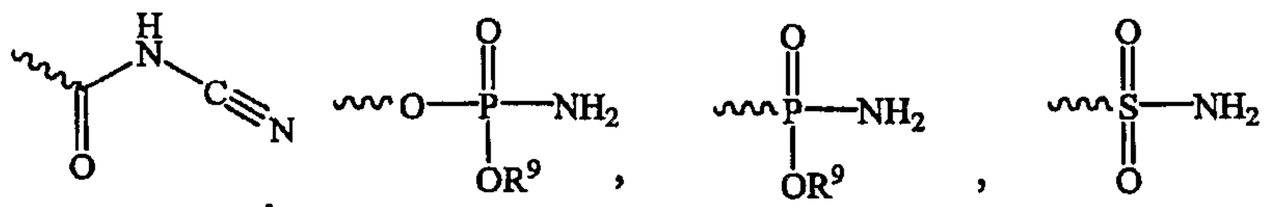

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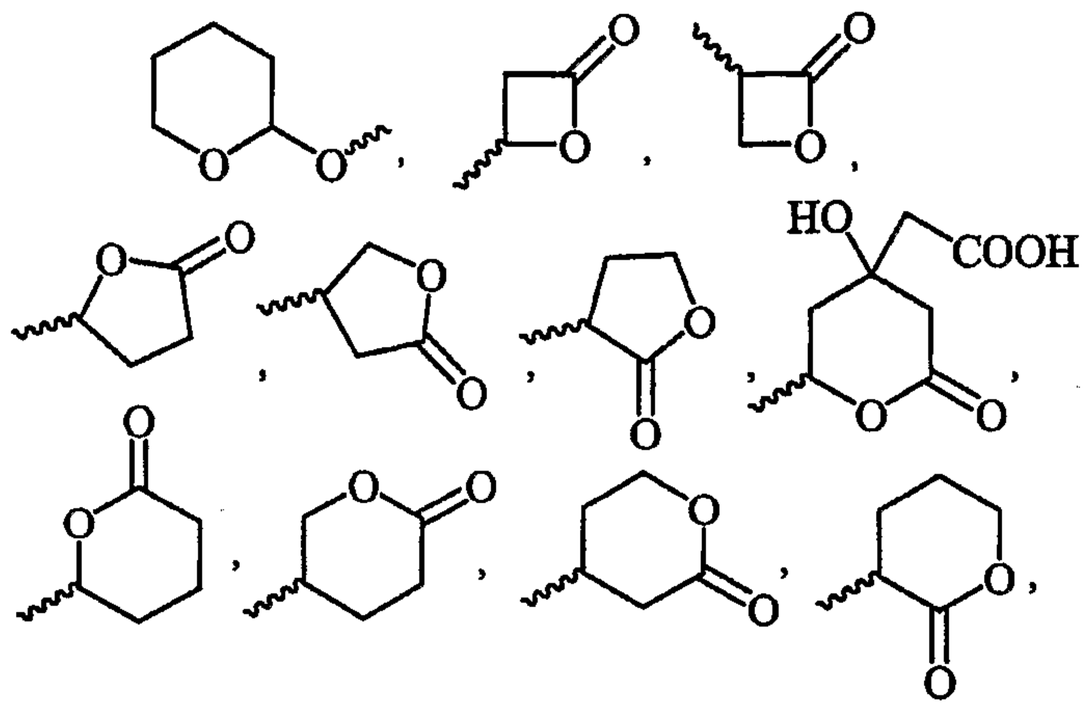
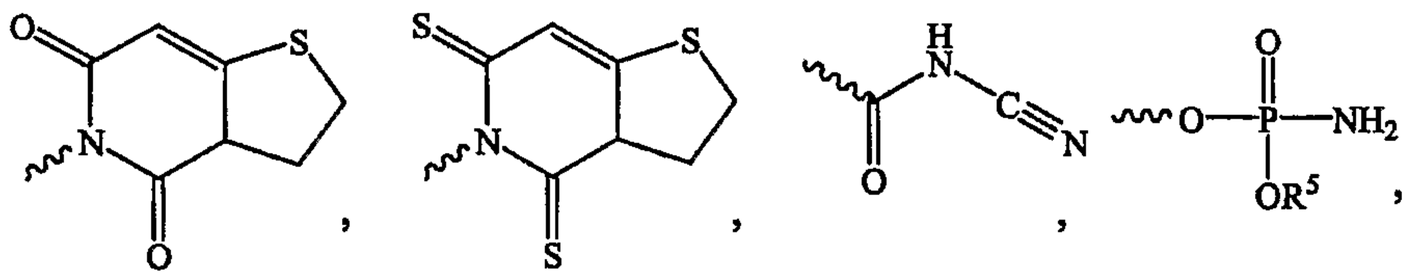
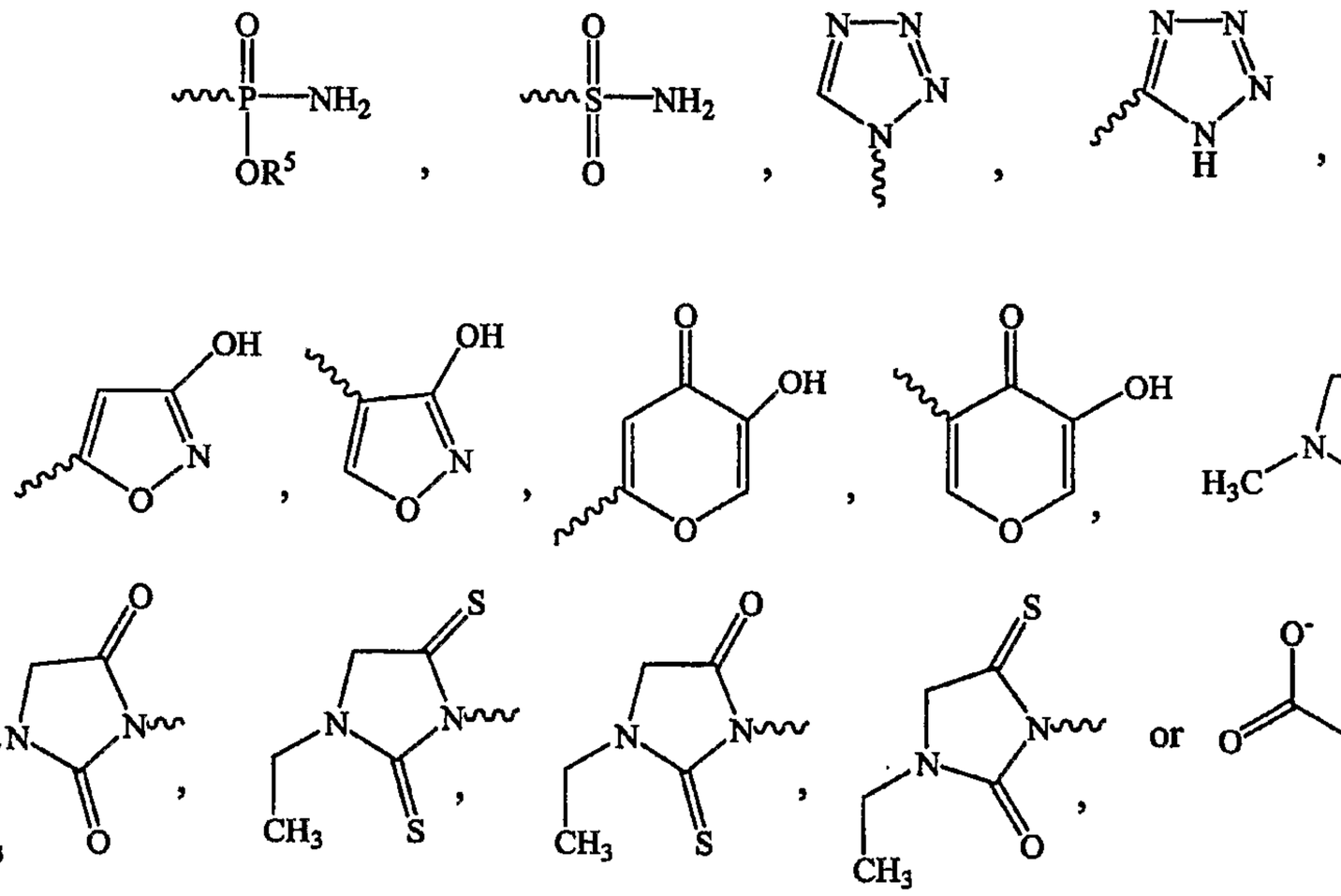






wherein:

(i) R^7 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^8 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1–C_6$ alkoxy, or phenyl groups,

(iii) each occurrence of R^9 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl;

(e) R^3 and R^4 are $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl;

(f) R^5 and R^6 are H, halogen, $(C_1–C_4)$alkyl, $(C_1–C_4)$alkoxy, (C_6)aryloxy, CN, or NO_2, $N(R^5)_2$ where R^5 is H, $(C_1–C_4)$ alkyl, phenyl, or benzyl;

(g) C^{*1} and C^{*2} represent independent chiral-carbon centers wherein each center may independently be R or S.

Exemplary compounds of formula II are those wherein each occurrence of Y^1 and Y^2 is independently OH, $COOR^7$, or COOH.

Other compounds of formula **II** are those wherein m is 4.

Other compounds of formula **II** are those wherein m is 5.

Other compounds of formula **II** are those wherein X is $(CH_2)_z$ and z is 0.

Other compounds of formula **II** are those wherein X is $(CH_2)_z$ and z is 1.

Other compounds of formula **II** are those wherein Y^1 and/or Y^2 is C(O)OH or CH_2OH.

Other compounds of formula **II** are those wherein R^3 and R^4 are each independently $(C_1–C_6)$ alkyl.

Other compounds of formula **II** are those wherein R^3 and R^4 are each methyl.

Other compounds of formula **II** are those wherein C^{*1} is of the stereochemical configuration R or substantially R.

Other compounds of formula **II** are those wherein C^{*1} is of the stereochemical configuration S or substantially S.

Other compounds of formula **II** are those wherein C^{*2} is of the stereochemical configuration R or substantially R.

Other compounds of formula **II** are those wherein C^{*2} is of the stereochemical configuration S or substantially S.

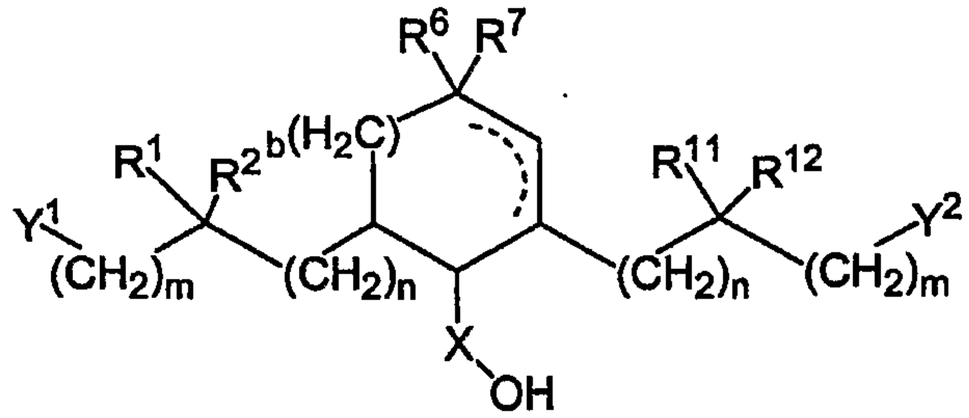
In a particular embodiment, compounds of formula **II** are those wherein C^{*1} C^{*2} are of the stereochemical configuration (S^1, S^2) or substantially (S^1, S^2).

In another particular embodiment, compounds of formula **II** are those wherein C^{*1} C^{*2} are of the stereochemical configuration (S^1, R^2) or substantially (S^1, R^2).

In another particular embodiment, compounds of formula **II** are those wherein C^{*1} C^{*2} are of the stereochemical configuration (R^1, R^2) or substantially (R^1, R^2).

In another particular embodiment, compounds of formula **II** are those wherein C^{*1} C^{*2} are of the stereochemical configuration (R^1, S^2) or substantially (R^1, S^2).

In another embodiment, the invention encompasses compounds of formula **III**:



III

or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein

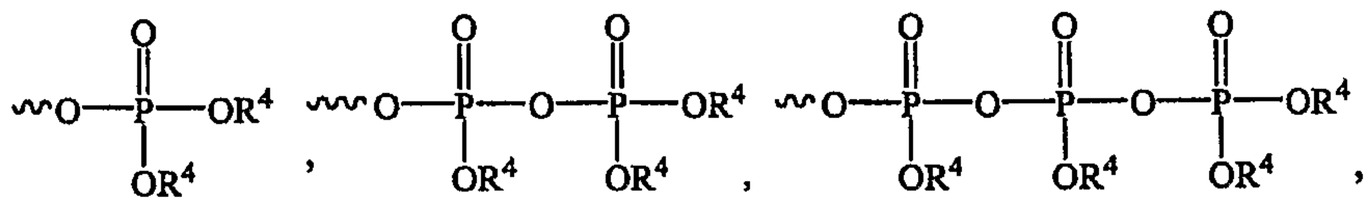
(a) each occurrence of R^1, R^2, R^6, R^7, R^{11}, or R^{12} is independently hydrogen, (C_1–C_6)alkyl, (C_2–C_6)alkenyl, (C_2–C_6)alkynyl, phenyl, or benzyl;

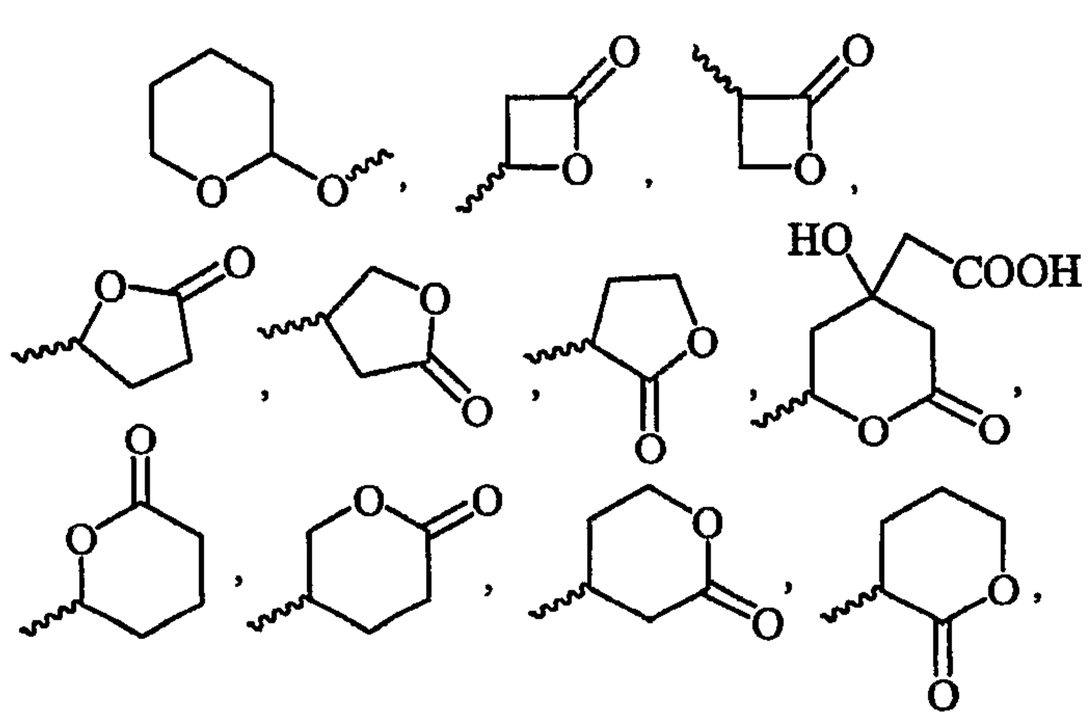
(b) each occurrence of n is independently an integer ranging from 1 to 7;

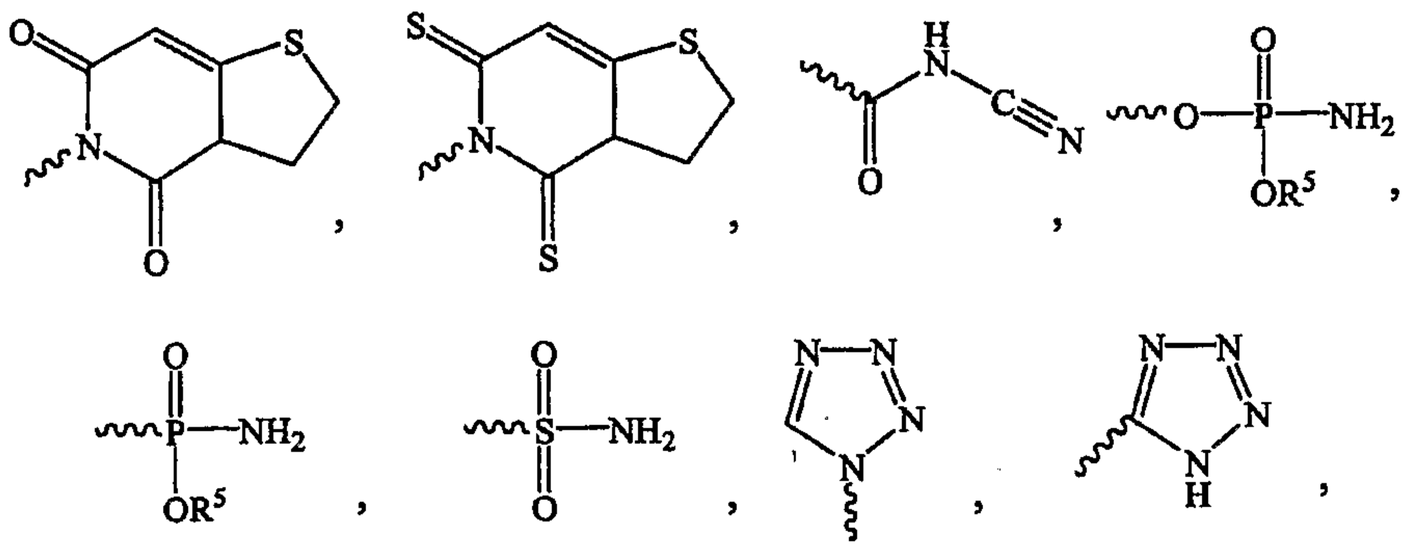
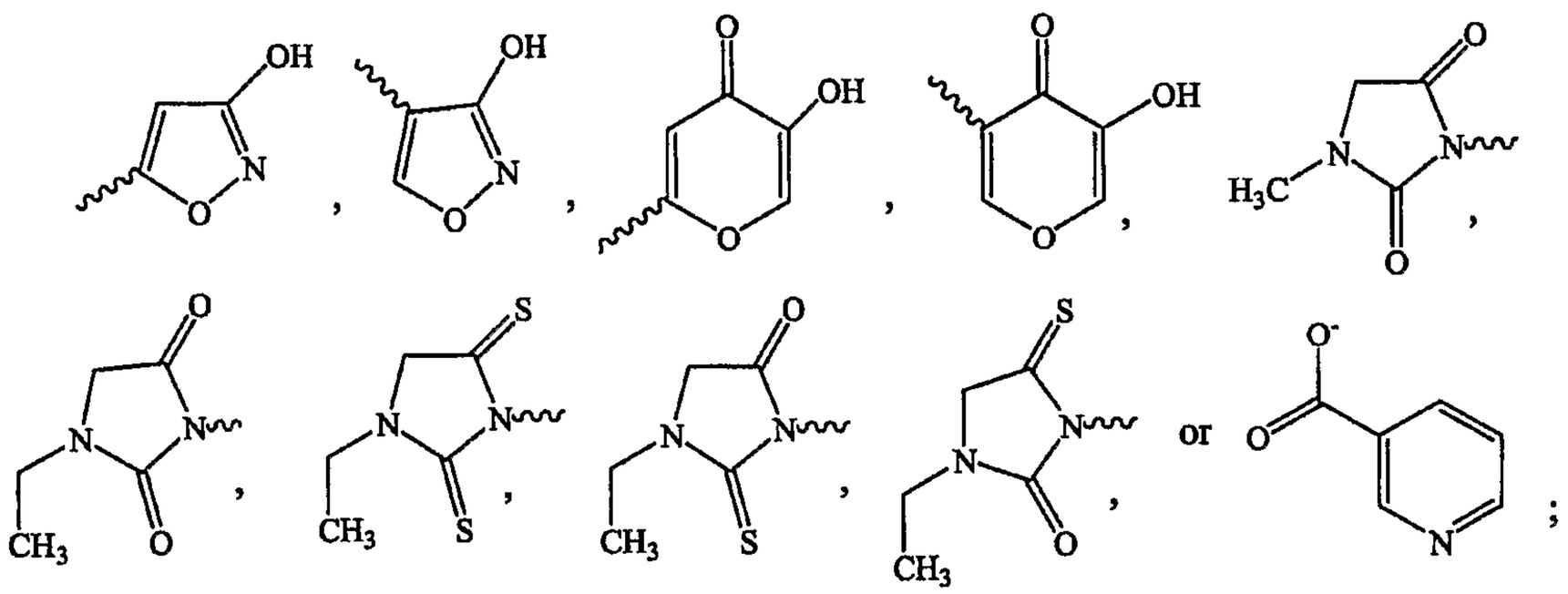
(c) X is $(CH_2)_z$ or PH, wherein z is an integer from 0 to 4;

(d) each occurrence of m is independently an integer ranging from 0 to 4;

(e) each occurrence of Y^1 and Y^2 is independently (C_1–C_6)alkyl, CH_2OH, C(O)OH, $OC(O)R^3$, $C(O)OR^3$, SO_3H,





wherein:

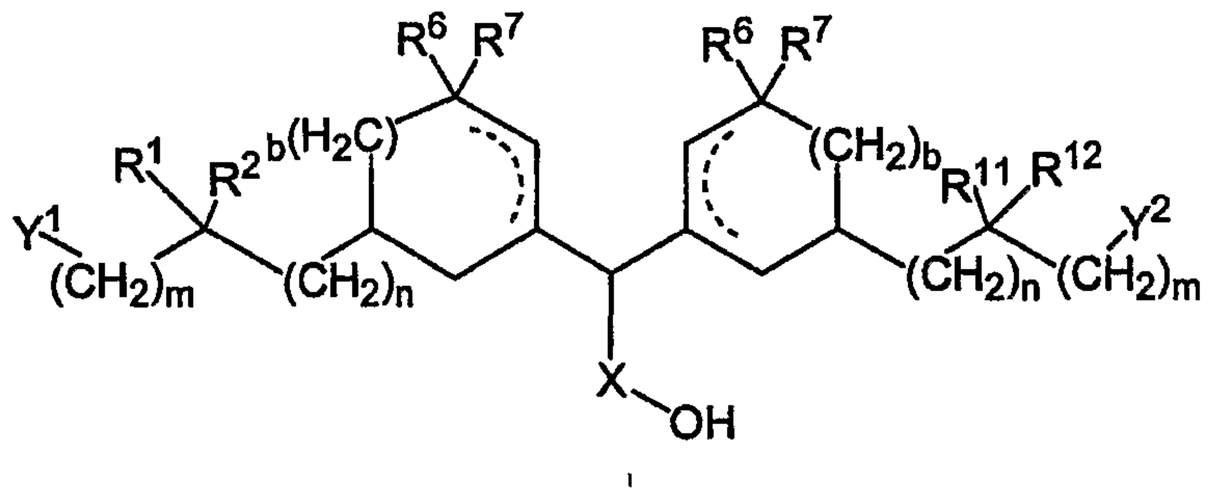
(i) R^3 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1–C_6$ alkoxy, or phenyl groups;

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl; and

(f) b is 0 or 1 and optionally the ring contains the presence of one or more additional carbon-carbon bonds that when present complete one or more carbon-carbon double bonds such that when b is 0 the maximum number of carbon-carbon bonds is two or when b is 1 the maximum number of carbon-carbon bonds is three.

In another embodiment, the invention encompasses compounds of formula **IV**:



IV

or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein

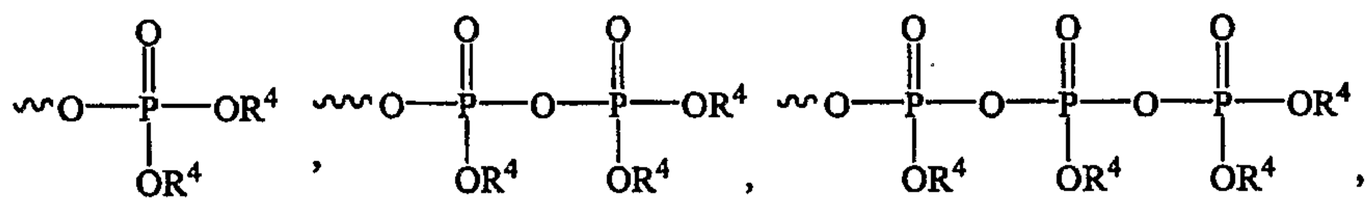
(a) each occurrence of R^1, R^2, R^6, R^7, R^{11}, or R^{12} is independently hydrogen, (C_1–C_6)alkyl, (C_2–C_6)alkenyl, (C_2–C_6)alkynyl, phenyl, or benzyl;

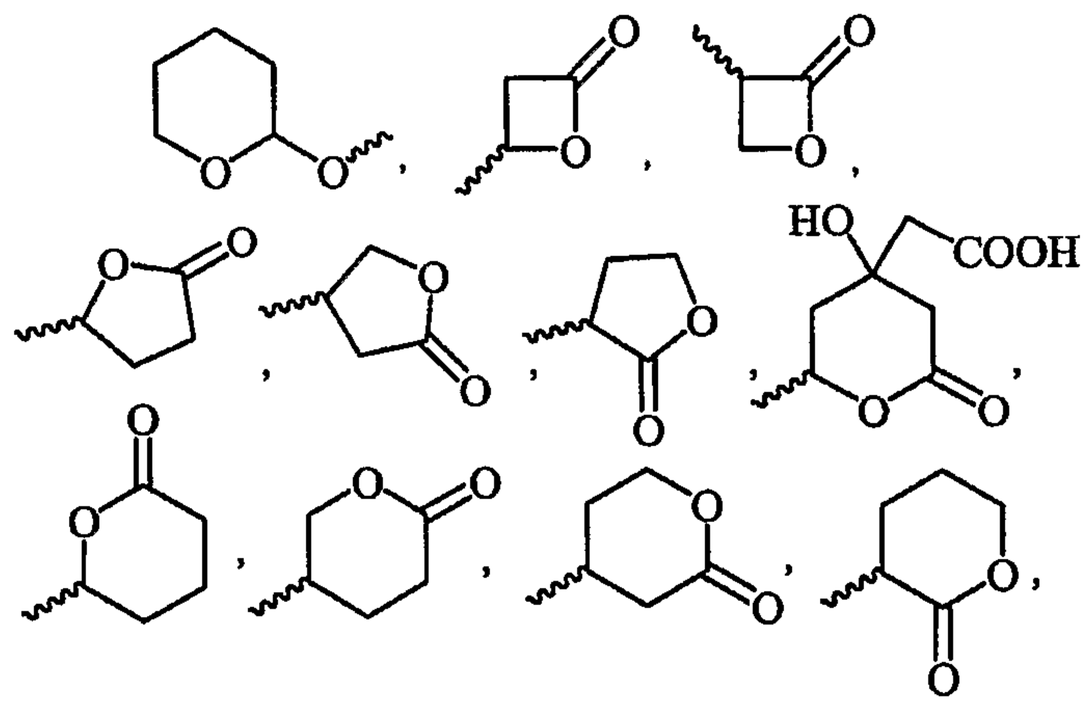
(b) each occurrence of n is independently an integer ranging from 1 to 7;

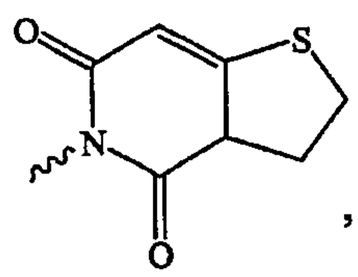
(c) X is $(CH_2)_z$ or PH, wherein z is an integer from 0 to 4;

(d) each occurrence of m is independently an integer ranging from 0 to 4;

(e) each occurrence of Y^1 and Y^2 is independently (C_1–C_6)alkyl, CH_2OH, C(O)OH, $OC(O)R^3$, $C(O)OR^3$, SO_3H,



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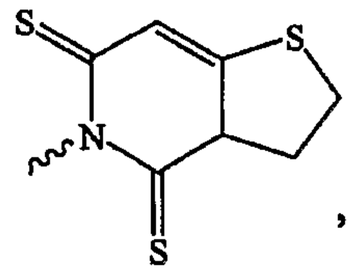
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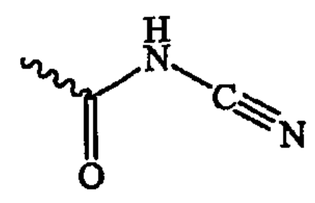
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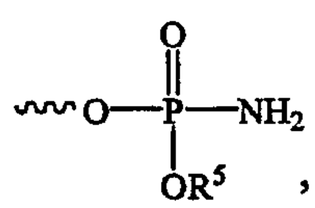
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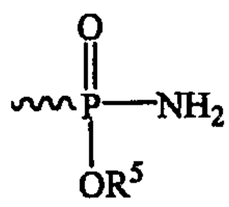
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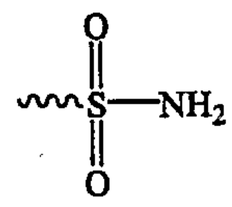
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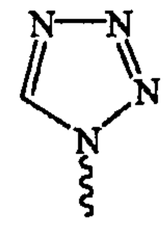
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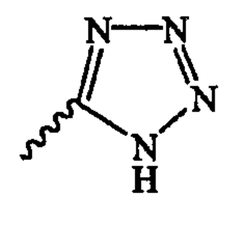
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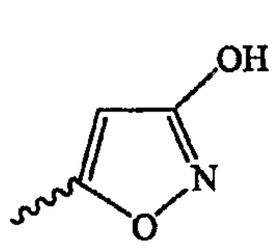
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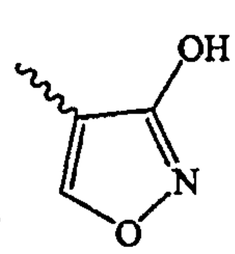
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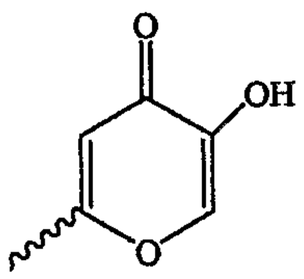
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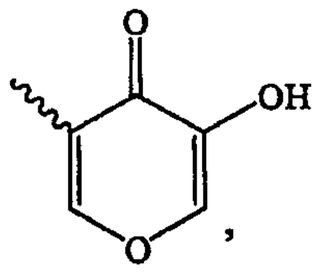
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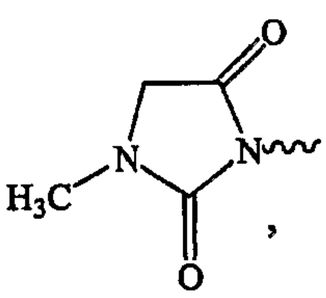
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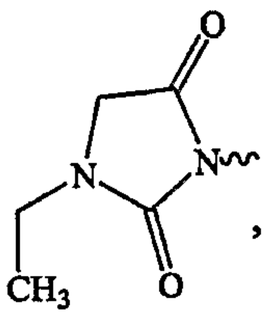
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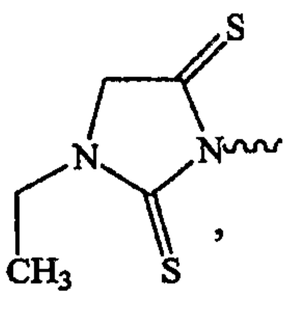
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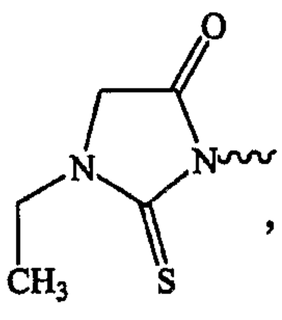
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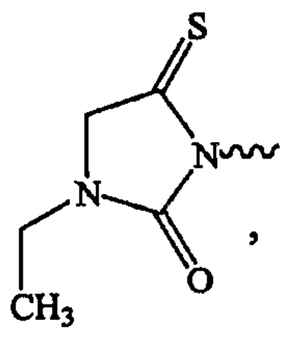
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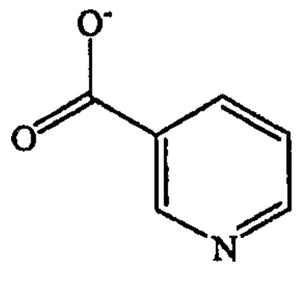

;

wherein:

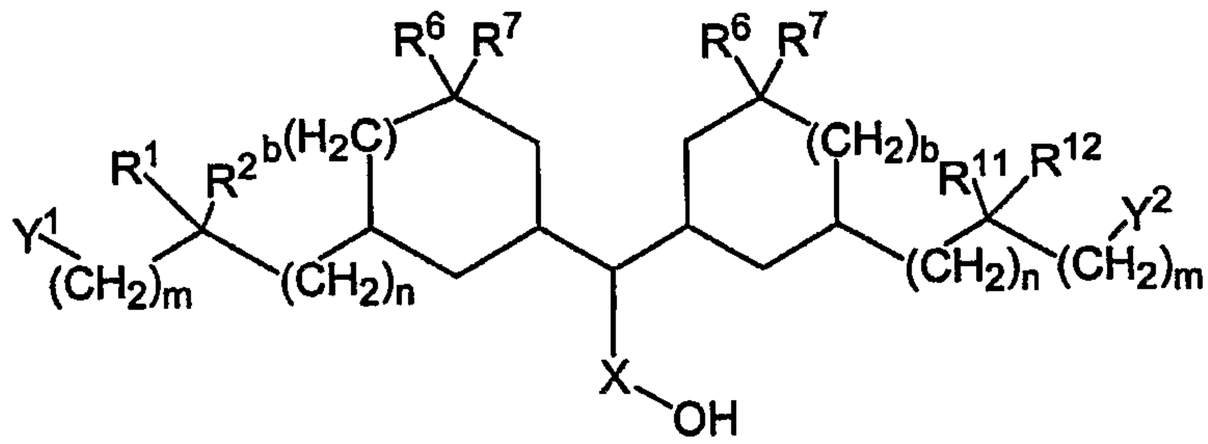
(i) R^3 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1–C_6$ alkoxy, or phenyl groups;

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl; and

(f) each occurrence of b is independently 0 or 1 and optionally each of the rings independently contains the presence of one or more additional carbon-carbon bonds that when present complete one or more carbon-carbon double bonds such that when b is 0 the maximum number of carbon-carbon bonds is two or when b is 1 the maximum number of carbon-carbon bonds is three.

In another embodiment, the invention encompasses compounds of formula V:



V

or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein

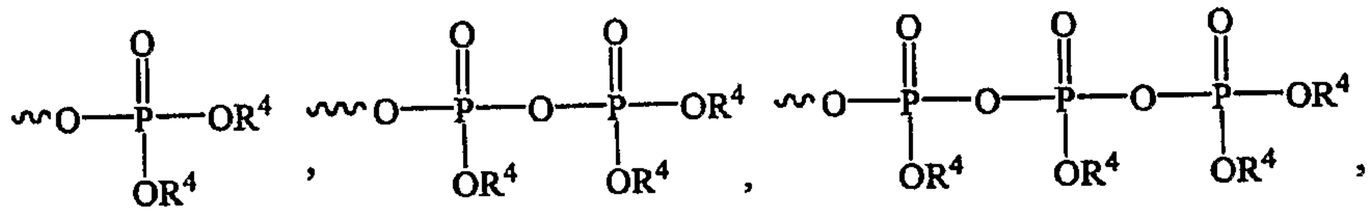
(a) each occurrence of R^1, R^2, R^6, R^7, R^{11}, or R^{12} is independently hydrogen, (C_1–C_6)alkyl, (C_2–C_6)alkenyl, (C_2–C_6)alkynyl, phenyl, or benyl;

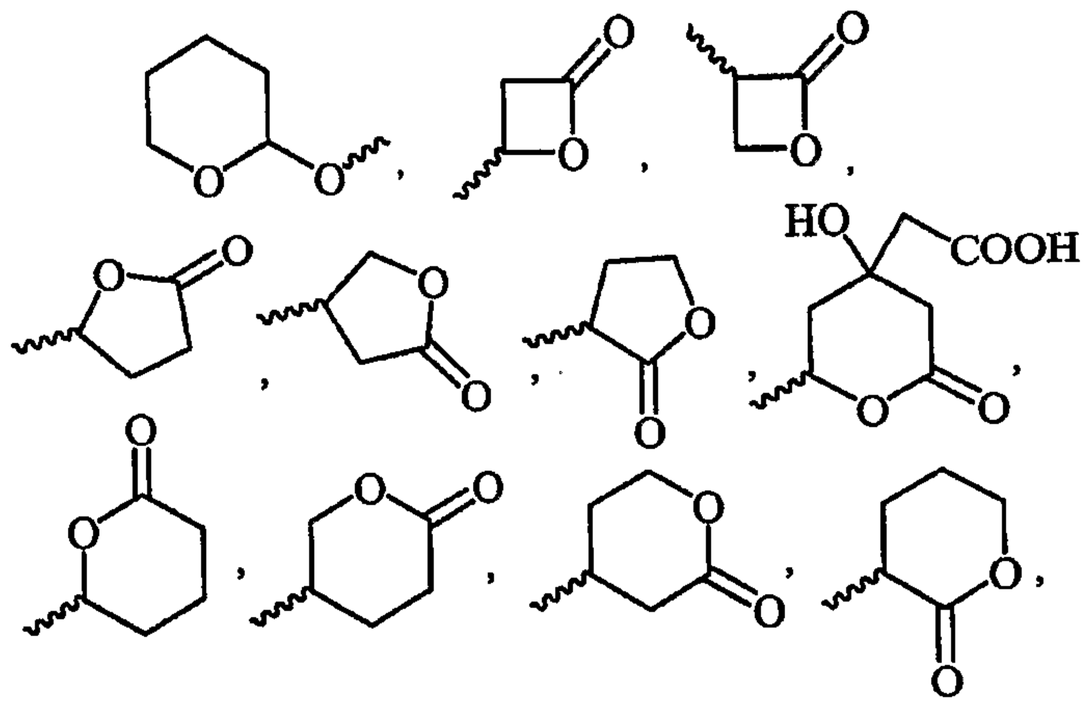
(b) each occurrence of n is independently an integer ranging from 1 to 7;

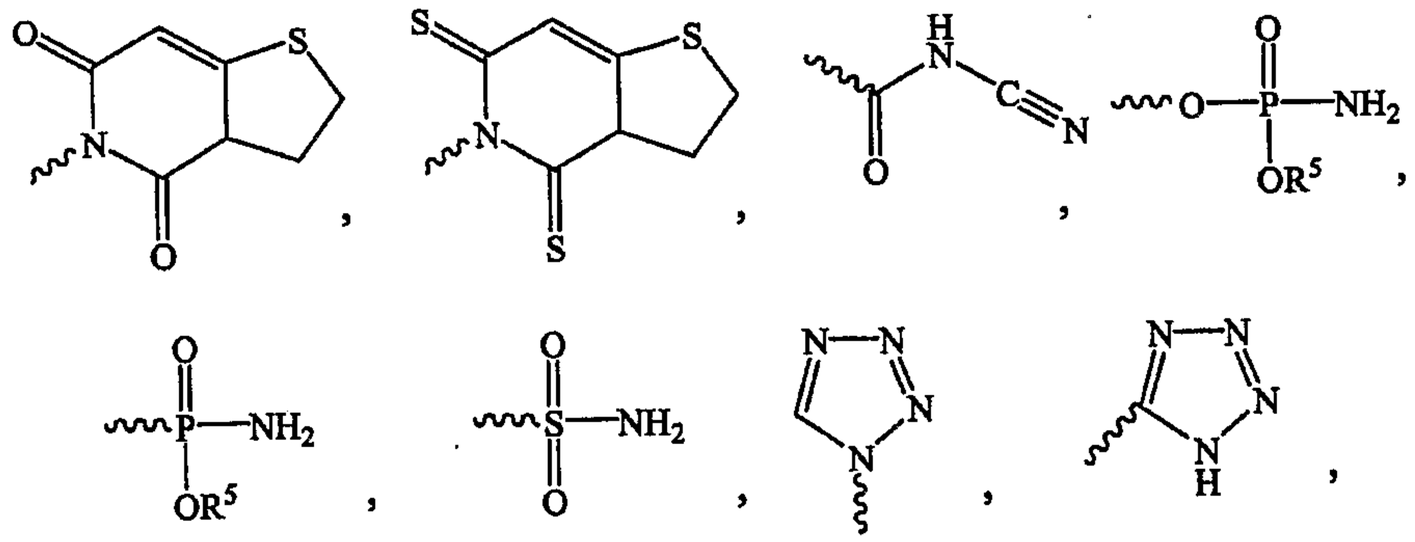
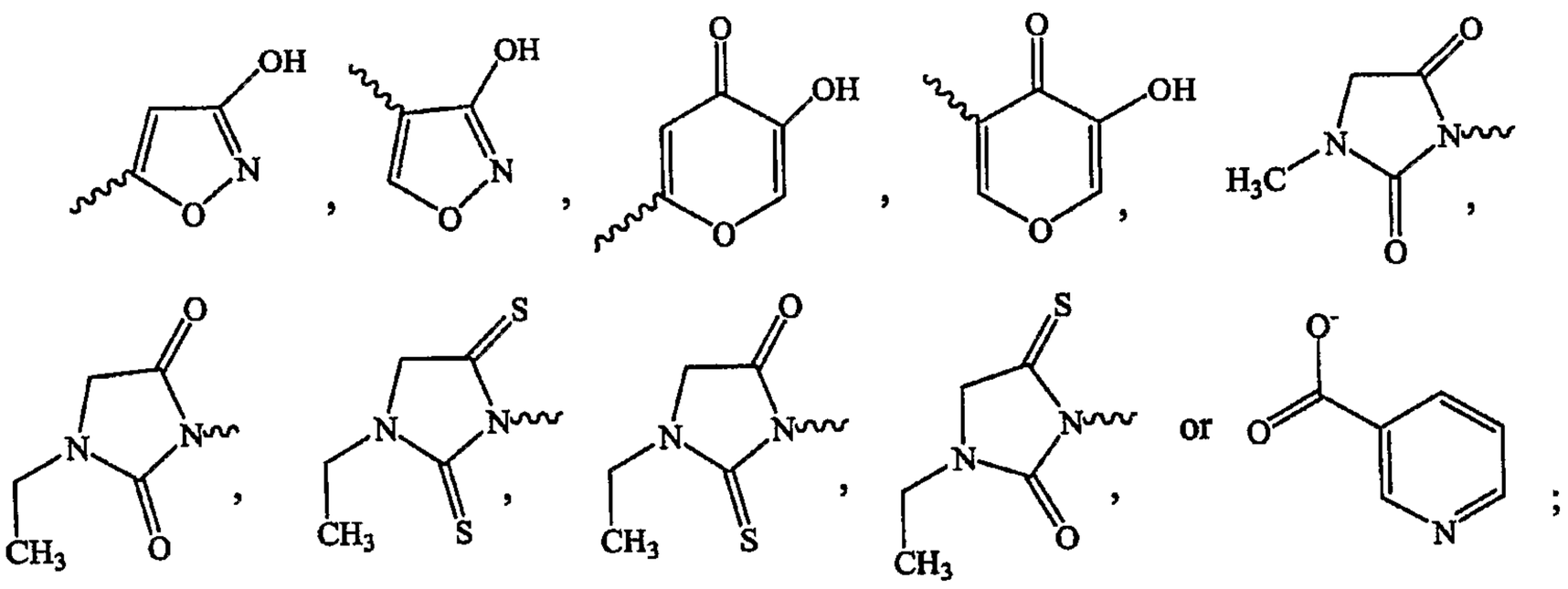
(c) X is $(CH_2)_z$ or PH, wherein z is an integer from 0 to 4;

(d) each occurrence of m is independently an integer ranging from 0 to 4;

(e) each occurrence of Y^1 and Y^2 is independently (C_1–C_6)alkyl, CH_2OH, C(O)OH, $OC(O)R^3$, $C(O)OR^3$, SO_3H,





wherein:

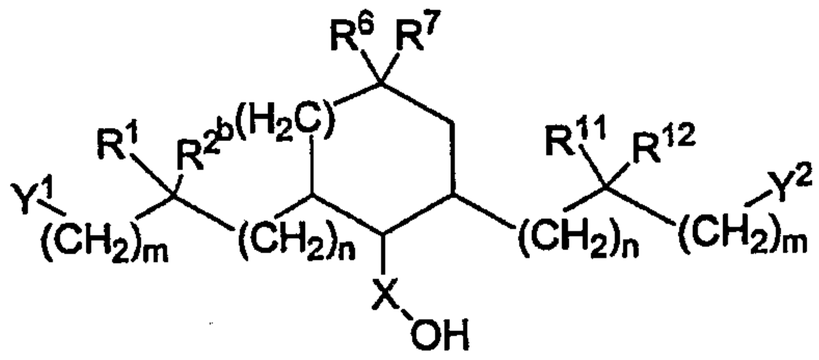
(i) R^3 is (C_1–C_6)alkyl, (C_2–C_6)alkenyl, (C_2–C_6)alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, (C_1–C_6)alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, (C_1–C_6)alkyl, (C_2–C_6)alkenyl, or (C_2–C_6)alkynyl and is unsubstituted or substituted with one or two halo, OH, C_1–C_6 alkoxy, or phenyl groups;

(iii) each occurrence of R^5 is independently H, (C_1–C_6)alkyl, (C_2–C_6)alkenyl, or (C_2–C_6)alkynyl; and

(f) b is 0 or 1 and optionally the ring contains one or more carbon-carbon bonds that when present complete one or more carbon-carbon double bonds.

In another embodiment, the invention encompasses compounds of the formula **VI**:



VI

or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein:

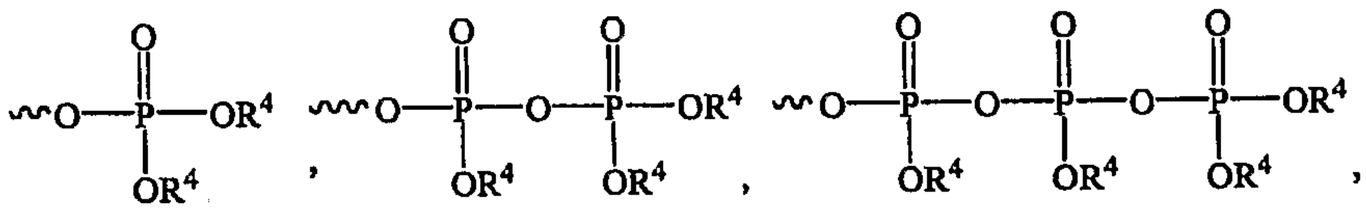
(a) each occurrence of R^1, R^2, R^6, R^7, R^{11}, or R^{12} is independently hydrogen, (C_1–C_6)alkyl, (C_2– C_6)alkenyl, (C_2–C_6)alkynyl, phenyl, or benzyl;

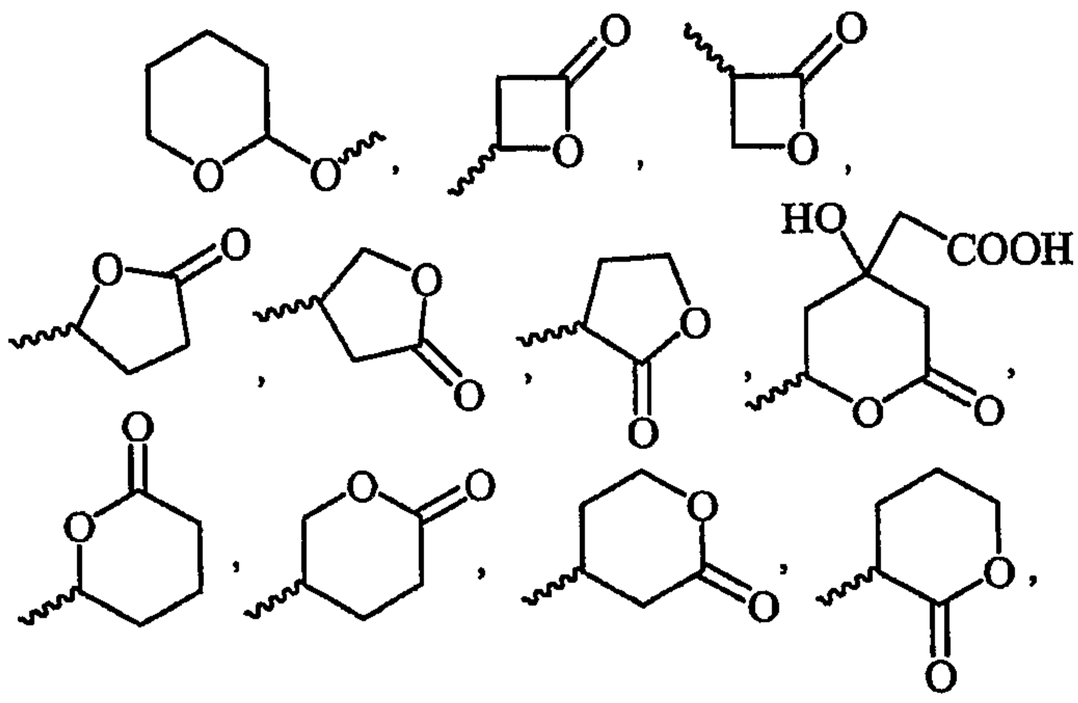
(b) each occurrence of n is independently an integer ranging from 1 to 7;

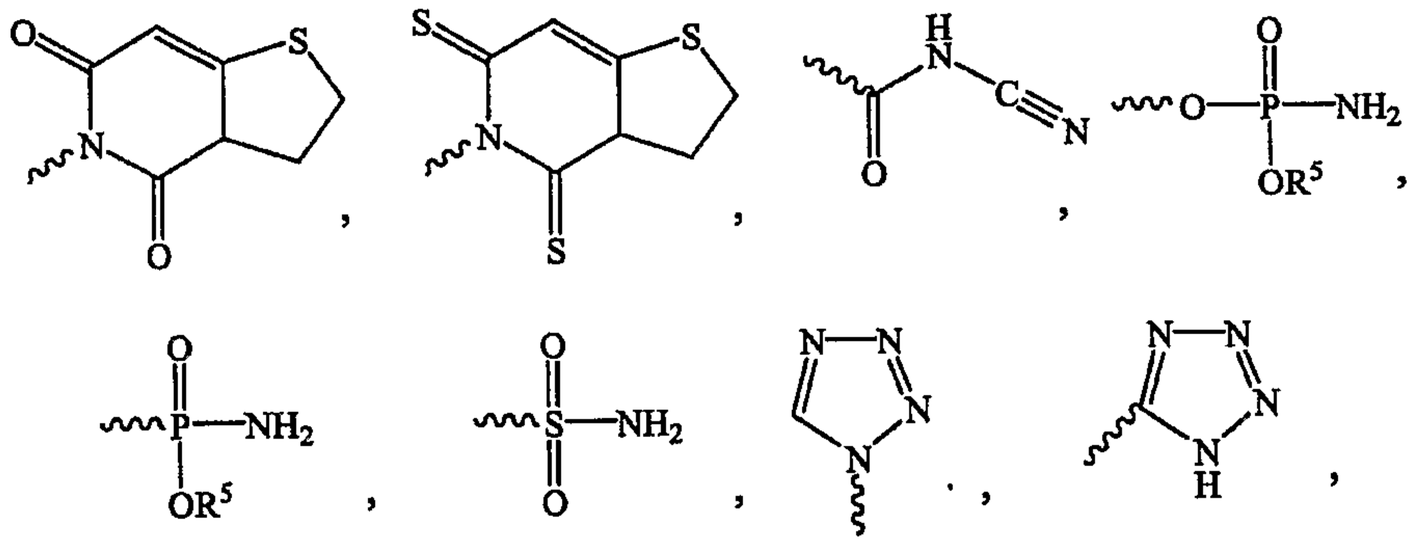
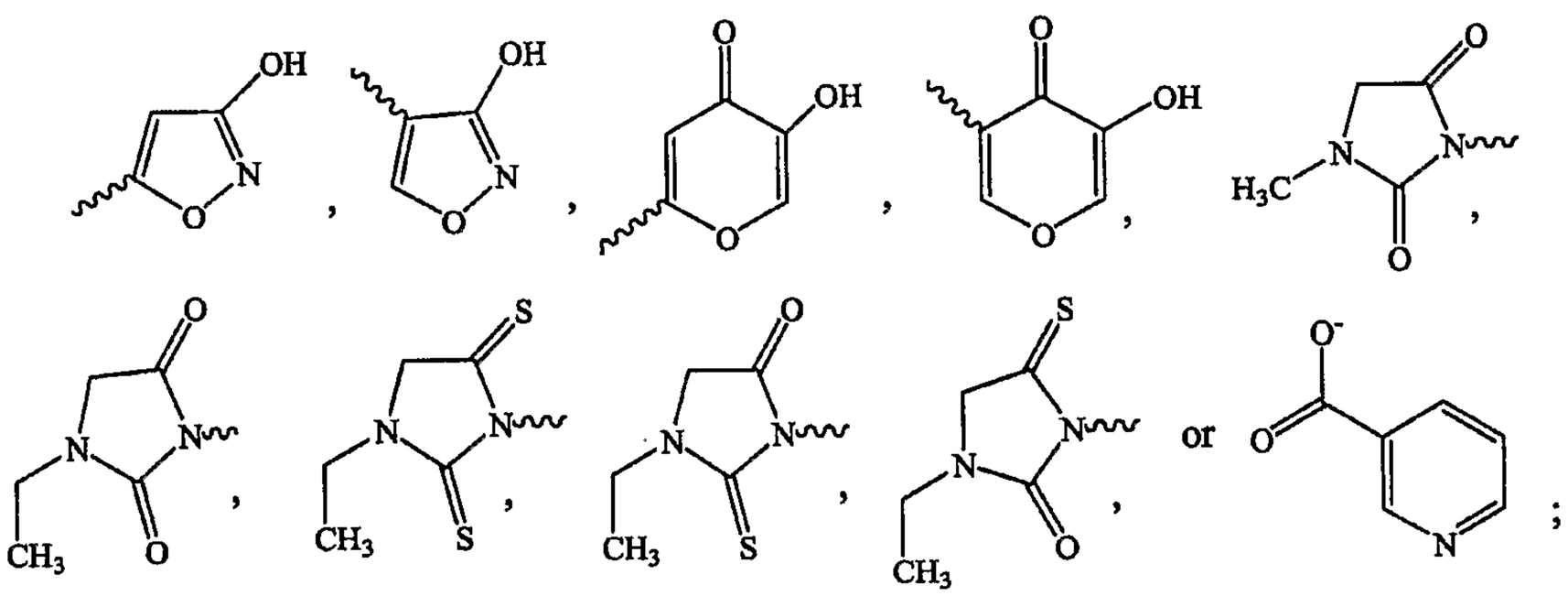
(c) X is $(CH_2)_z$ or PH, wherein z is an integer from 0 to 4;

(d) each occurrence of m is independently an integer ranging from 0 to 4;

(e) each occurrence of Y^1 and Y^2 is independently (C_1–C_6)alkyl, CH_2OH, C(O)OH, $OC(O)R^3$, $C(O)OR^3$, SO_3H,





wherein:

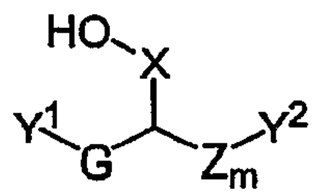
(i) R^3 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1–C_6$ alkoxy, or phenyl groups; and

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl; and

(f) b is 0 or 1 and optionally the ring contains one or more carbon-carbon bonds that when present complete one or more carbon-carbon double bonds.

In another embodiment, the invention encompasses compounds of the formula **VII**:



VII

or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein

(a) Z is CH_2, CH=CH, or phenyl, where each occurrence of m is independently an integer ranging from 1 to 9, but when Z is phenyl then its associated m is 1;

(b) G is $(CH_2)_x$, where x is 1, 2, 3, or 4, $CH_2CH=CHCH_2$, CH=CH, CH_2–phenyl–CH_2, or phenyl;

(c) each occurrence of Y^1 and Y^2 is independently L, V, $C(R^1)(R^2)$–$(CH_2)c$–$C(R^3)(R^4)$–$(CH_2)n$–Y, or $C(R^1)(R^2)$–$(CH_2)c$–V where c is 1 or 2 and n is an integer ranging from 0 to 4; when G is $(CH_2)_x$, where x is 1, 2, 3, or 4, W^2 is CH_3;

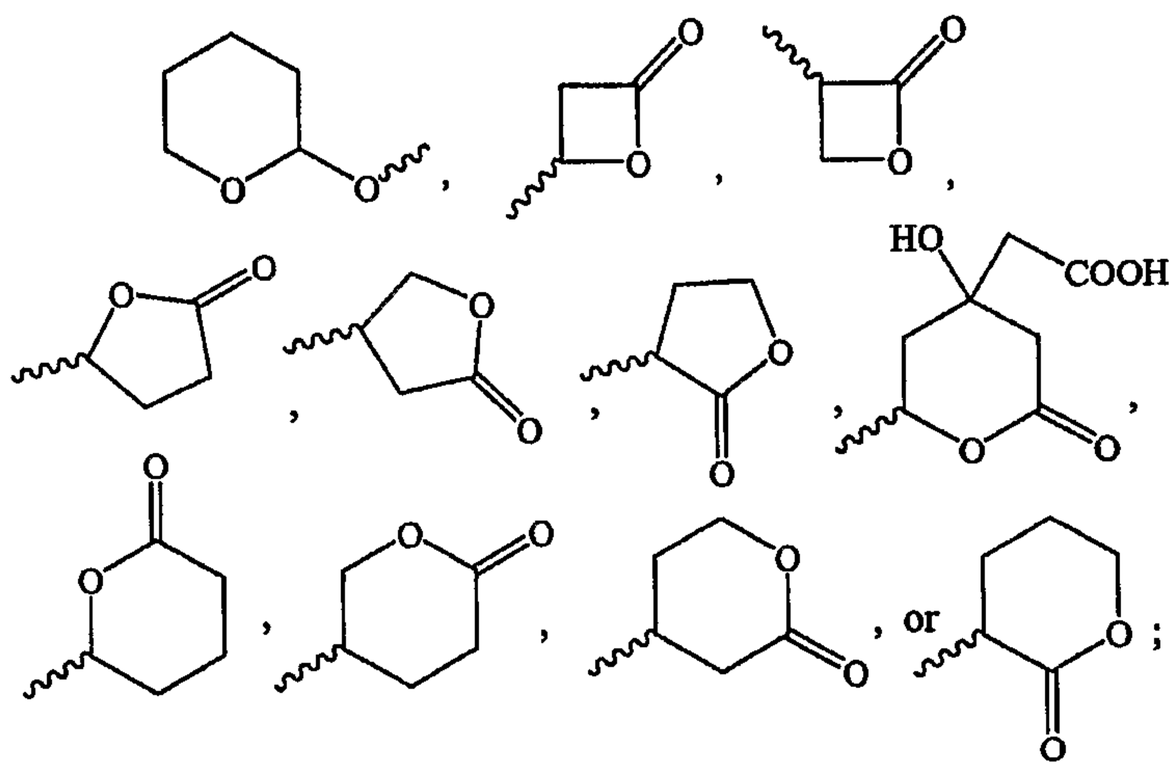
(d) each occurrence of R^1 or R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl or when one or both of Y^1 and Y^2 is $C(R^1)(R^2)$–$(CH_2)c$–$C(R^3)(R^4)$–$(CH_2)n$–W, then R^1 and R^2 can both be H to form a methylene group;

(e) R^3 is H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, $(C_1–C_6)$alkoxy, phenyl, benzyl, Cl, Br, CN, NO_2, or CF_3;

(f) R^4 is OH, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, $(C_1–C_6)$alkoxy, phenyl, benzyl, Cl, Br, CN, NO_2, or CF_3;

(g) L is $C(R^1)(R^2)$–$(CH_2)n$–W;

(h) V is: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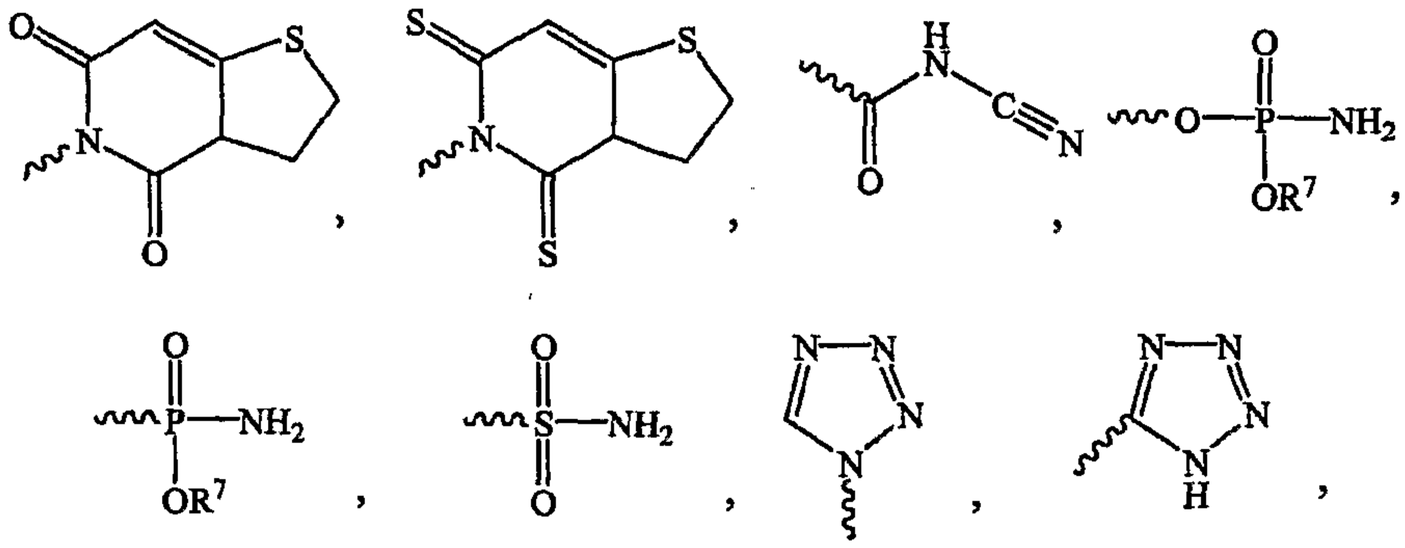
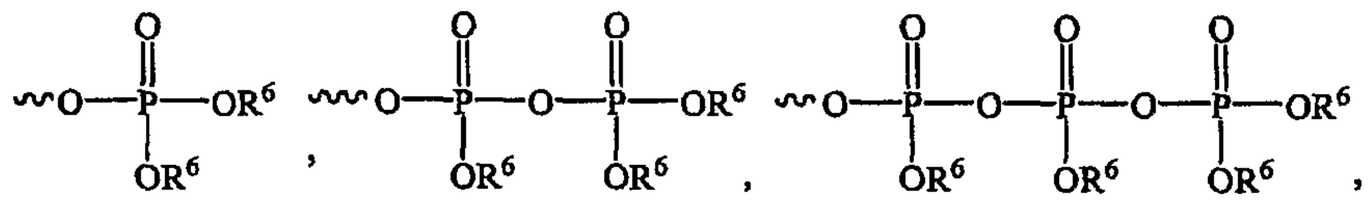
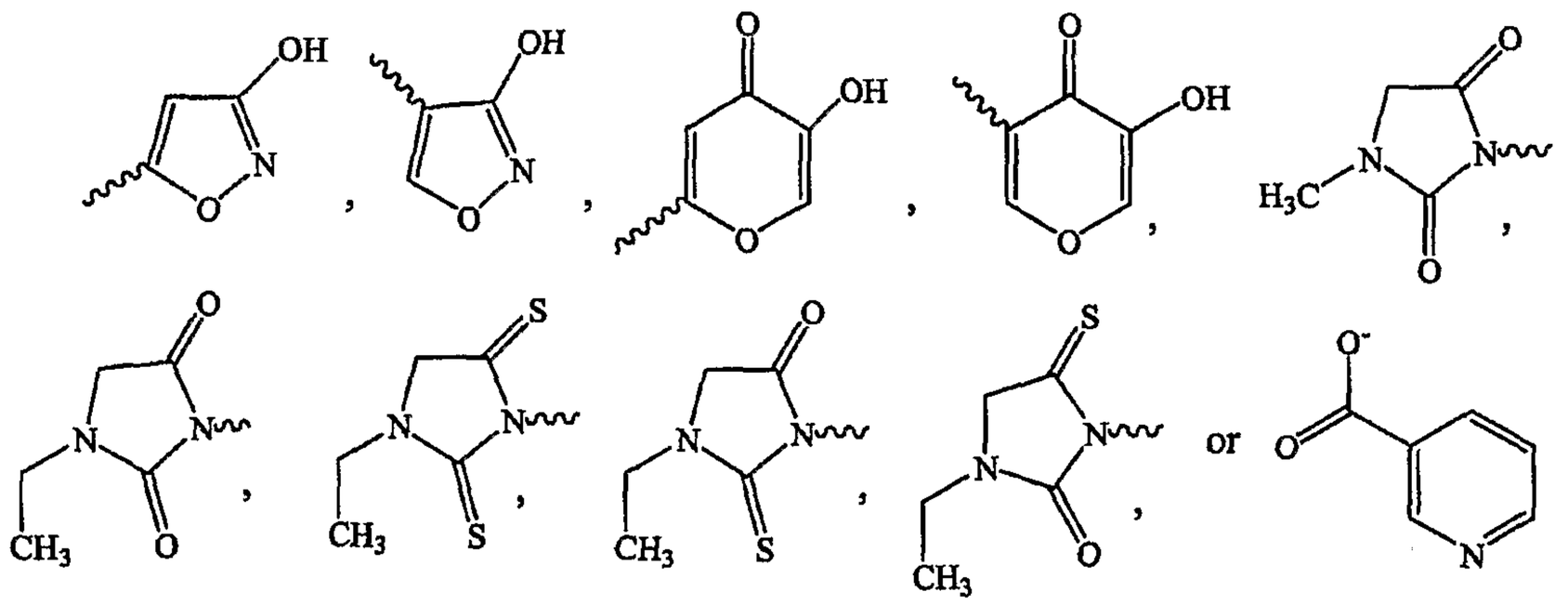




wherein:

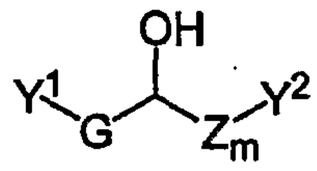
(i) R^5 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^6 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1–C_6)$ alkoxy, or phenyl groups;

(iii) each occurrence of R^7 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl; and

(j) X is $(CH_2)_z$ or PH, wherein z is an integer from 0 to 4.

In a particular embodiment, the invention encompasses compounds of the formula **VIII**:



VIII

or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein

(a) Z is CH_2, CH=CH, or phenyl, where each occurrence of m is independently an integer ranging from 1 to 9, but when Z is phenyl then its associated m is 1;

(b) G is $(CH_2)_x$, where x is 1, 2, 3, or 4, $CH_2CH=CHCH_2$, CH=CH, CH_2–phenyl–CH_2, or phenyl;

(c) each occurrence of Y^1 and Y^2 is independently L, V, $C(R^1)(R^2)$–$(CH_2)c$–$C(R^3)(R^4)$–$(CH_2)n$–Y, or $C(R^1)(R^2)$–$(CH_2)c$–V where c is 1 or 2 and n is an integer ranging from 0 to 4; when G is $(CH_2)_x$, where x is 1, 2, 3, or 4, W^2 is CH_3;

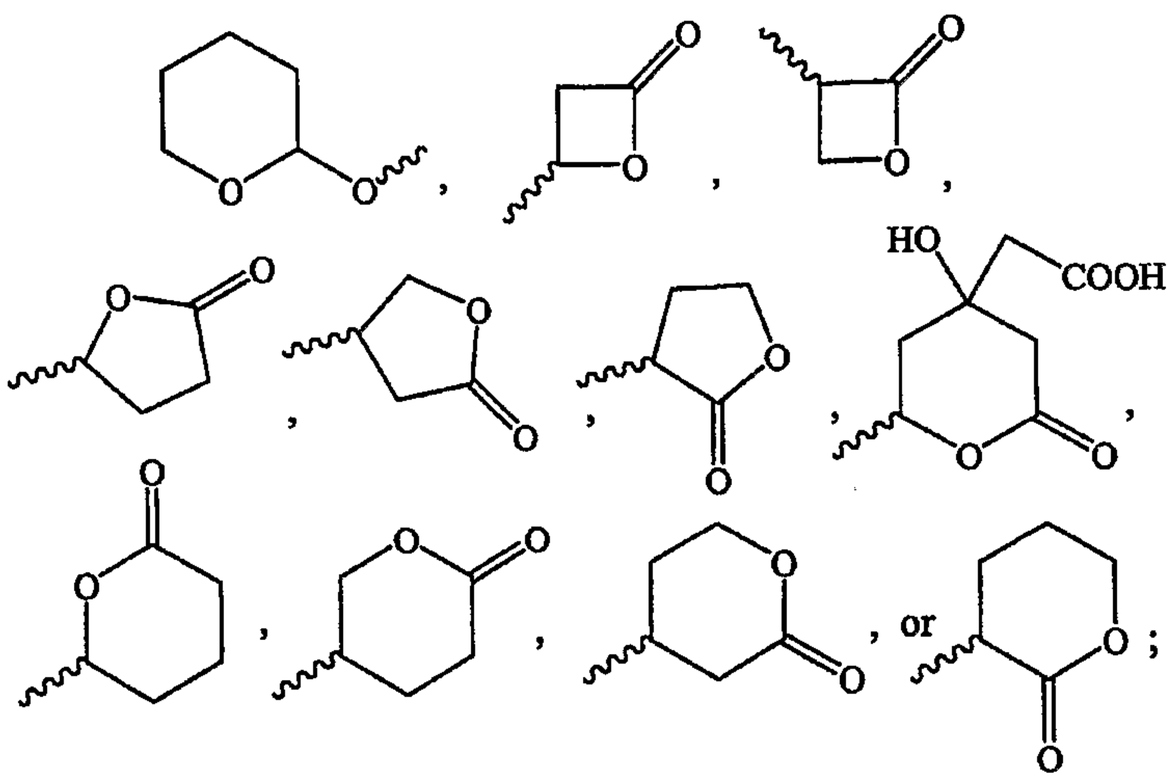
(d) each occurrence of R^1 or R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl or when one or both of Y^1 and Y^2 is $C(R^1)(R^2)$–$(CH_2)c$–$C(R^3)(R^4)$–$(CH_2)n$–W, then R^1 and R^2 can both be H to form a methylene group;

(e) R^3 is H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, $(C_1–C_6)$alkoxy, phenyl, benzyl, Cl, Br, CN, NO_2, or CF_3;

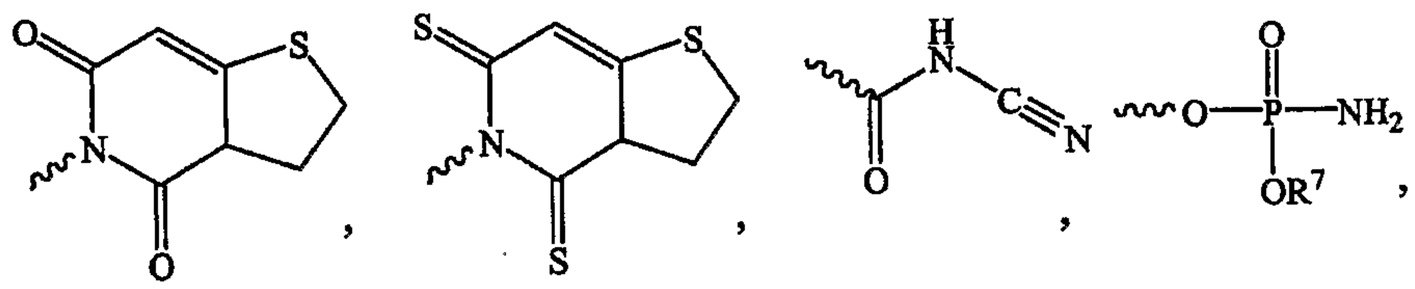
(f) R^4 is OH, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, $(C_1–C_6)$alkoxy, phenyl, benzyl, Cl, Br, CN, NO_2, or CF_3;

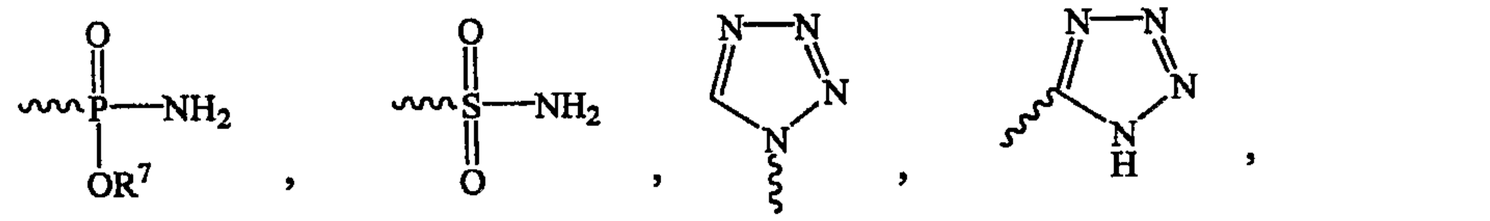
(g) L is $C(R^1)(R^2)$–$(CH_2)n$–W;

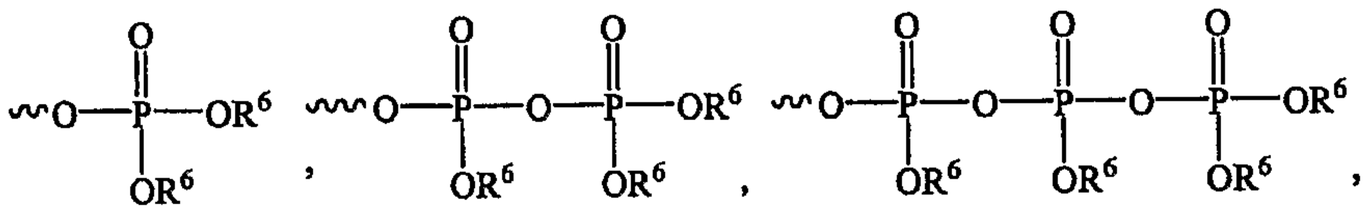
(h) V is:

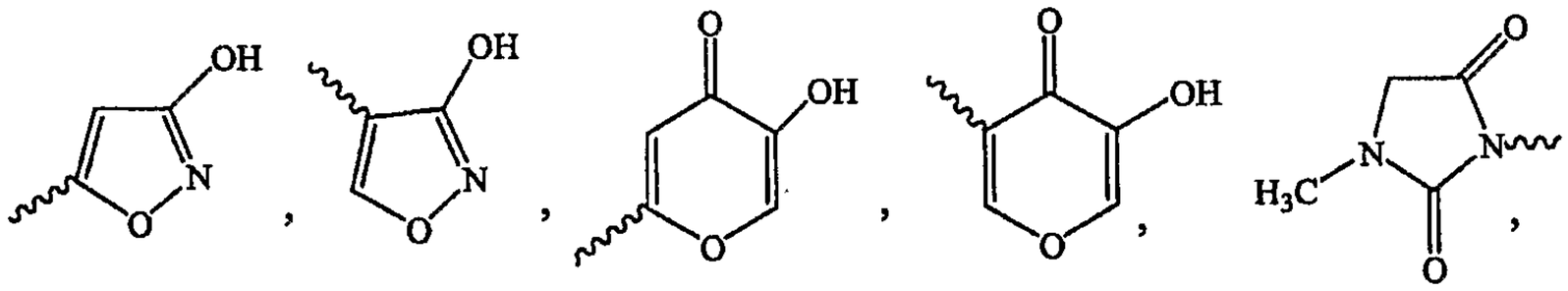


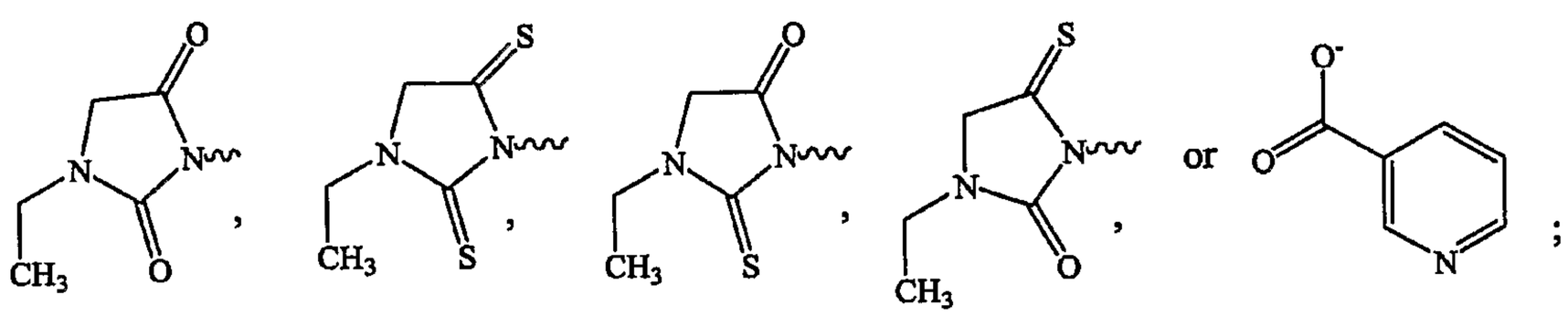
(i) each occurrence of W is independently OH, COOH, CHO, $COOR^5$, SO_3H,











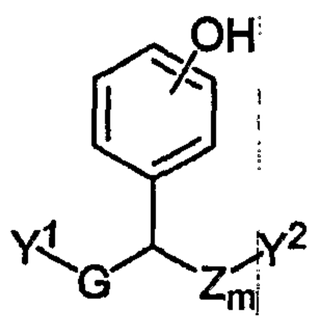
wherein:

(i) R^5 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^6 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1–C_6)$ alkoxy, or phenyl groups; and

(iii) each occurrence of R^7 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl.

In another particular embodiment, the invention encompasses compounds of formula **IX**:



IX

or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein

(a) Z is CH_2, CH=CH, or phenyl, where each occurrence of m is independently an integer ranging from 1 to 9, but when Z is phenyl then its associated m is 1;

(b) G is $(CH_2)_x$, where x is 1, 2, 3, or 4, $CH_2CH=CHCH_2$, CH=CH, CH_2–phenyl–CH_2, or phenyl;

(c) each occurrence of Y^1 and Y^2 is independently L, V, $C(R^1)(R^2)–(CH_2)c–C(R^3)(R^4)–(CH_2)n–Y$, or $C(R^1)(R^2)–(CH_2)c–V$ where c is 1 or 2 and n is an integer ranging from 0 to 4; when G is $(CH_2)_x$, where x is 1, 2, 3, or 4, W^2 is CH_3;

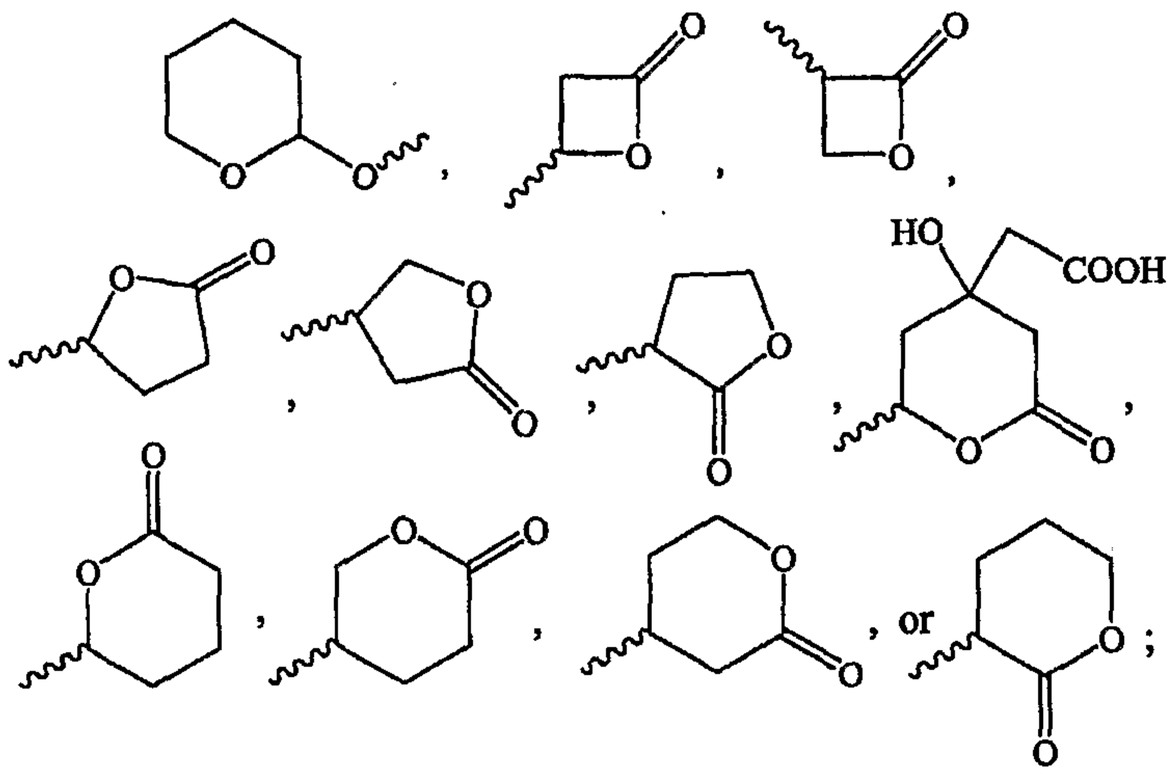
(d) each occurrence of R^1 or R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl or when one or both of Y^1 and Y^2 is $C(R^1)(R^2)–(CH_2)c–C(R^3)(R^4)–(CH_2)n–W$, then R^1 and R^2 can both be H to form a methylene group;

(e) R^3 is H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, $(C_1–C_6)$alkoxy, phenyl, benzyl, Cl, Br, CN, NO_2, or CF_3;

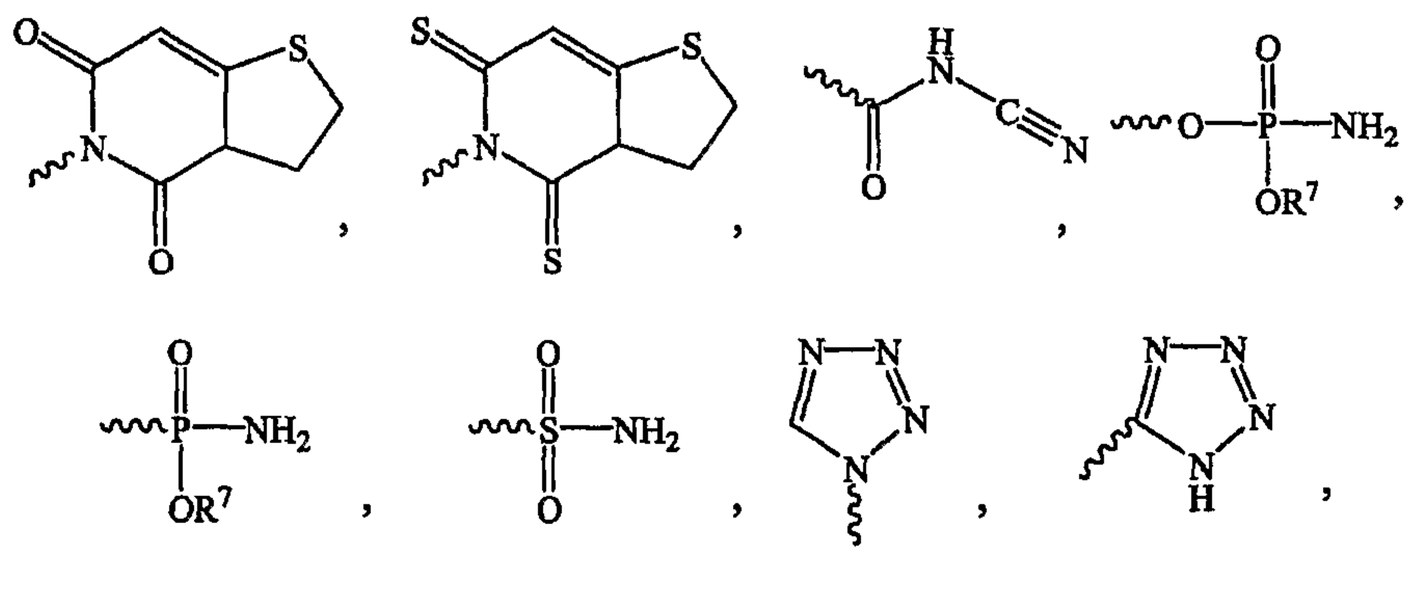
(f) R^4 is OH, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, $(C_1–C_6)$alkoxy, phenyl, benzyl, Cl, Br, CN, NO_2, or CF_3;

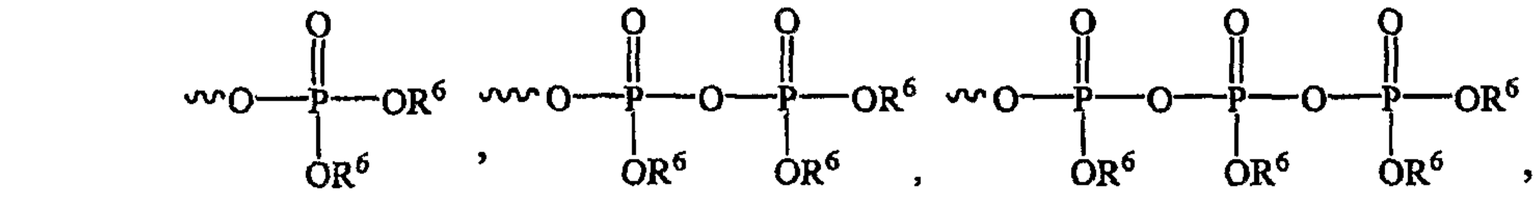
(g) L is $C(R^1)(R^2)–(CH_2)n–W$;

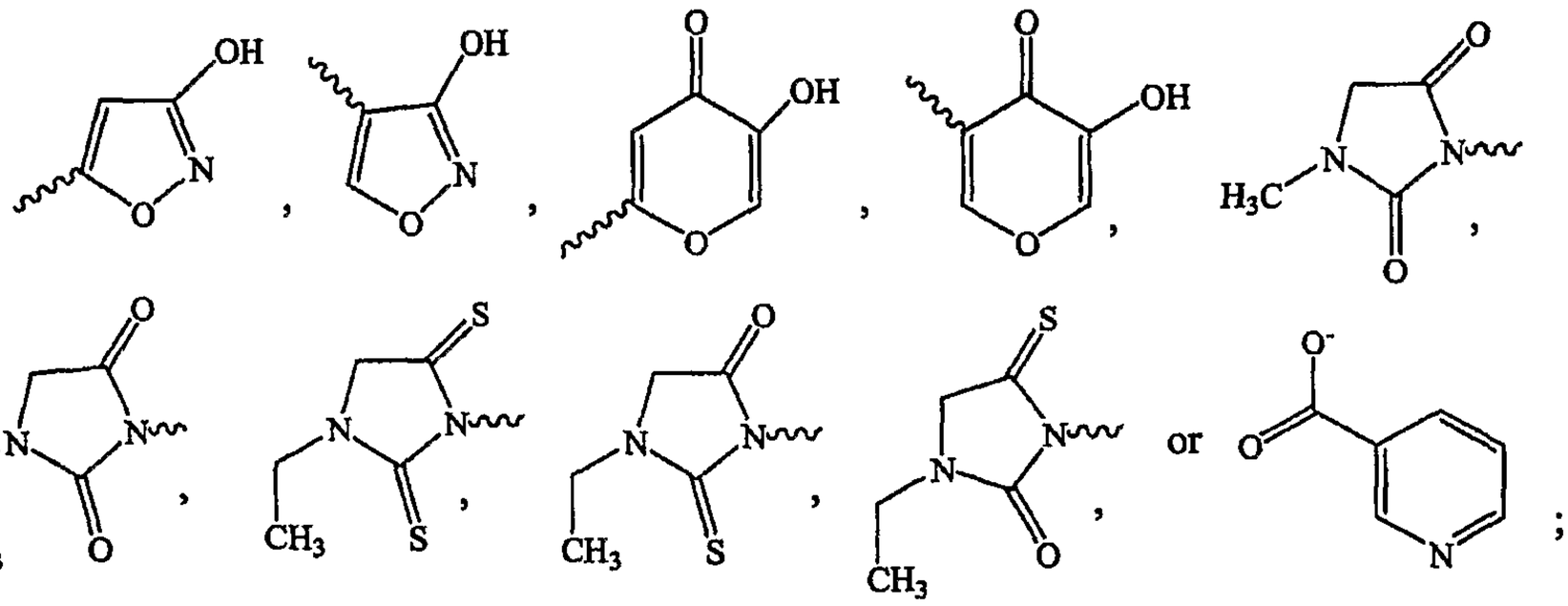
(h) V is:



(i) each occurrence of W is independently OH, COOH, CHO, $COOR^5$, SO_3H,







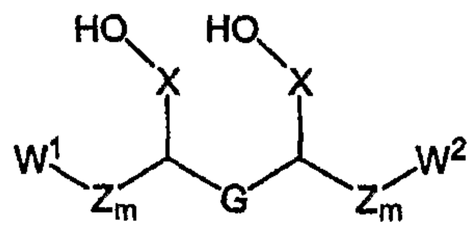
wherein:

(i) R^5 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^6 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1–C_6)$ alkoxy, or phenyl groups; and

(iii) each occurrence of R^7 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl.

The invention further encompasses compounds of formula **X**:



X

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein

(a) each occurrence of Z is independently CH_2, CH=CH, or phenyl, where each occurrence of m is independently an integer ranging from 1 to 9, but when Z is phenyl then m is 1;

(b) G is $(CH_2)_x$, where x is 1-7, $CH_2CH=CHCH_2$, CH=CH, CH_2-phenyl-CH_2, or phenyl;

(c) W^1 and W^2 are independently L, V, $C(R^1)(R^2)–(CH_2)_c–C(R^3)(R^4)–(CH_2)_n–Y$, or $C(R^1)(R^2)–(CH_2)_c–V$ where c is 1 or 2 and n is an integer ranging from 0 to 7;

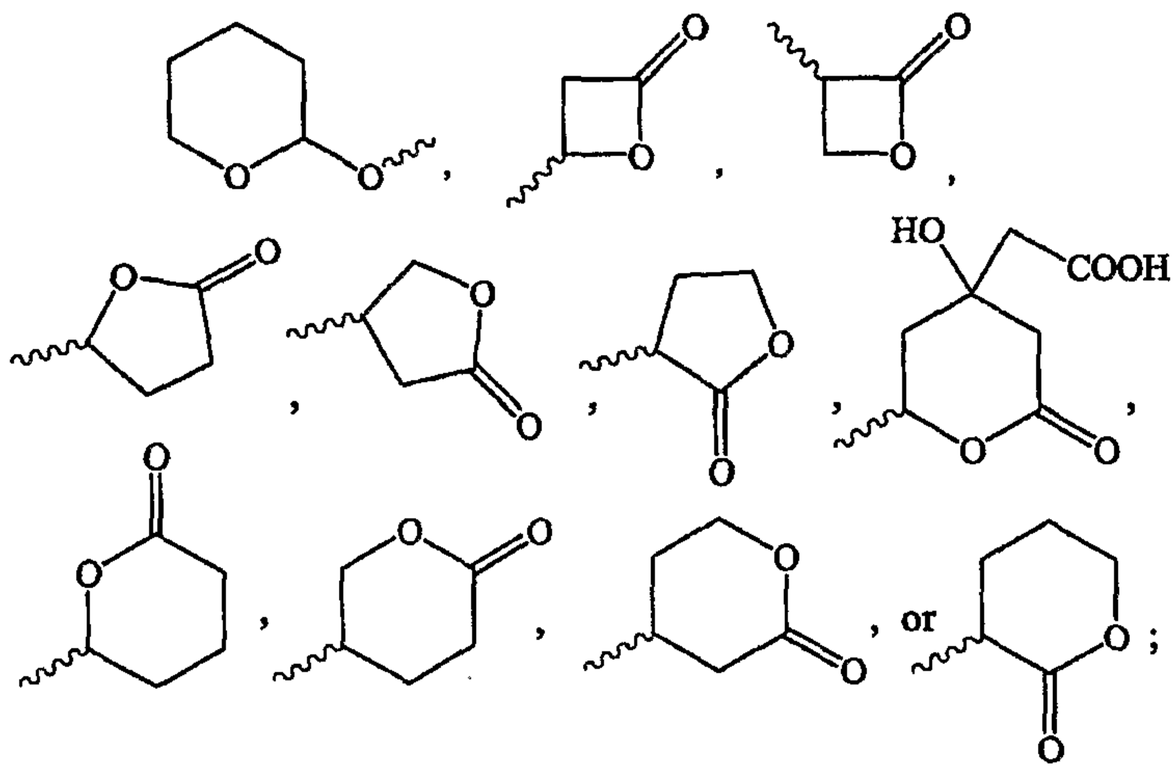
(d) each occurrence of R^1 or R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl or when one or both of W^1 and W^2 is $C(R^1)(R^2)–(CH_2)_c–C(R^3)(R^4)–(CH_2)_n–Y$, then R^1 and R^2 can both be H to form a methylene group; or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group;

(e) R^3 is H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, $(C_1–C_6)$alkoxy, phenyl, benzyl, Cl, Br, CN, NO_2, or CF_3;

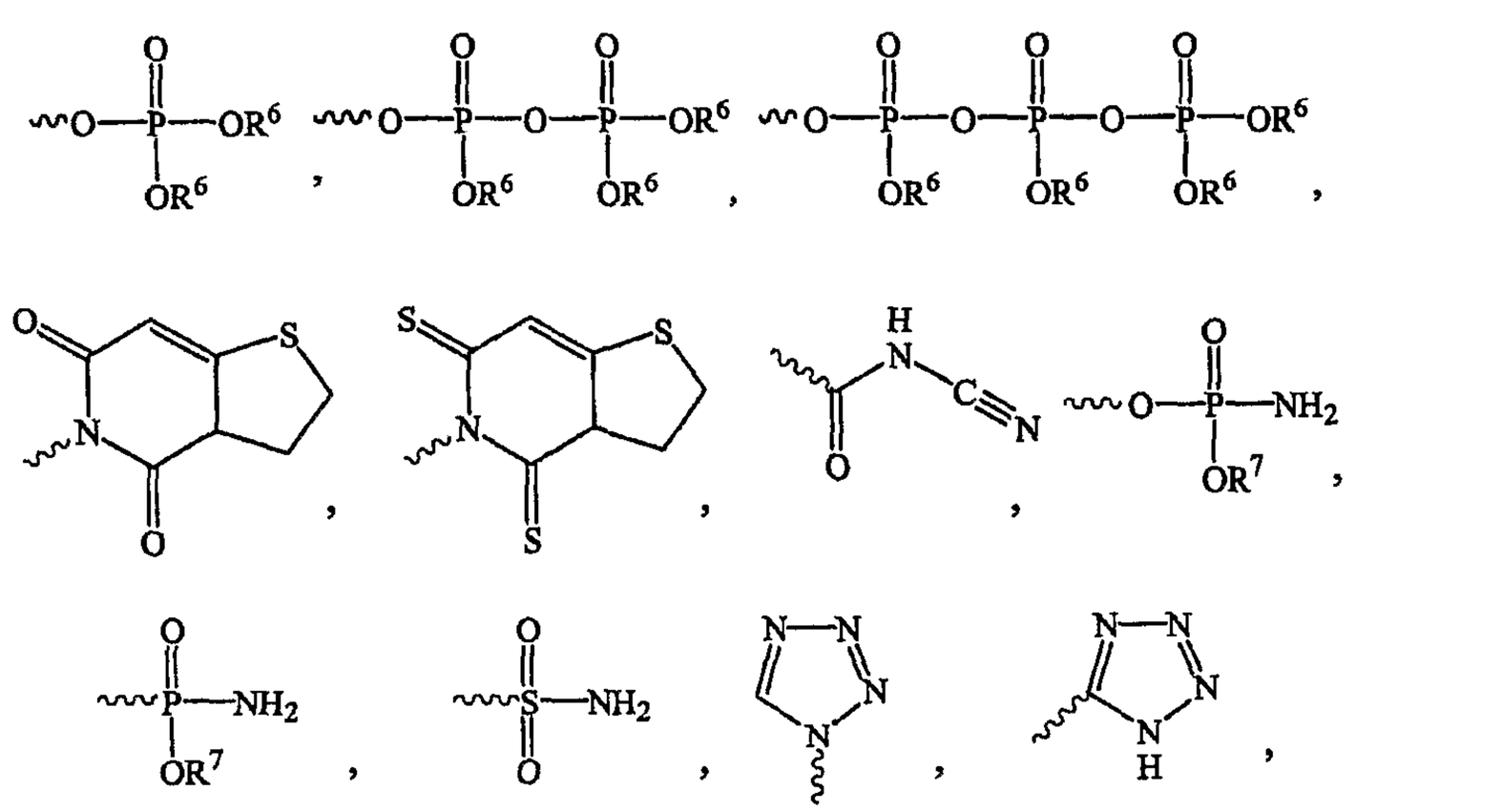
(f) R^4 is OH, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, $(C_1–C_6)$alkoxy, phenyl, benzyl, Cl, Br, CN, NO_2, or CF_3;

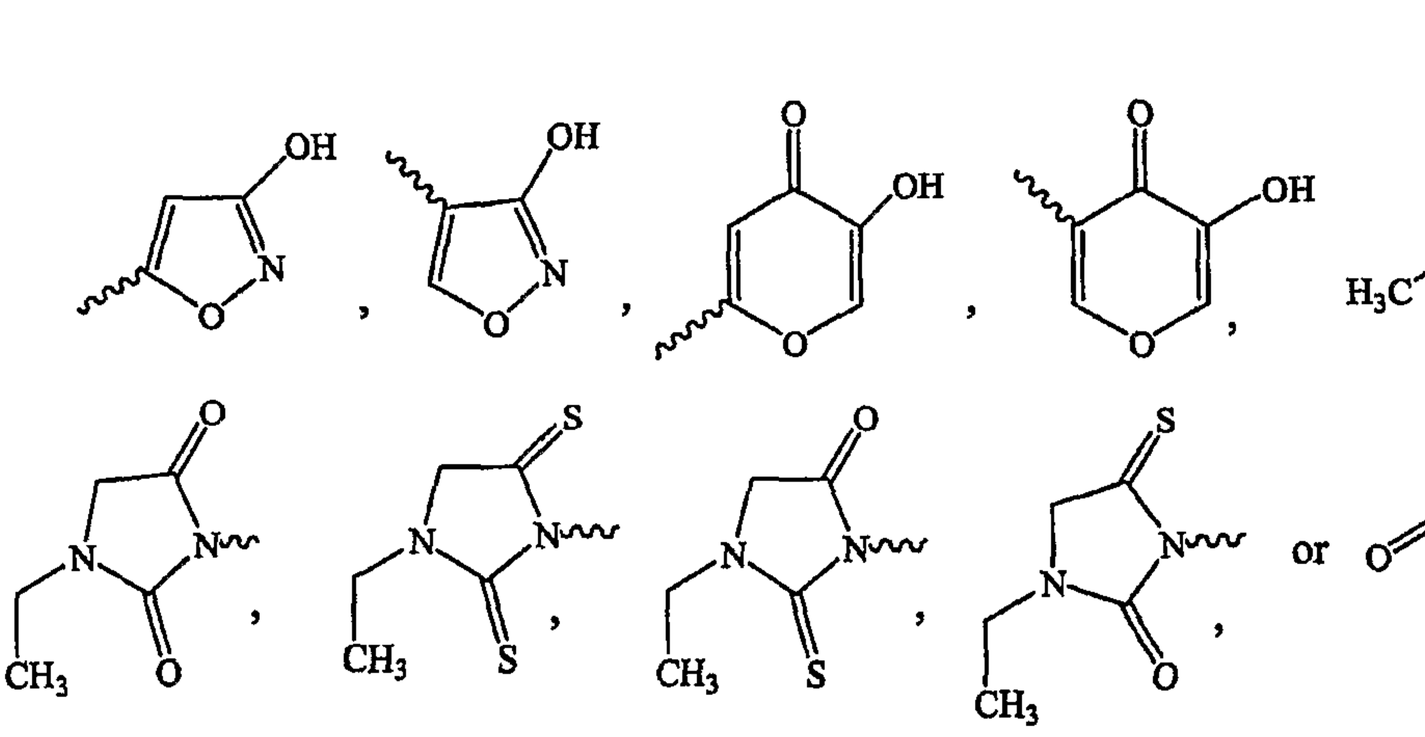
(g) L is $C(R^1)(R^2)$–$(CH_2)_n$–Y, wherein n is an integer from 0 to 5;

(h) V is:



(i) each occurrence of Y is independently $(C_1$–$C_6)$alkyl, OH, COOH, $COOR^5$, SO_3H,





wherein:

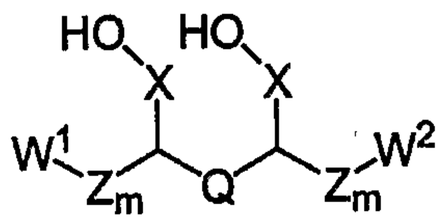
(i) R^5 is $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, $(C_2\text{-}C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1\text{-}C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^6 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1\text{-}C_6)$ alkoxy, or phenyl groups;

(iii) each occurrence of R^7 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl; and

(j) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4.

In another embodiment, the invention encompasses compounds of formula **XI**:



XI

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein:

(a) each occurrence of Z is independently CH_2 or CH=CH, wherein each occurrence of m is independently an integer ranging from 1 to 9;

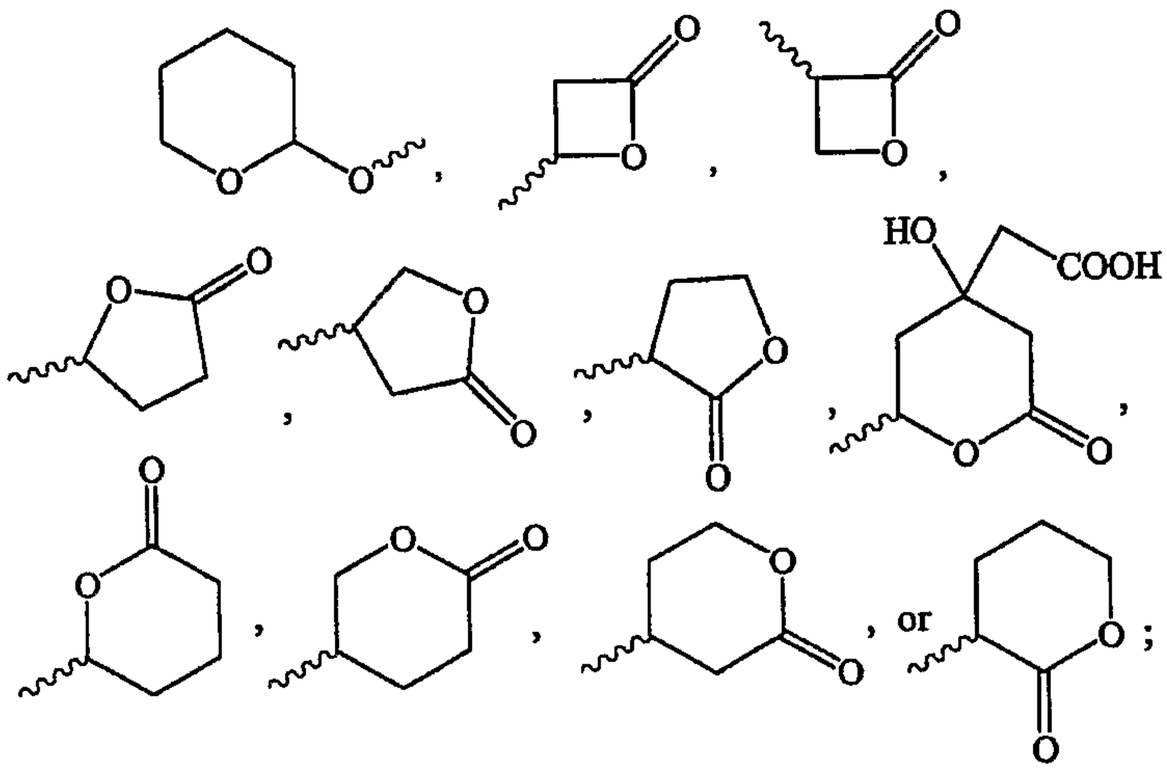
(b) Q is $(CH_2)_x$, $CH_2CH{=}CHCH_2$, or CH=CH, where x is 2, 3, or 4;

(c) W^1 and W^2 are independently L, V, or $C(R^1)(R^2)\text{–}(CH_2)_c\text{–}V$, where c is 1 or 2;

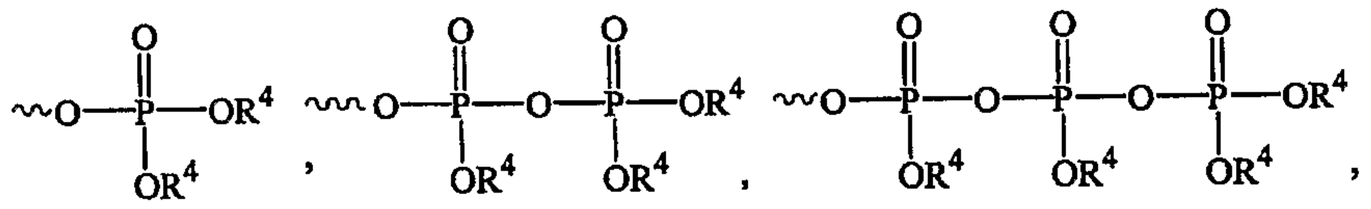
(d) each occurrence of R^1 and R^2 is independently $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, $(C_2\text{-}C_6)$alkynyl, phenyl, benzyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3\text{-}C_7)$cycloakyl group;

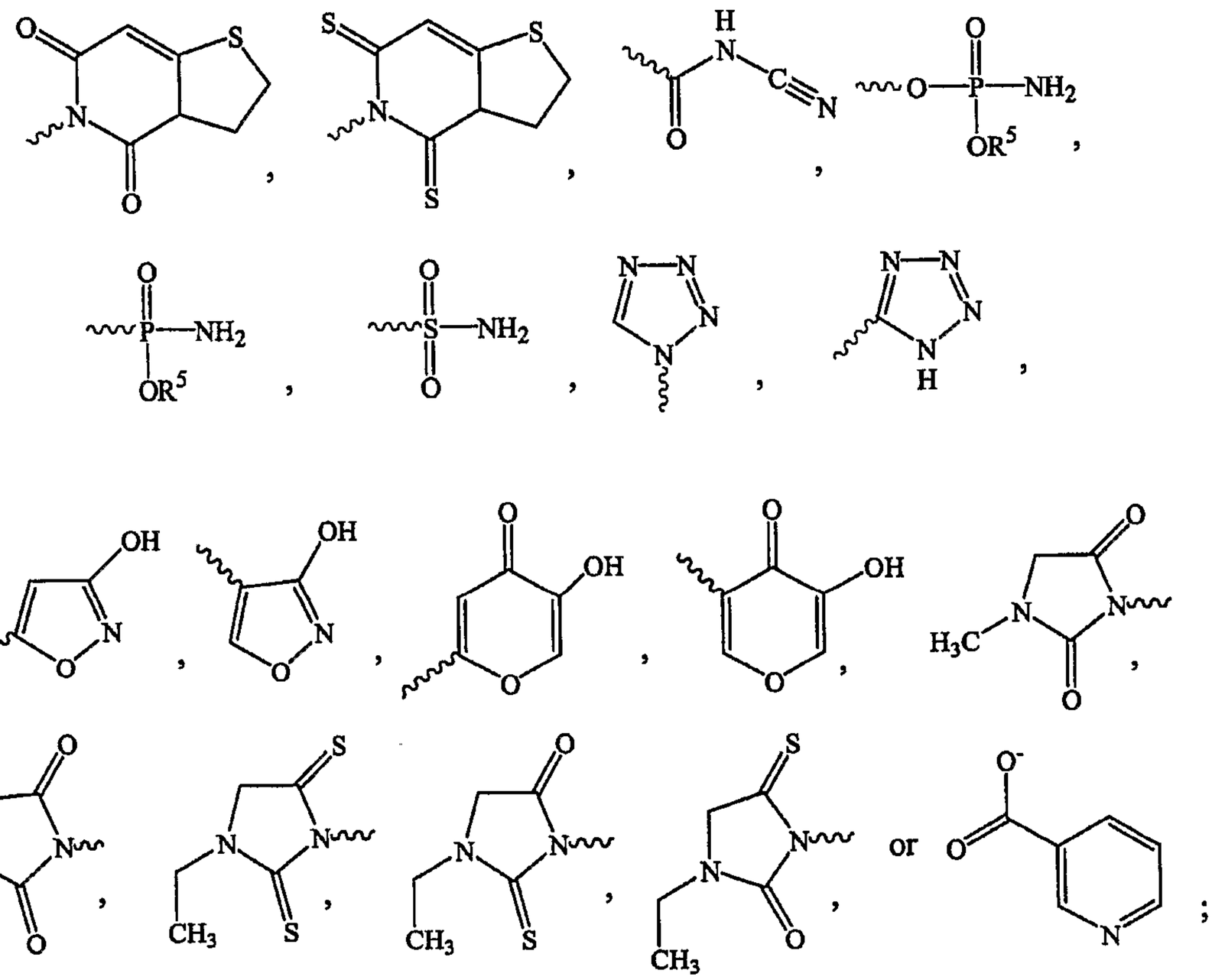
(e) L is $C(R^1)(R^2)\text{–}(CH_2)_n\text{–}Y$, where n is an integer ranging from 0 to 5;

(f) V is:



(g) each occurrence of Y is independently $(C_1$-$C_6)$alkyl, OH, COOH, $COOR^3$, SO_3H,





wherein:

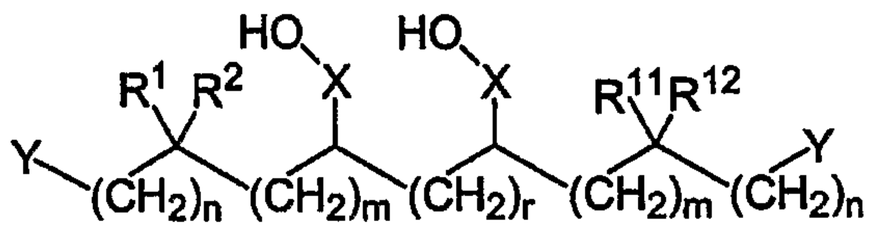
(i) R^3 is $(C_1$-$C_6)$alkyl, $(C_2$-$C_6)$alkenyl, $(C_2$-$C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1$-$C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1\text{-}C_6)$ alkoxy, or phenyl groups; and

(iii) each occurrence of R^5 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl.

Preferably, in formula **XI** each occurrence of Y is independently OH, $COOR^3$, or COOH.

In yet another embodiment, the invention encompasses compounds of formula **XII**



XII

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein:

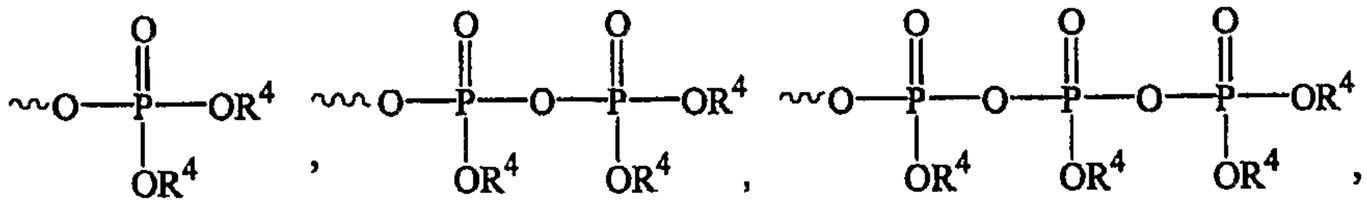
(a) each occurrence of m is independently an integer ranging from 1 to 9;

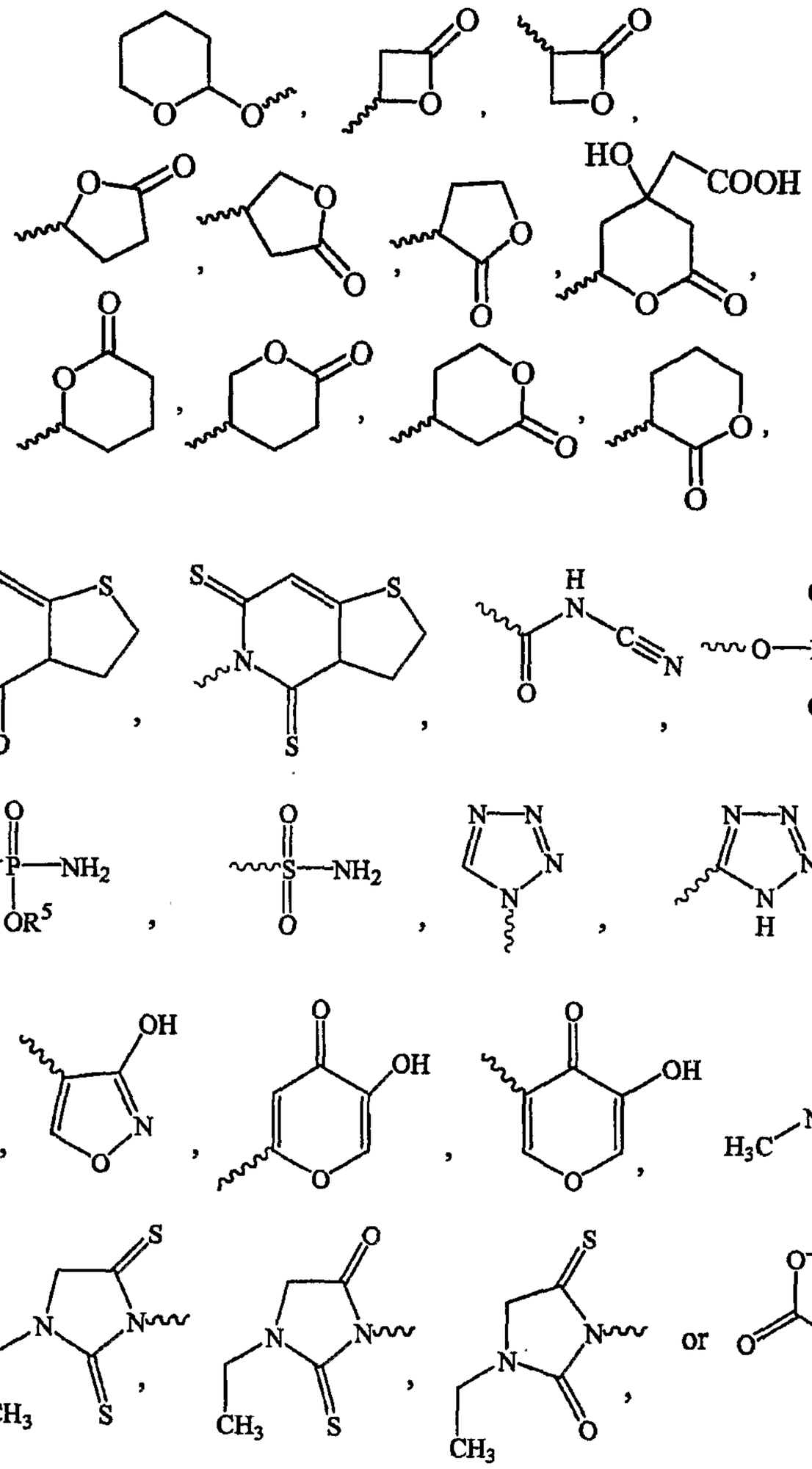
(b) r is 2, 3, or 4;

(c) each occurrence of n is independently an integer ranging from 0 to 7;

(d) each occurrence of R^1, R^2, R^{11}, and R^{12} is independently $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, $(C_2\text{-}C_6)$alkynyl, phenyl, benzyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3\text{-}C_7)$cycloakyl group; or R^{11} and R^{12} and the carbon to which they are both attached are taken together to form a $(C_3\text{-}C_7)$cycloakyl group; and

(e) each occurrence of Y is independently $(C_1\text{-}C_6)$alkyl, OH, COOH, $COOR^3$, SO_3H,





wherein:

(i) R^3 is $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, $(C_2\text{-}C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1\text{-}C_6)$alkoxy, or phenyl groups,

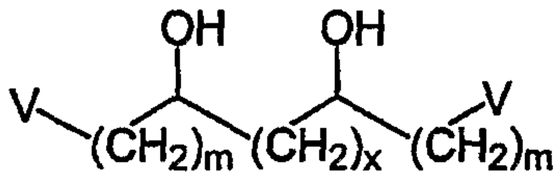
(ii) each occurrence of R^4 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1\text{-}C_6$ alkoxy, or phenyl groups;

(iii) each occurrence of R^5 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl; and

(f) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4;

Preferably in formula **XII**, each occurrence of Y is independently OH, $COOR^3$, or COOH.

In still another embodiment, the invention encompasses compounds of formula **XIII**



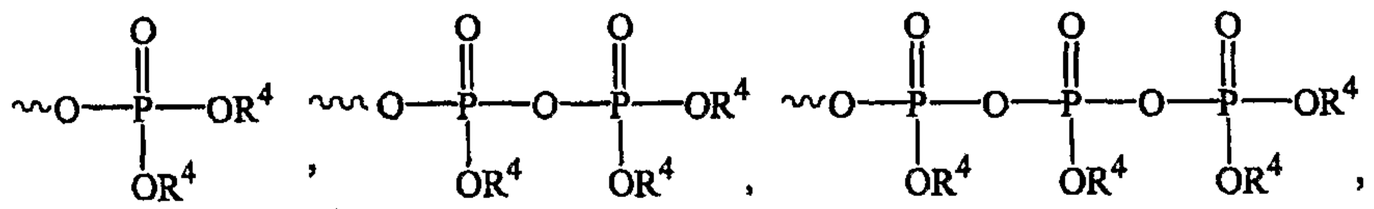
XIII

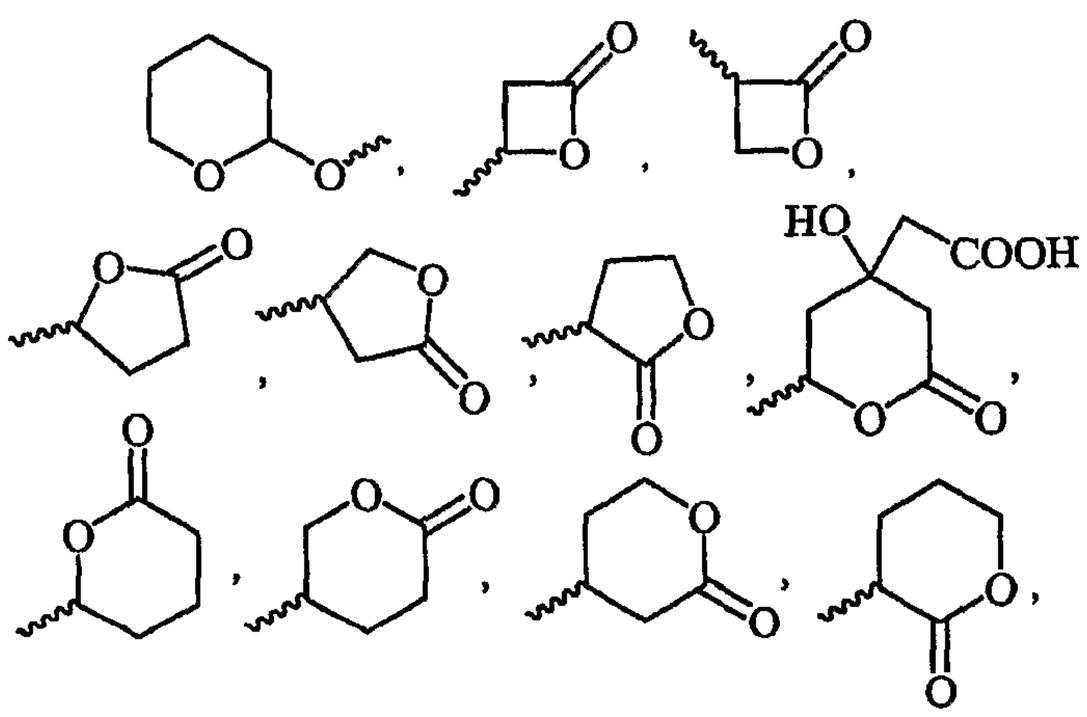
or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein:

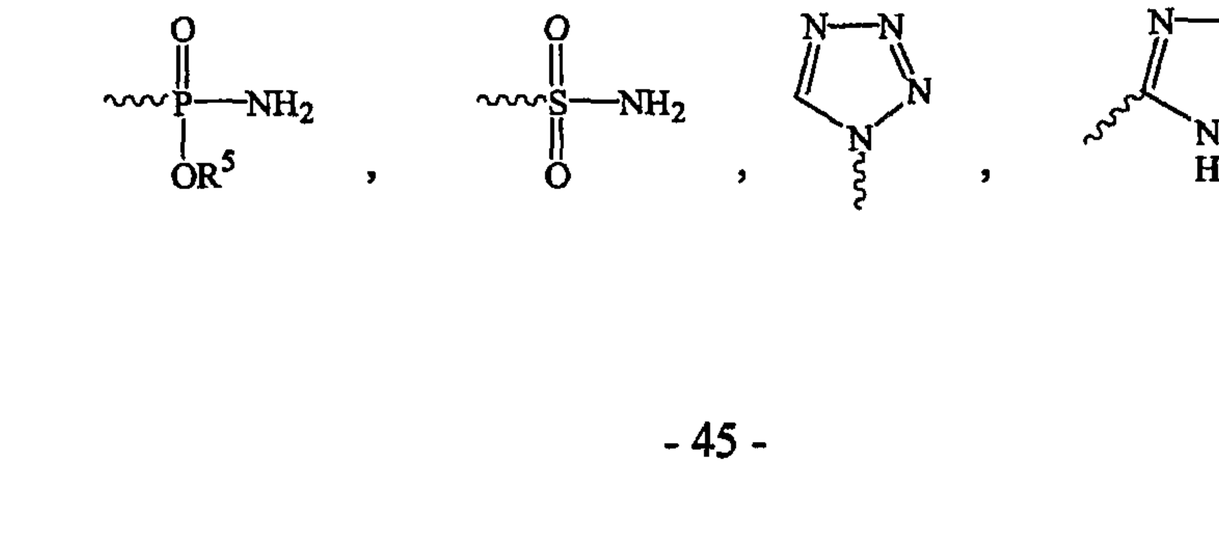
(a) each occurrence of m is an independent integer ranging from 1 to 9;

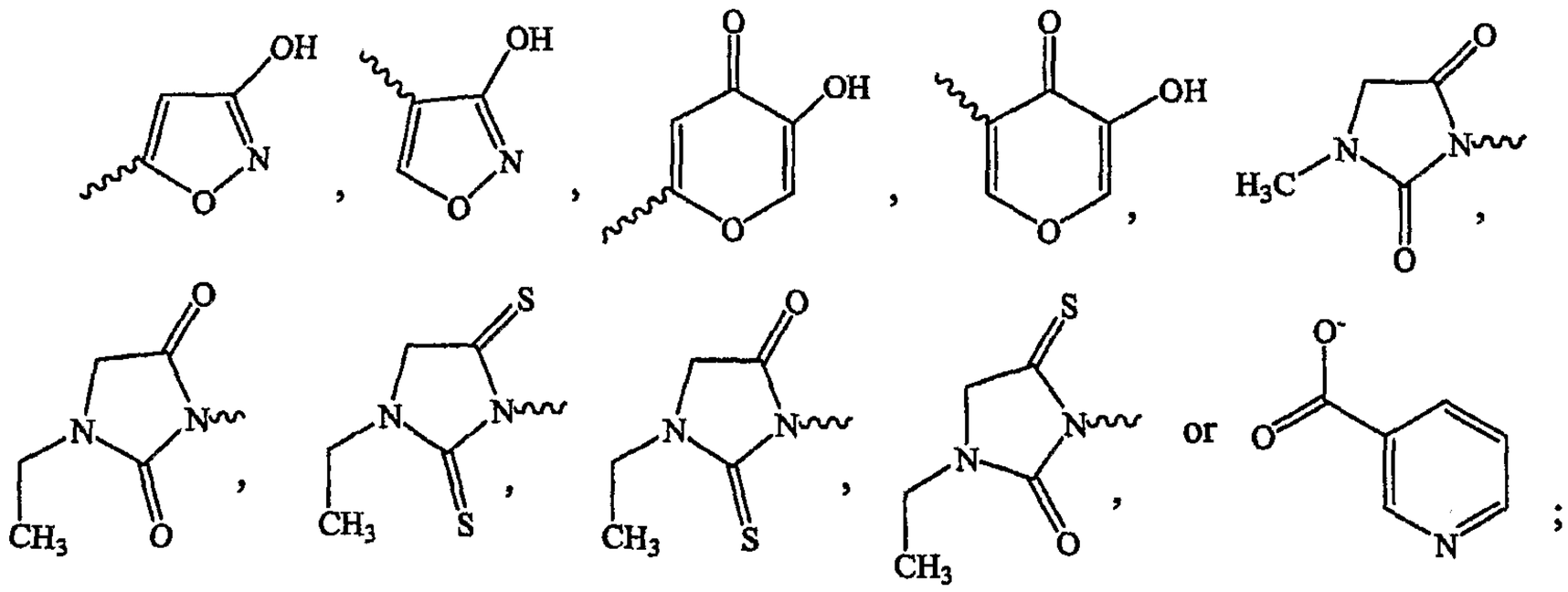
(b) x is 2, 3, or 4;

(c) V is:

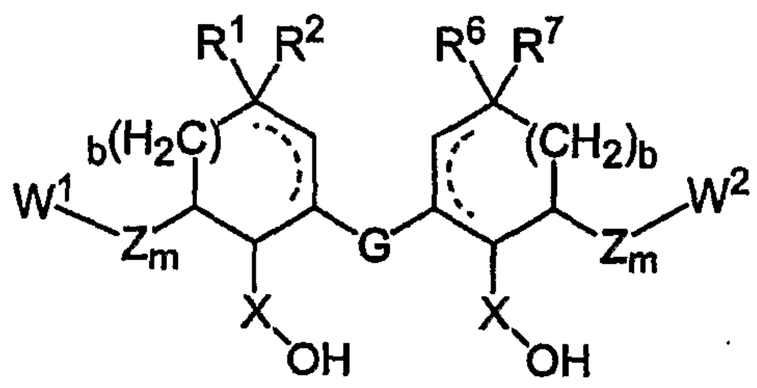








In yet another embodiment, the invention encompasses compounds of formula **XIV:**



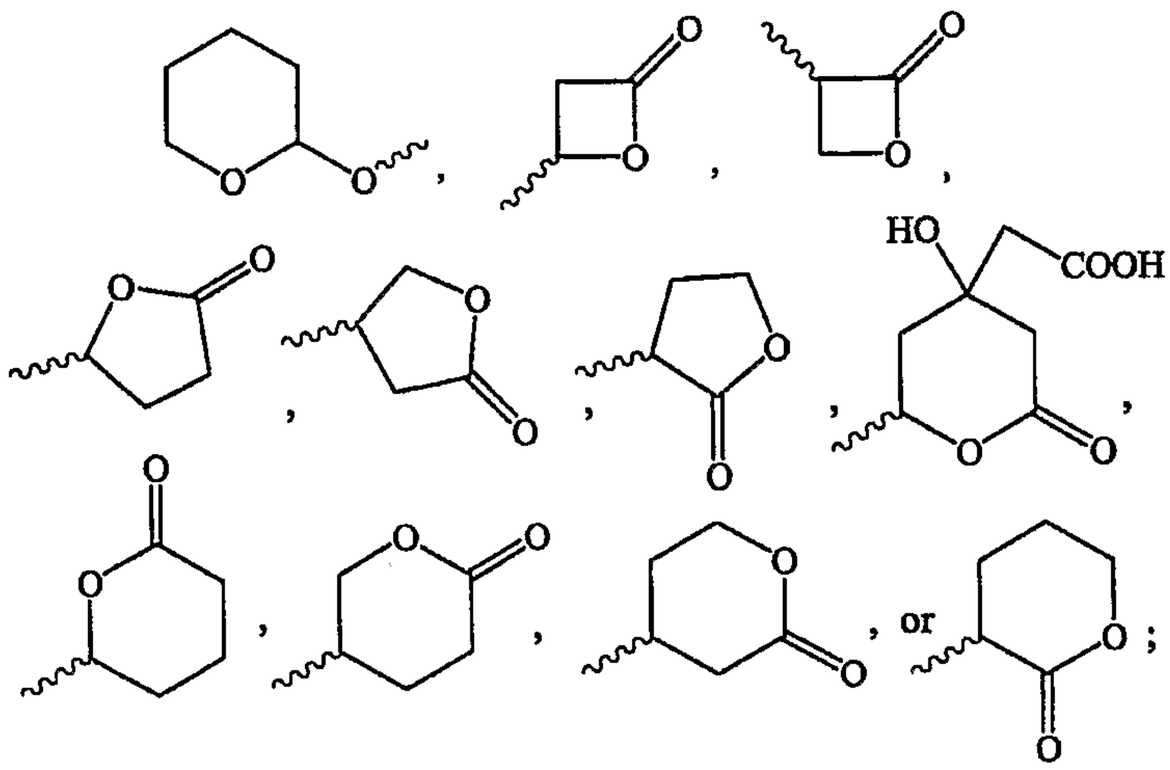
XIV

or a pharmaceutically acceptable salt, hydrate, solvate, enantiomer, diastereomer, geometric isomer or mixtures thereof, wherein:

(a) each occurrence of Z is independently CH_2, CH=CH, or phenyl, where each occurrence of m is independently an integer ranging from 1 to 5, but when Z is phenyl then its associated m is 1;

(b) G is $(CH_2)_x$, $CH_2CH=CHCH_2$, CH=CH, CH_2-phenyl-CH_2, or phenyl, where x is an integer ranging from 1 to 7;

(c) W^1 and W^2 are independently $C(R^1)(R^2)$-$(CH_2)_n$-Y, where n is an integer ranging from 0 to 7;

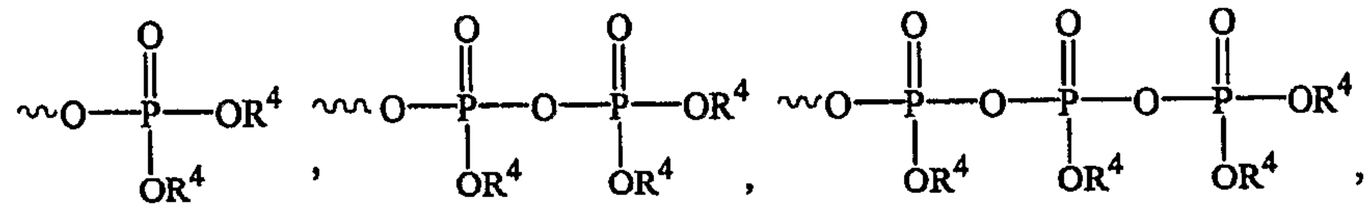


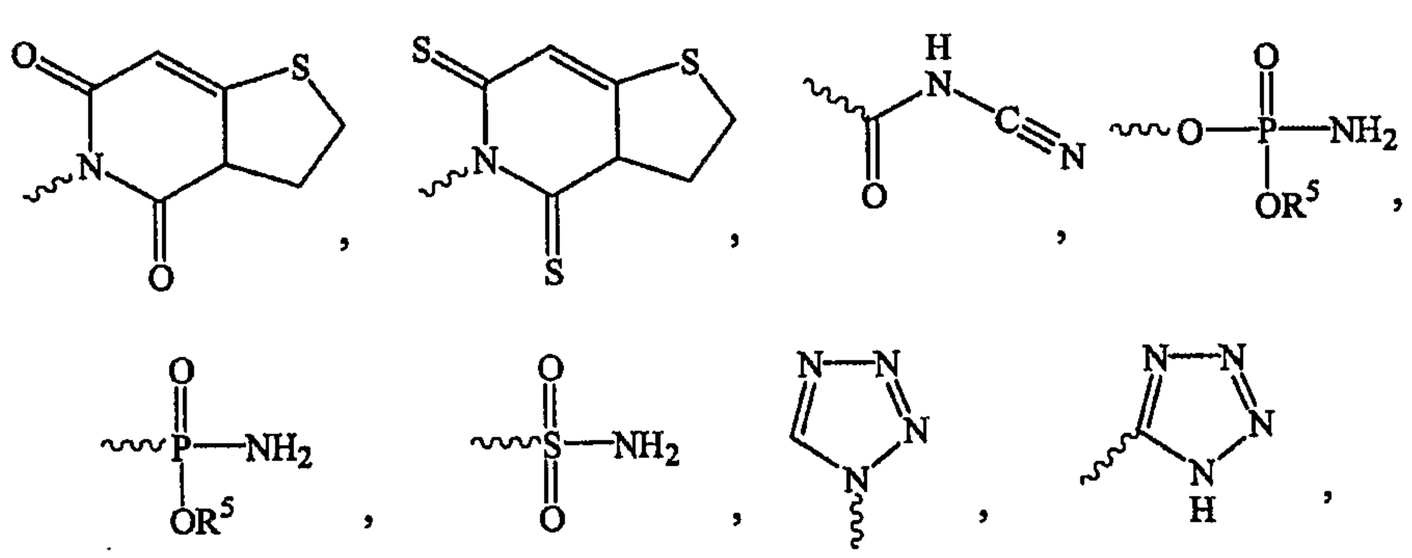
(d) each occurrence of R^8 and R^9 is independently H, $(C_1$-$C_6)$alkyl, $(C_2$-$C_6)$alkenyl, $(C_2$-$C_6)$alkynyl, phenyl, or benzyl or R^8 and R^9 can be taken together to form a carbonyl group;

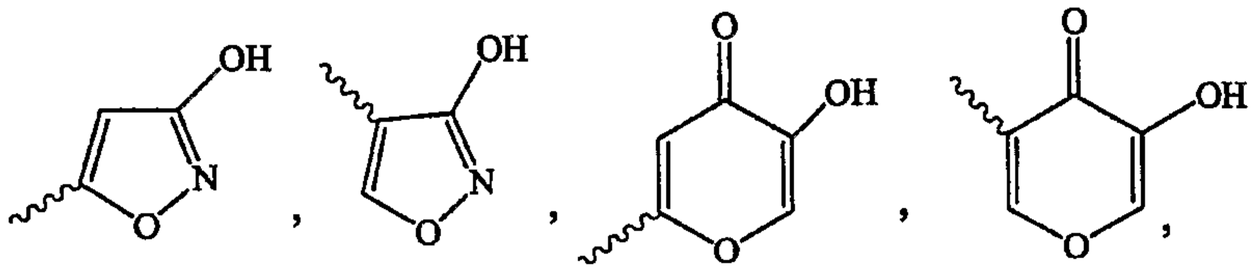
(e) each occurrence of R^1 and R^2 is independently H, $(C_1$-$C_6)$alkyl, $(C_2$-$C_6)$alkenyl, $(C_2$-$C_6)$alkynyl, phenyl, or benzyl or R^1 and R^2 can be taken together to form a carbonyl group or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group;

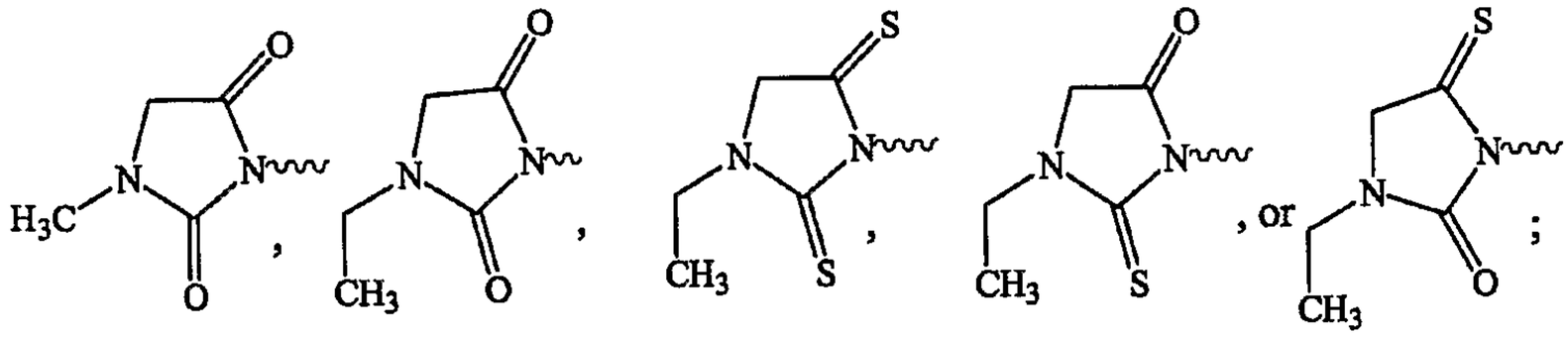
(f) each occurrence of R^6 and R^7 is independently H, $(C_1$-$C_6)$alkyl, or R^6 and R^7 can be taken together to form a carbonyl group or R^6 and R^7 and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group;

(g) Y is $(C_1$-$C_6)$alkyl, OH, COOH, $COOR^3$, SO_3H,









wherein:

(i) R^3 is $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, $(C_2\text{-}C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1\text{-}C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1\text{-}C_6$ alkoxy, or phenyl groups;

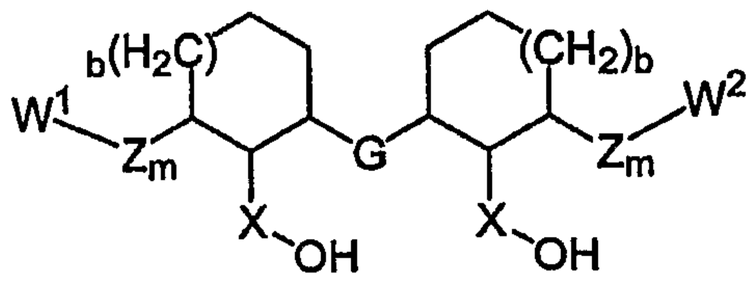
(iii) each occurrence of R^5 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl;

(h) each occurrence of b is independently 0 or 1 or optionally the presence of one or more additional carbon-carbon bonds that when present complete one or more carbon-carbon double bonds; and

(i) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4.

Preferably in formula **XIV**, each occurrence of W^1 and W^2 is an independent $C(R^1)(R^2)\text{-}(CH_2)_n\text{-}Y$ group and each occurrence of Y is independently OH, $COOR^3$, or COOH.

In yet another embodiment, the invention encompasses compounds of formula **XV**:



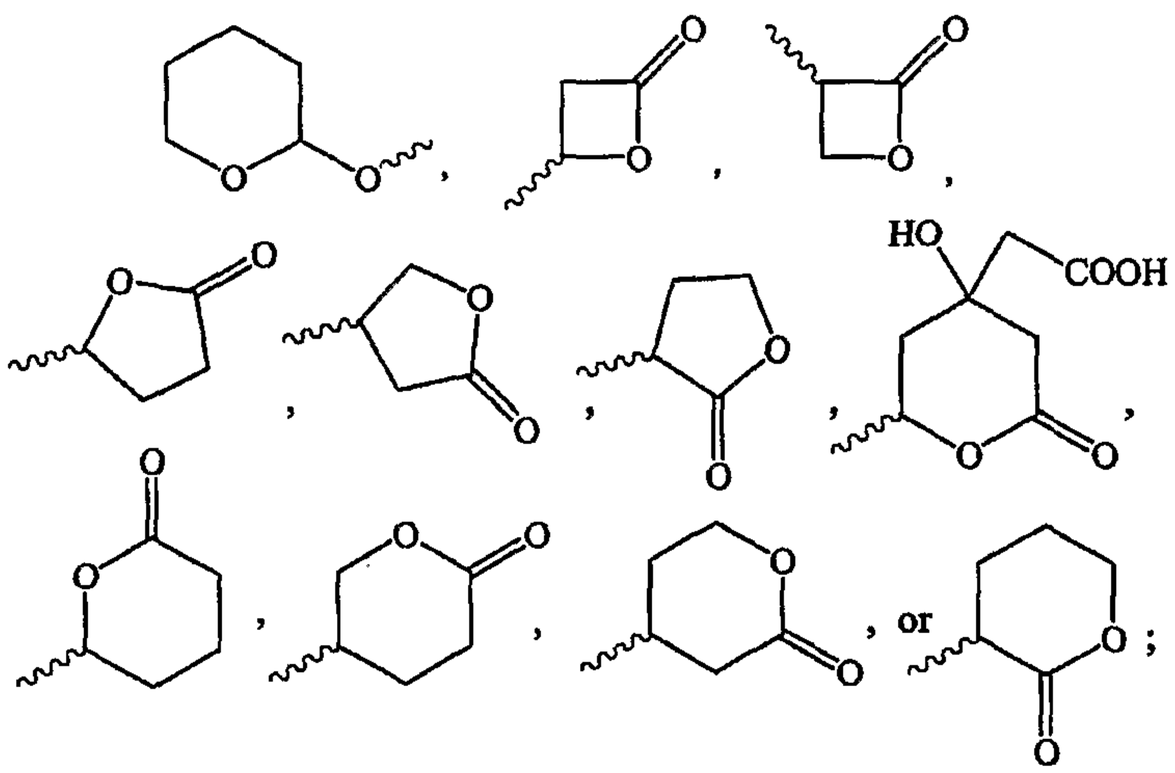
XV

or a pharmaceutically acceptable salt, hydrate, solvate, stereoisomer, diastereomer, geometric isomer or mixtures thereof, wherein

(a) each occurrence of m is independently an integer ranging from 1 to 5;

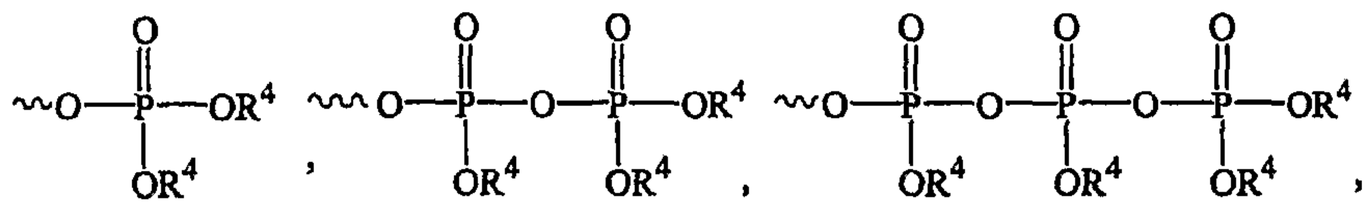
(b) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4;

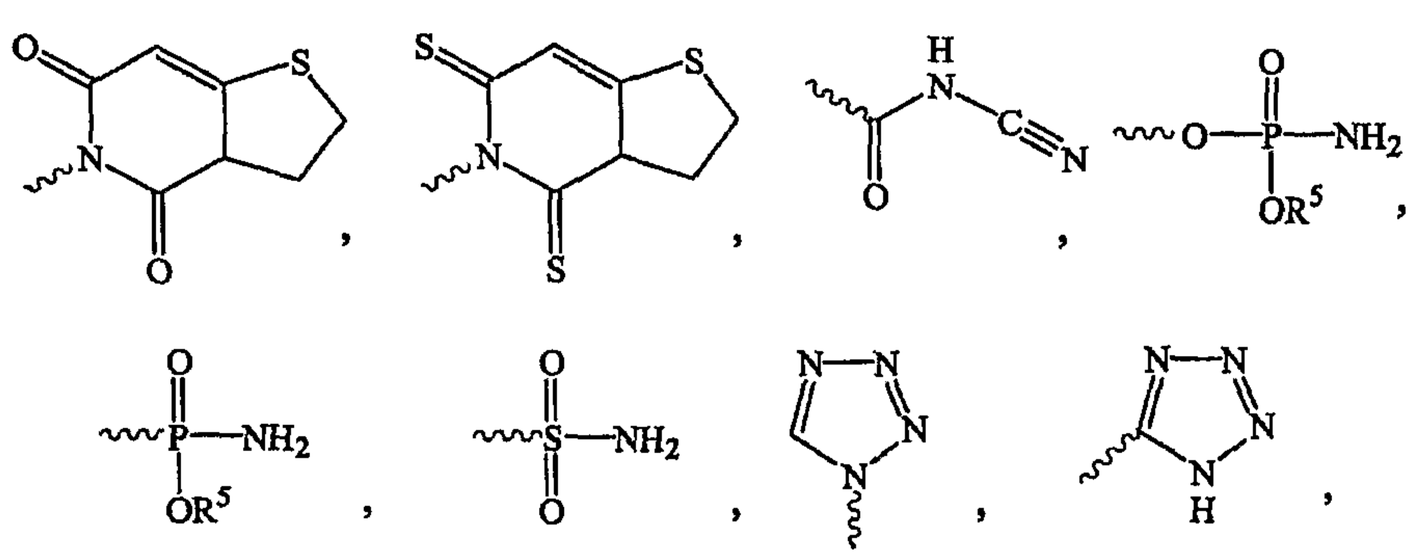
(c) W^1 and W^2 are independently $C(R^1)(R^2)$–$(CH_2)_n$–Y, where n is an integer ranging from 0 to 7;

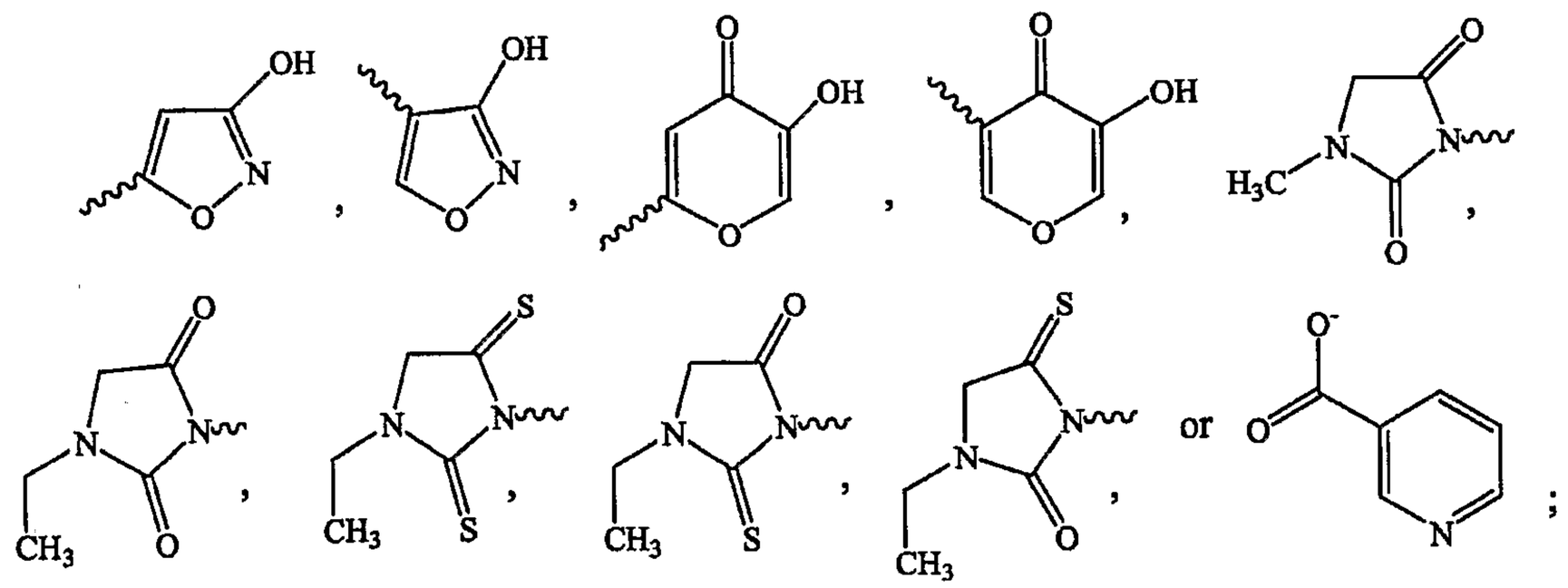


(d) each occurrence of R^1 or R^2 is independently $(C_1$–$C_6)$alkyl, $(C_2$–$C_6)$alkenyl, $(C_2$–$C_6)$alkynyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group

(e) Y is $(C_1$–$C_6)$alkyl, $(CH_2)_nOH$, $(CH_2)_nCOOH$, $(CH_2)_nCOOR^3$, SO_3H,







wherein:

(i) R^3 is $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, $(C_2\text{-}C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1\text{-}C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1\text{-}C_6$ alkoxy, or phenyl groups,

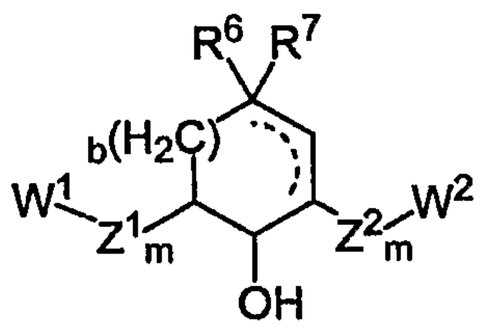
(iii) each occurrence of R^5 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl;

(f) each occurrence of b is independently 0 or 1; and

(g) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4.

Preferably in compound **XV**, W^1 and W^2 are independent $C(R^1)(R^2)\text{-}(CH_2)_n\text{-}Y$, groups and each occurrence of Y is independently OH, $COOR^3$, or COOH.

In another embodiment, the invention encompasses compounds of formula **XVI**:

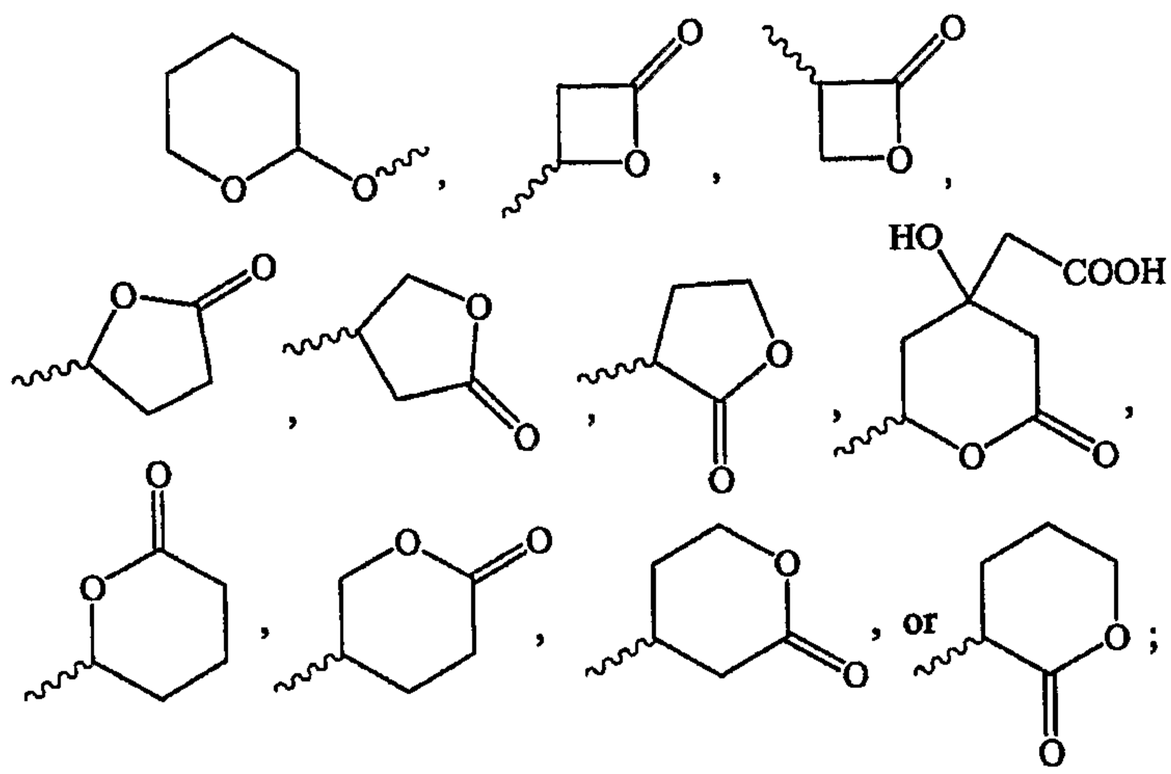


XVI

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein:

(a) each occurrence of $Z^1{}_m$ and $Z^2{}_m$ is independently CH_2, CH=CH, or phenyl, where each occurrence of m is independently an integer ranging from 1 to 5, but when Z is phenyl then its associated m is 1;

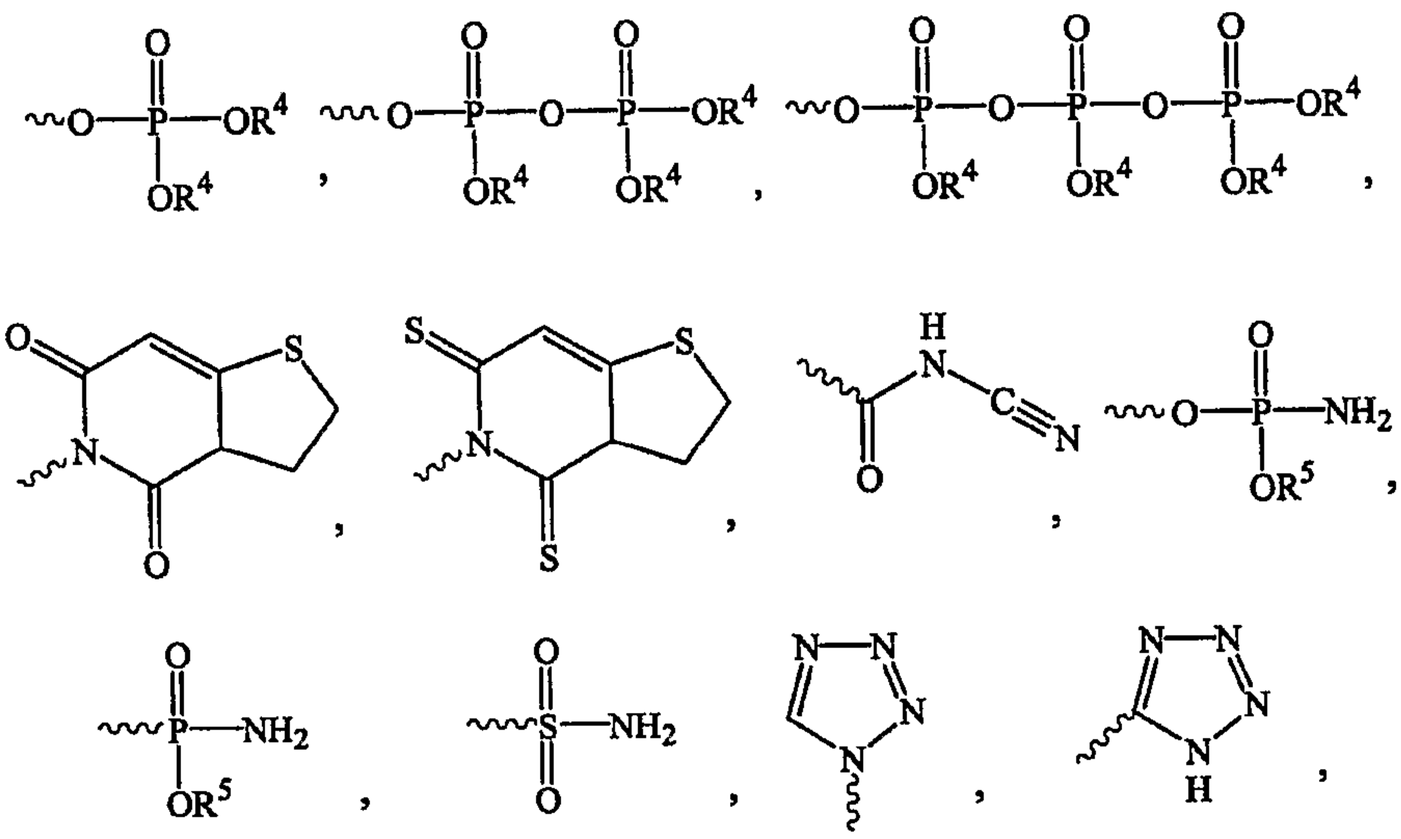
(b) W^1 and W^2 are independently $C(R^1)(R^2)$–$(CH_2)_n$–Y, where n is an integer ranging from 0 to 4;

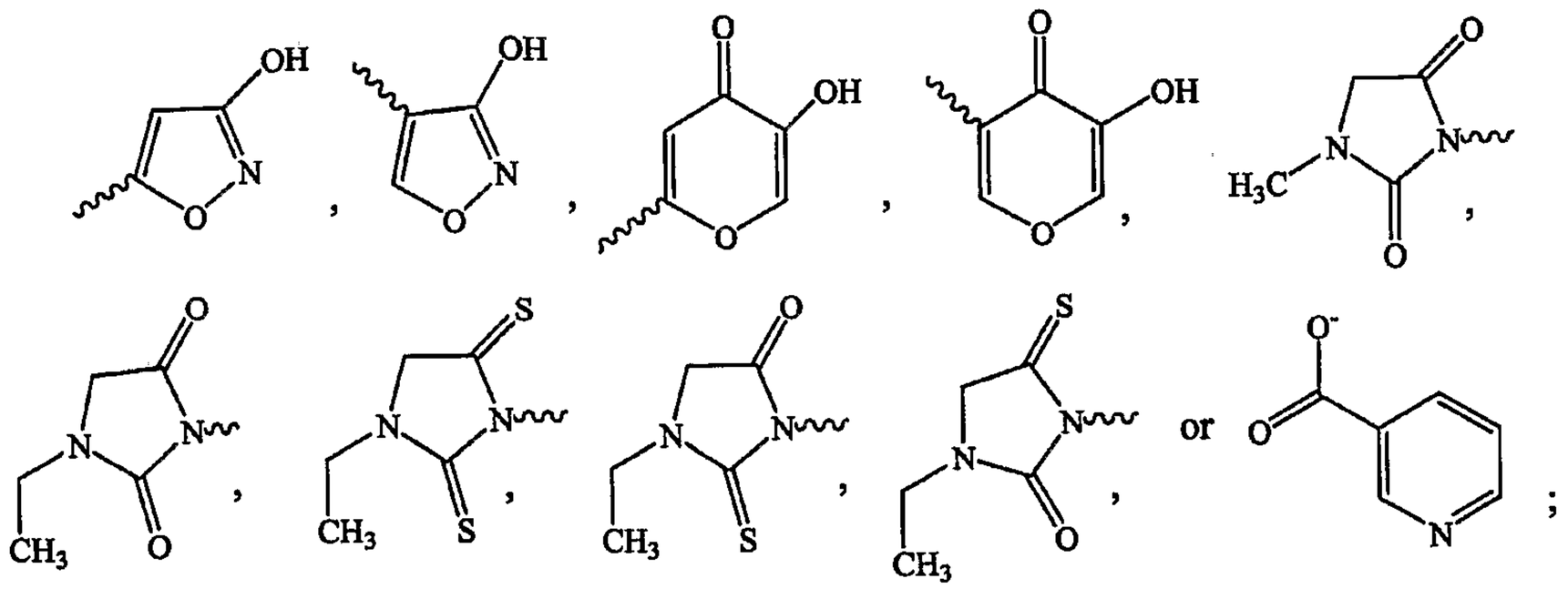


(c) each occurrence of R^1 and R^2 is independently $(C_1$–$C_6)$alkyl, $(C_2$–$C_6)$alkenyl, $(C_2$–$C_6)$alkynyl, phenyl, or benzyl or R^1 and R^2 are both H;

(d) each occurrence of R^6 and R^7 is independently H, $(C_1$-$C_6)$ alkyl, or R^6 and R^7 can be taken together to form a carbonyl group;

(e) Y is OH, COOH, $COOR^3$, SO_3H,





wherein:

(i) R_3 is $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, $(C_2\text{-}C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1\text{-}C_6)$alkoxy, or phenyl groups,

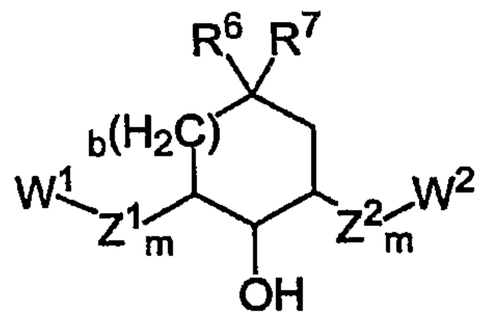
(ii) each occurrence of R_4 is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1\text{-}C_6$ alkoxy, or phenyl groups;

(iii) each occurrence of $_{R5}$ is independently H, $(C_1\text{-}C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl; and

(f) each occurrence of p is independently 0 or 1 or optionally the presence of one or more additional carbon-carbon bonds that when present complete one or more carbon-carbon double bonds.

Preferably in formula **XVI**, each occurrence of W^1 and W^2 is an independent $C(R^1)(R^2)\text{–}(CH_2)_n\text{–}Y$ group and each occurrence of Y is independently OH, $COOR^3$, or COOH.

In yet another embodiment, the invention encompasses compounds of formula **XVII**:



XVII

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein:

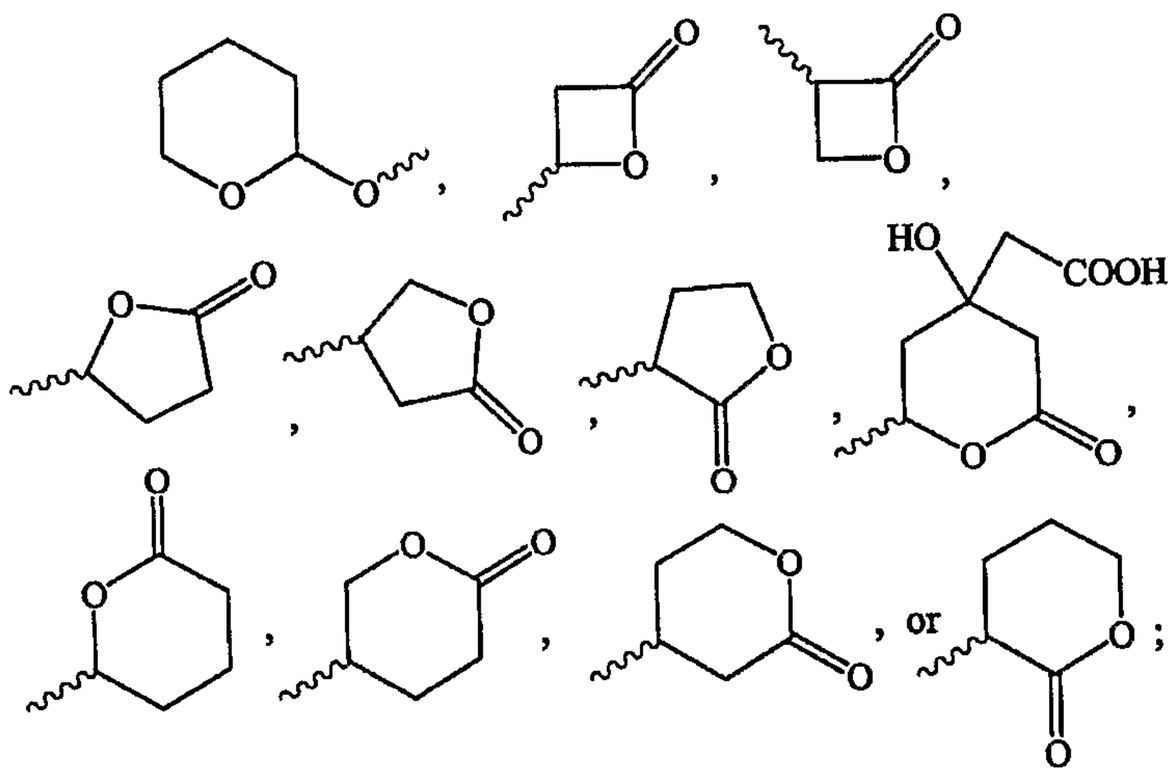
(a) each occurrence of Z is independently CH_2 or CH=CH, wherein each occurrence of m is independently an integer ranging from 1 to 9;

(b) W^1 and W^2 are independently L, V, or $C(R^1)(R^2)$–$(CH_2)_c$–V, where c is 1 or 2; when G is $(CH_2)_x$, where x is 1, 2, 3, or 4, W^2 is CH_3;

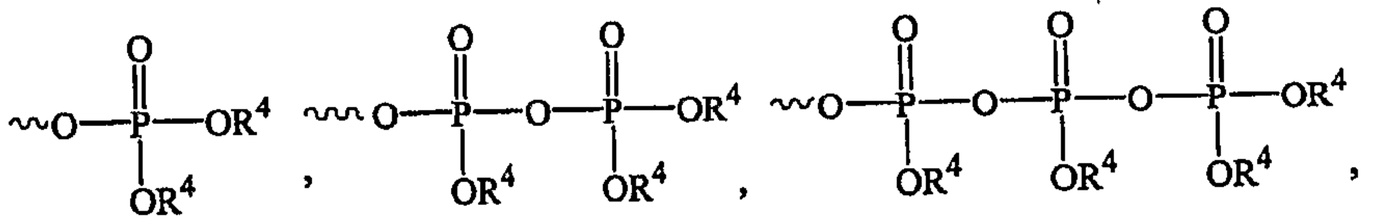
(c) each occurrence of R^1 and R^2 is independently $(C_1$–$C_6)$alkyl, $(C_2$–$C_6)$alkenyl, $(C_2$–$C_6)$alkynyl, phenyl, or benzyl;

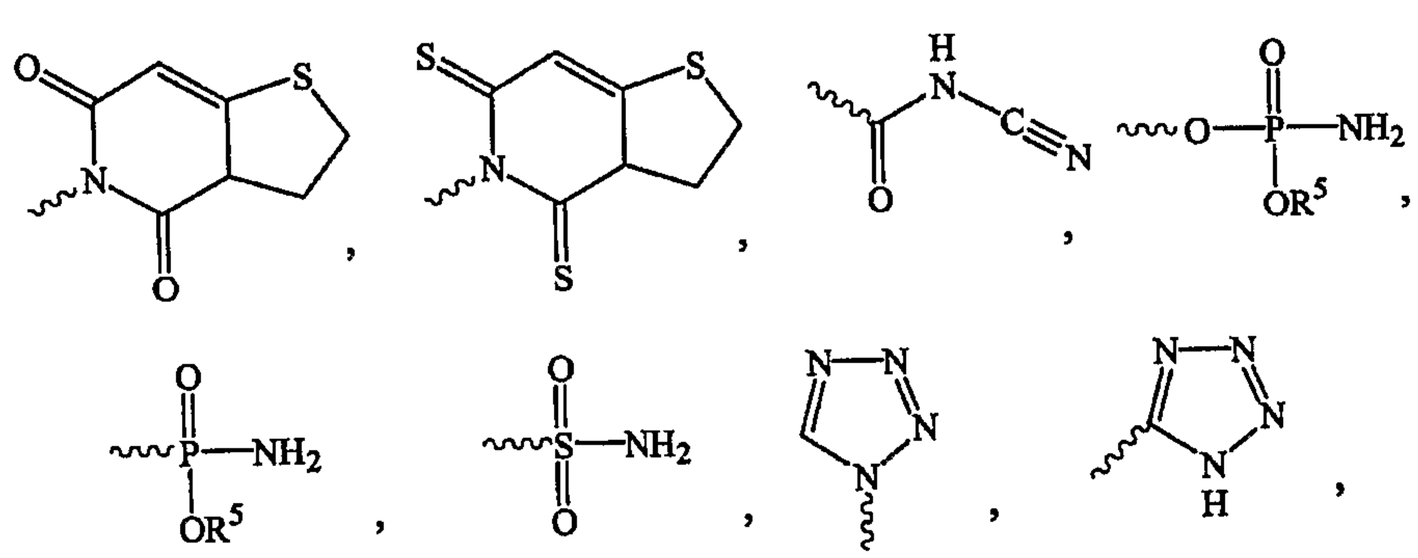
(d) L is $C(R^1)(R^2)$–$(CH_2)_n$–Y, where n is an integer ranging from 0 to 4;

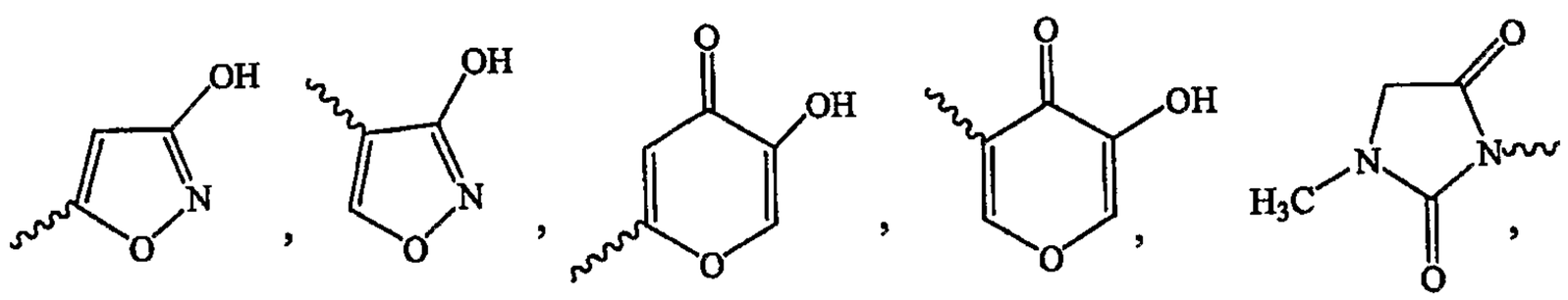
(e) V is

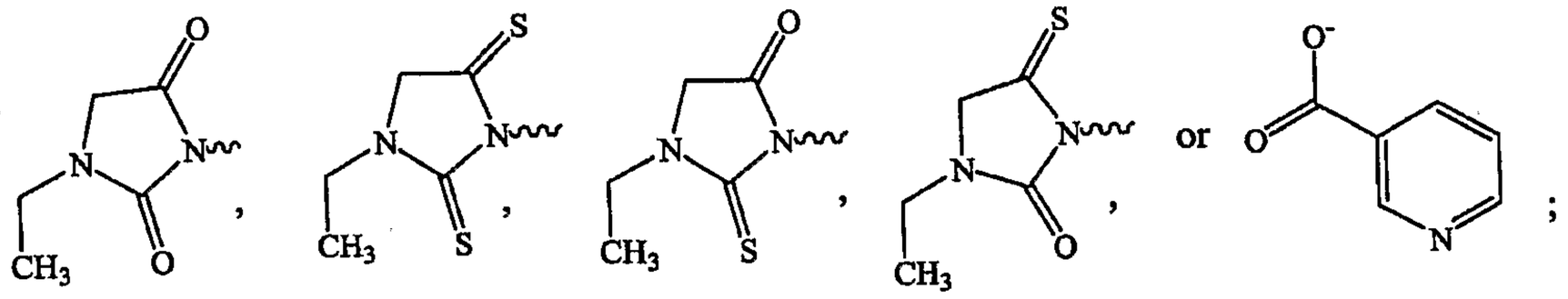


(f) each occurrence of Y is independently OH, COOH, CHO, $COOR^3$, SO_3H,









wherein:

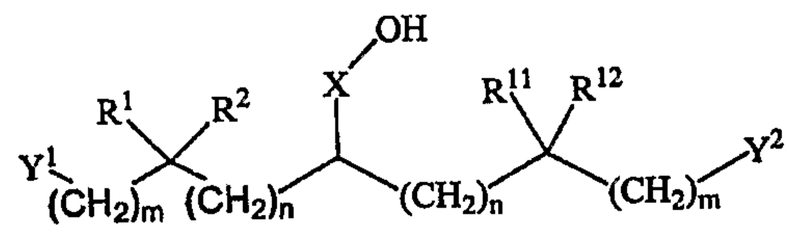
(i) R^3 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1–C_6)$ alkoxy, or phenyl groups;

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl; and

(g) each X is independently PH or $(CH_2)_r$, where r is 1, 2, 3, or 4.

The invention encompasses compounds of formula **XVIII**:



XVIII

or a pharmaceutically acceptable salt, hydrate, solvate, or mixtures thereof, wherein:

(a) each occurrence of m is independently an integer ranging from 0 to 5;

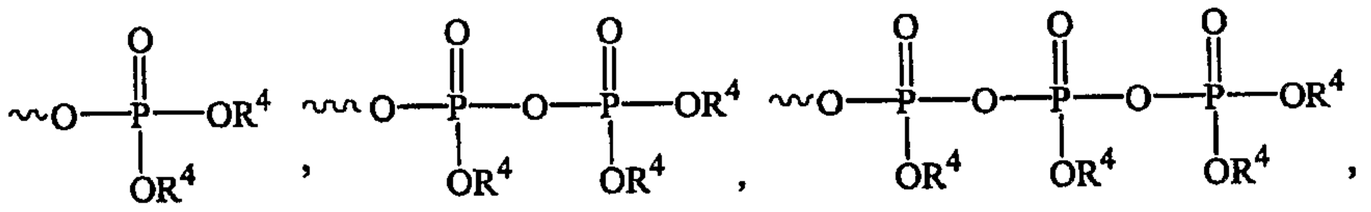
(b) each occurrence of n is independently an integer ranging from 3 to 7;

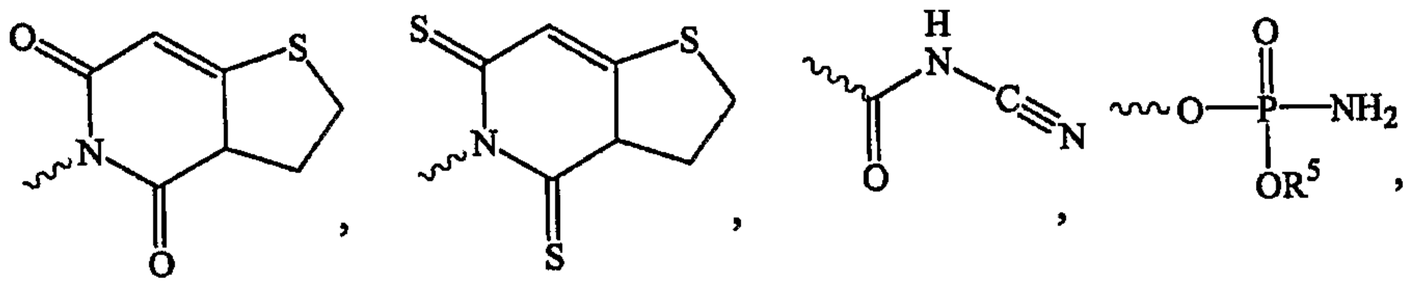
(c) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4;

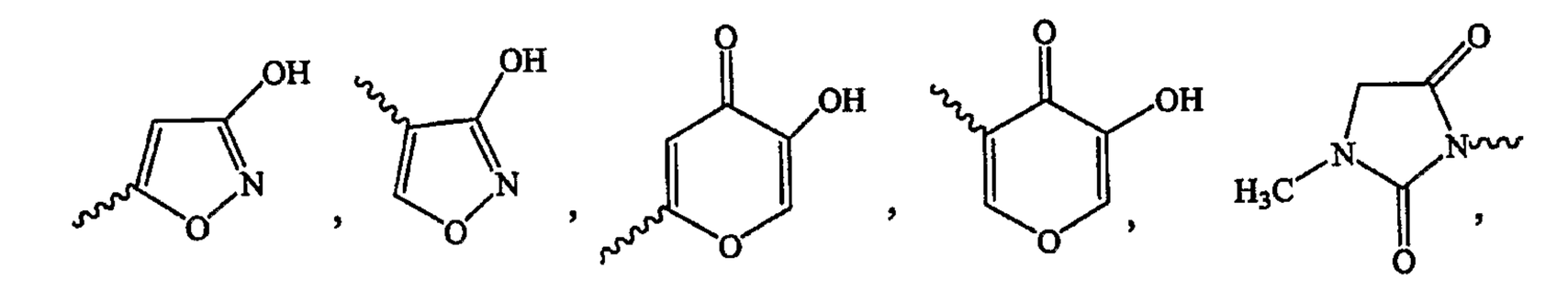
(d) each occurrence of R^1 and R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, benzyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group;

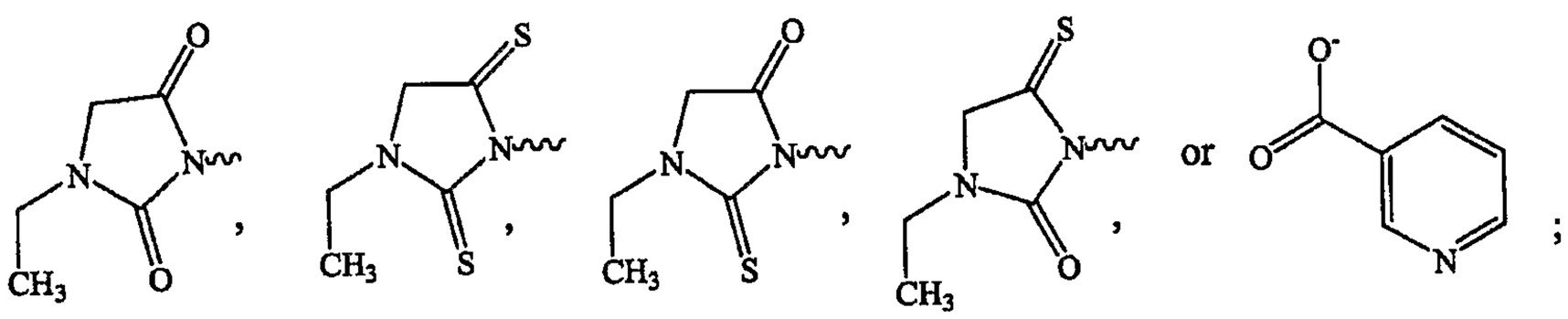
(e) each occurrence of R^{11} and R^{12} and the carbon to which they are both attached are taken together to form a (C_3-C_7)cycloakyl group;

(f) each occurrence of Y^1 and Y^2 is independently (C_1–C_6)alkyl, OH, COOH, $COOR^3$, SO_3H,









wherein:

(i) R^3 is (C_1–C_6)alkyl, (C_2–C_6)alkenyl, (C_2–C_6)alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, (C_1–C_6)alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, (C_1–C_6)alkyl, (C_2–C_6)alkenyl, or (C_2–C_6)alkynyl and is unsubstituted or substituted with one or two halo, OH, C_1–C_6 alkoxy, or phenyl groups; and

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl.

In an exemplary compound of formula I, each occurrence of Y is independently OH, $COOR^3$, or COOH.

Other compounds of formula **XVIII** are those wherein m is 0.

Other compounds of formula **XVIII** are those wherein m is 1.

Other compounds of formula **XVIII** are those wherein n is 4.

Other compounds of formula **XVIII** are those wherein n is 5.

Other compounds of formula **XVIII** are those wherein z is 0.

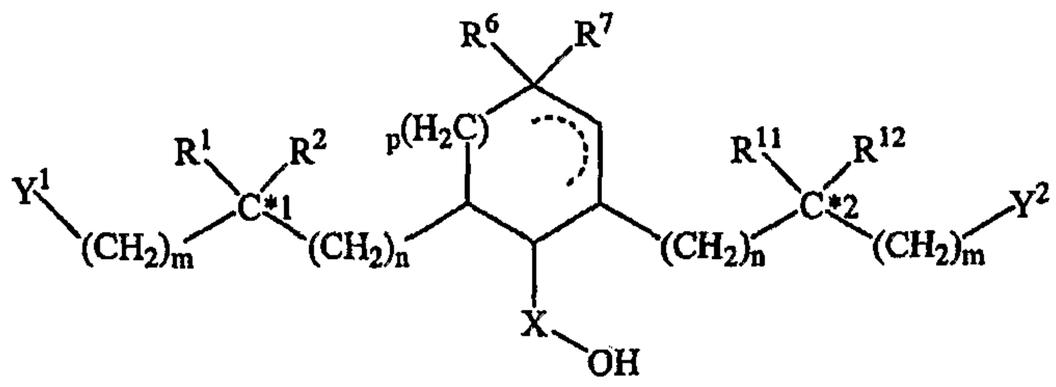
Other compounds of formula **XVIII** are those wherein z is 1.

Other compounds of formula **XVIII** are those wherein Y^1 and Y^2 are each independently $(C_1–C_6)$alkyl.

Other compounds of formula I are those wherein Y^1 and Y^2 are each methyl.

Other compounds of formula I are those wherein each occurrence R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group.

In another embodiment, the invention encompasses compounds of the formula **XIX**:



XIX

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein

(a) each occurrence of R^1 and R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, benzyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group;

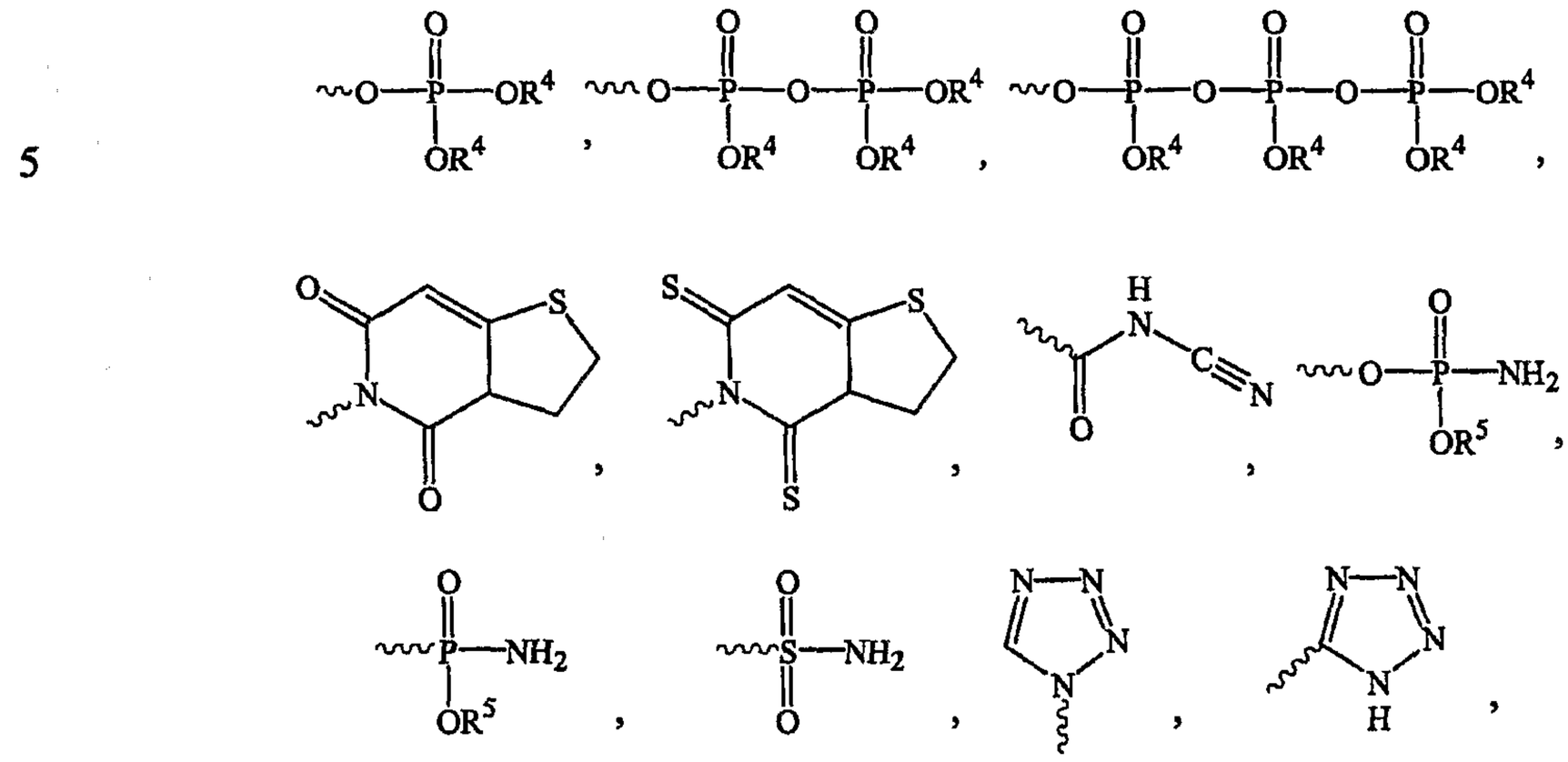
(b) each occurrence of R^{11} and R^{12} and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group;

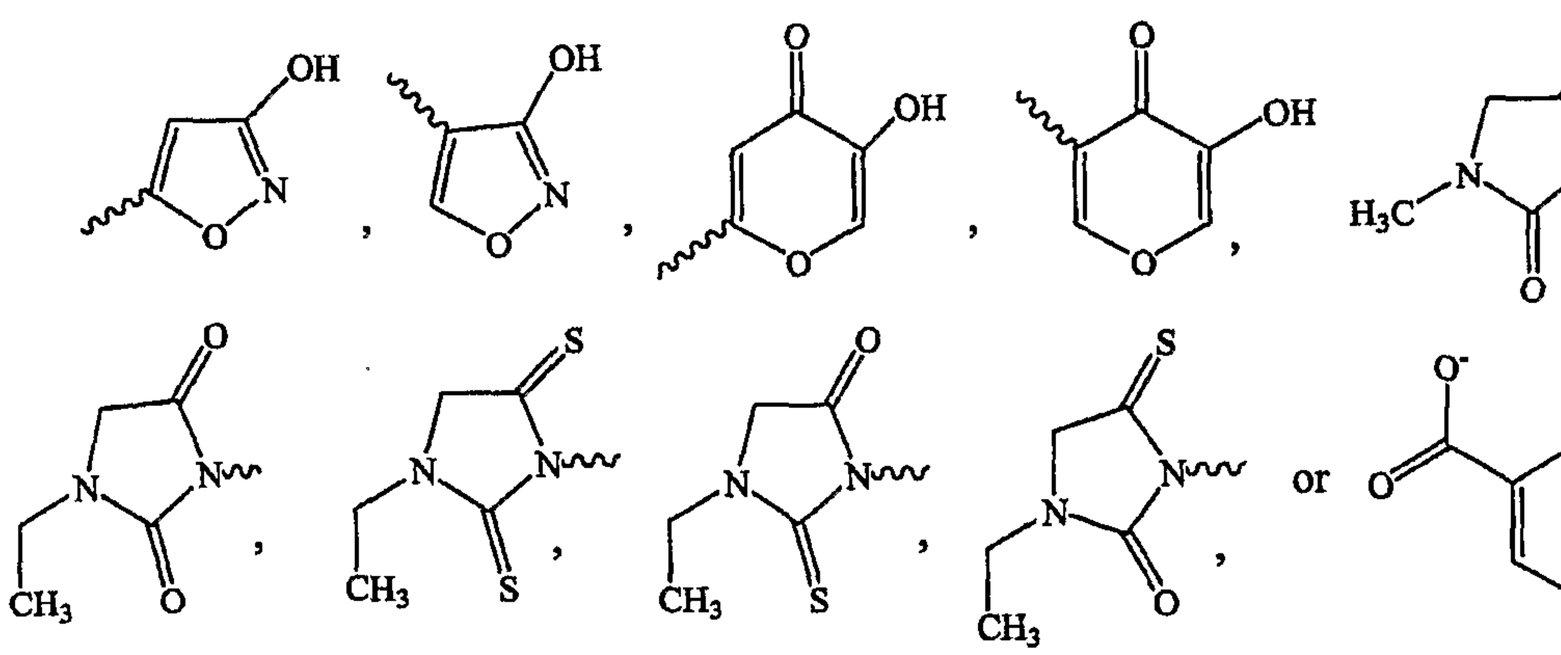
(c) each occurrence of n is independently an integer ranging from 1 to 7;

(d) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4;

(e) each occurrence of m is independently an integer ranging from 0 to 4;

(f) each occurrence of Y^1 and Y^2 is independently $(C_1–C_6)$alkyl, CH_2OH, C(O)OH, $OC(O)R^3$, $C(O)OR^3$, SO_3H,





wherein:

(i) R^3 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

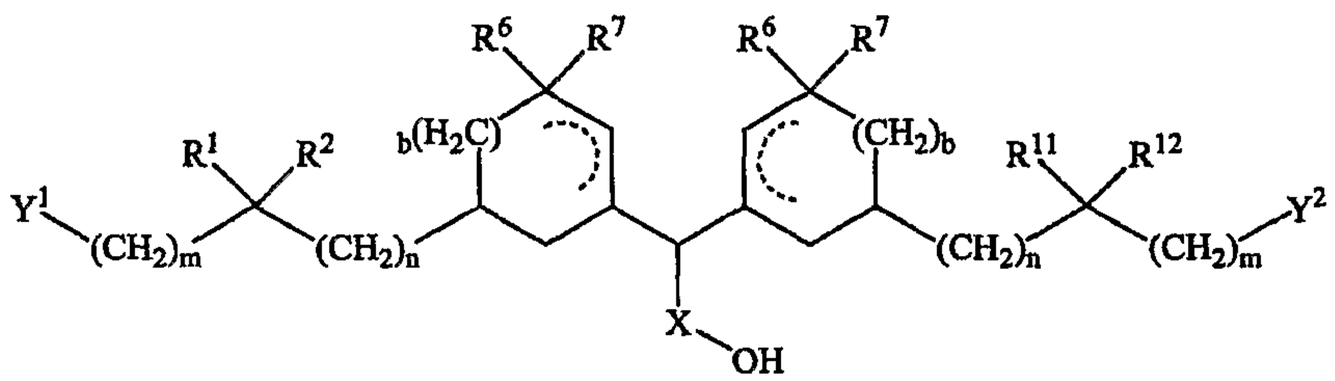
(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1–C_6$ alkoxy, or phenyl groups;

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl; and

(g) b is 0 or 1 or optionally the presence of one or more additional carbon-carbon bonds that when present complete one or more carbon-carbon double bonds.

Exemplary compounds of formula **XIX** are those in which each occurrence of R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3\text{-}C_7)$cycloakyl group.

In another embodiment, the invention encompasses compounds of formula **XX**:



XX

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein:

(a) each occurrence of R^1 and R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, benzyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3\text{-}C_7)$cycloakyl group;

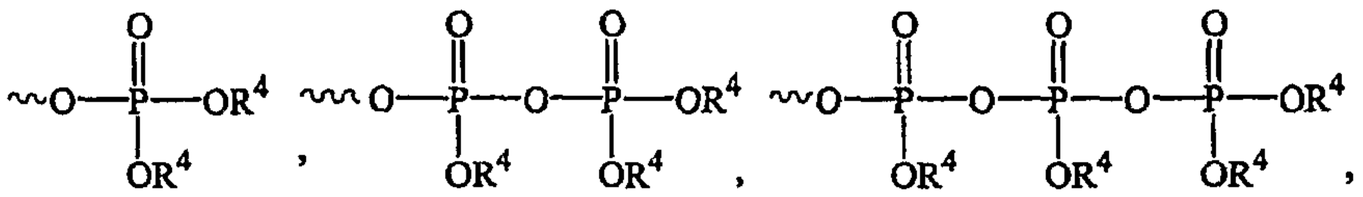
(b) each occurrence of R^{11} and R^{12} and the carbon to which they are both attached are taken together to form a $(C_3\text{-}C_7)$cycloakyl group;

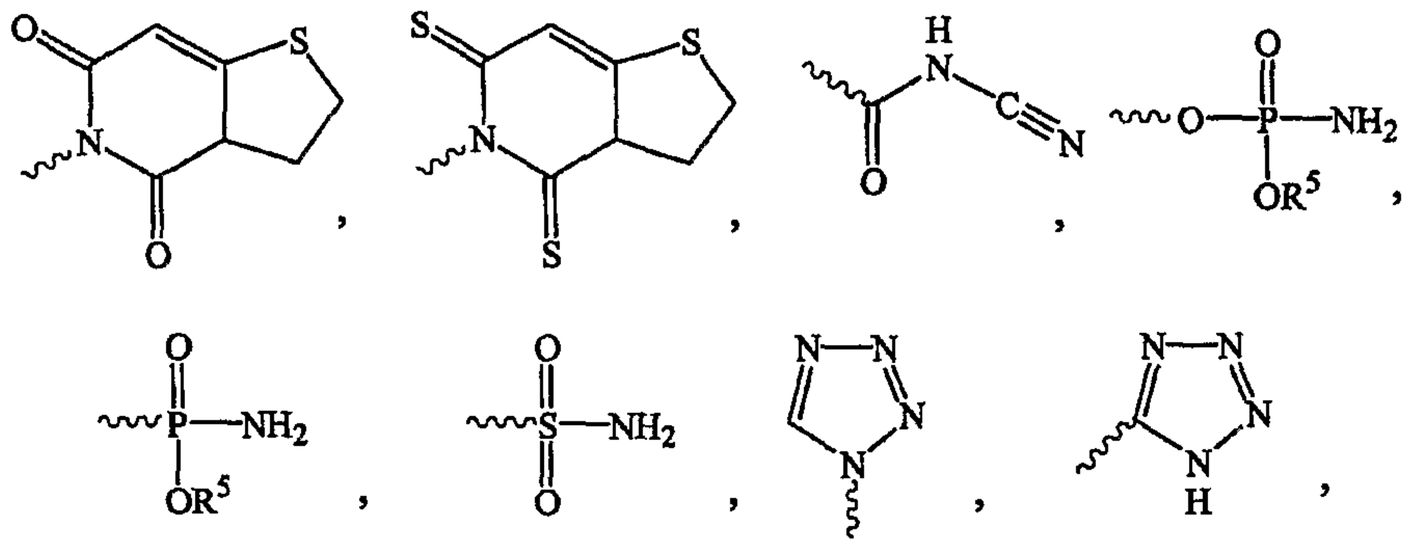
(c) each occurrence of n is independently an integer ranging from 1 to 7;

(d) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4;

(e) each occurrence of m is independently an integer ranging from 0 to 4;

(f) each occurrence of Y^1 and Y^2 is independently $(C_1–C_6)$alkyl, CH_2OH, C(O)OH, $OC(O)R^3$, $C(O)OR^3$, SO_3H,

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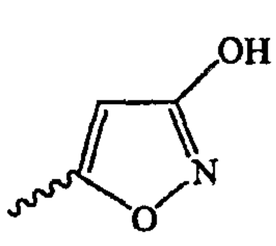
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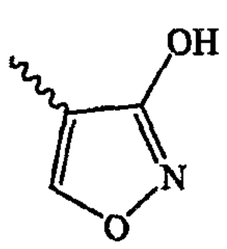
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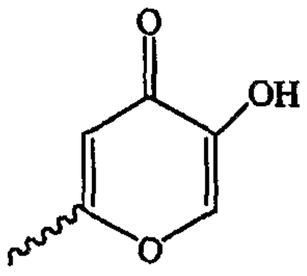
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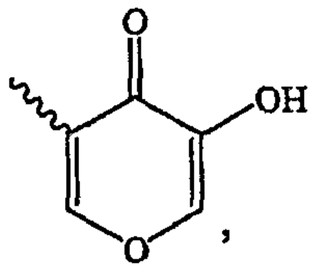
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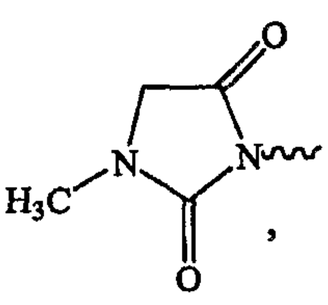
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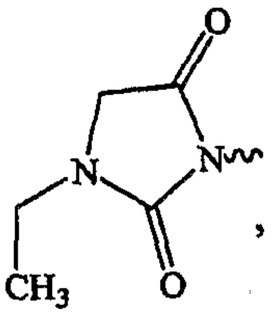
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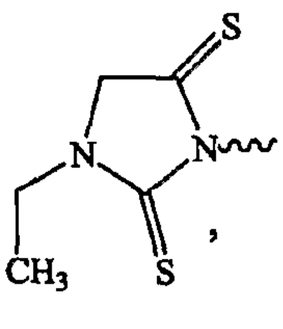
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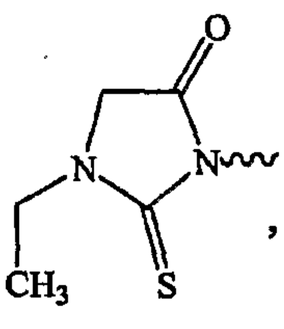
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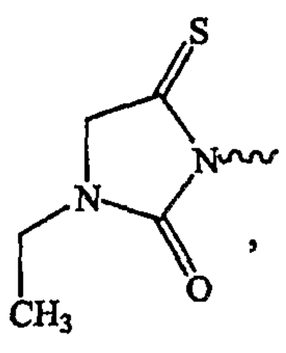
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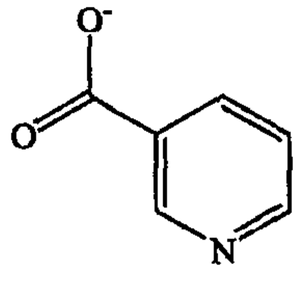

;

wherein:

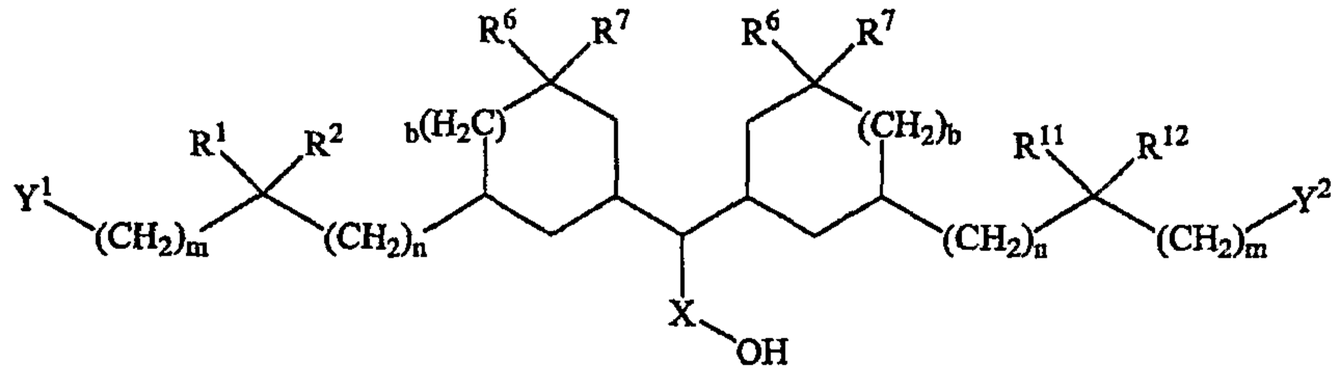
(i) R^3 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1–C_6$ alkoxy, or phenyl groups;

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl; and

(g) each occurrence of b is independently 0 or 1 or optionally the presence of one or more additional carbon-carbon bonds that when present complete one or more carbon-carbon double bonds.

In another embodiment, the invention encompasses compounds of formula **XXI**:



XXI

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein

(a) each occurrence of R^1 and R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, benzyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3\text{-}C_7)$cycloakyl group;

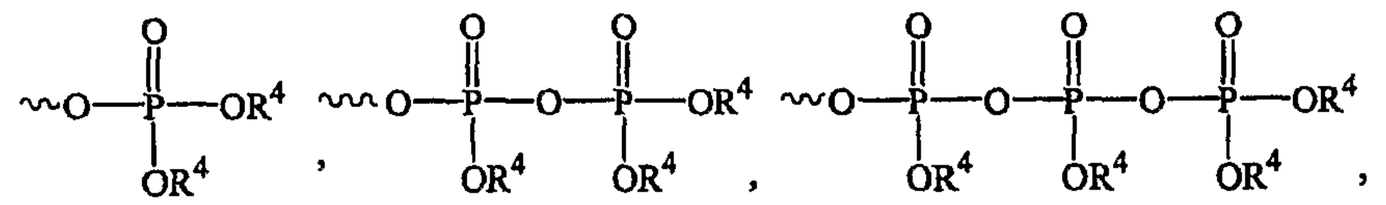
(b) each occurrence of R^{11} and R^{12} and the carbon to which they are both attached are taken together to form a $(C_3\text{-}C_7)$cycloakyl group;

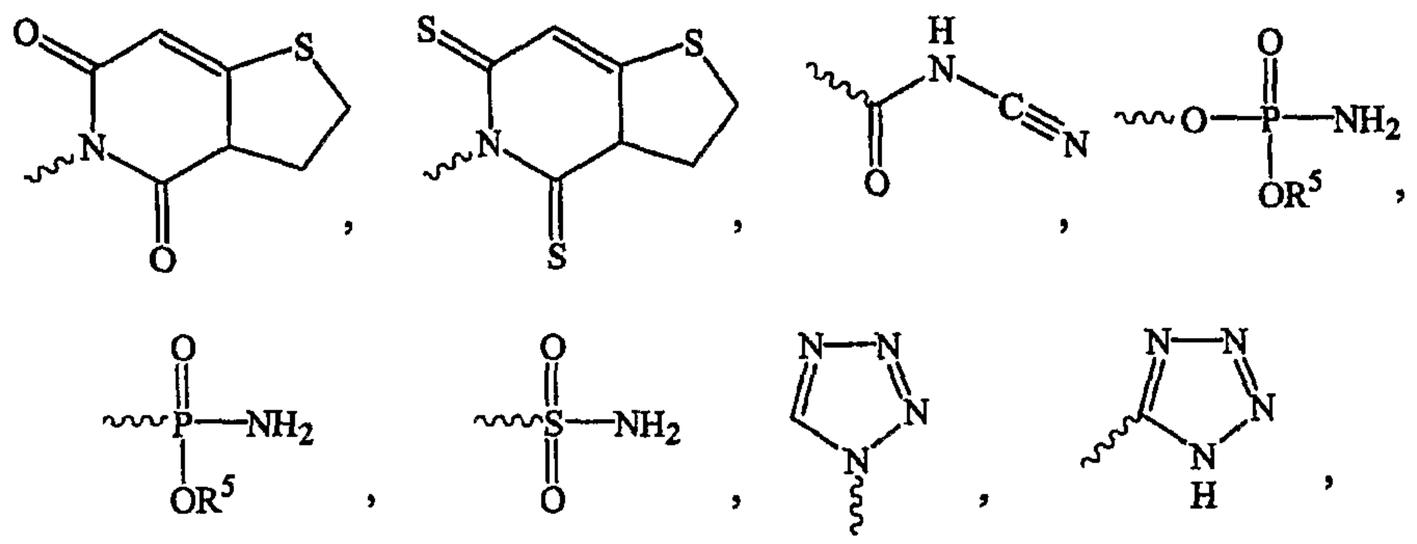
(c) each occurrence of n is independently an integer ranging from 1 to 7;

(d) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4;

(e) each occurrence of m is independently an integer ranging from 0 to 4;

(f) each occurrence of Y^1 and Y^2 is independently $(C_1–C_6)$alkyl, CH_2OH, C(O)OH, $OC(O)R^3$, $C(O)OR^3$, SO_3H,





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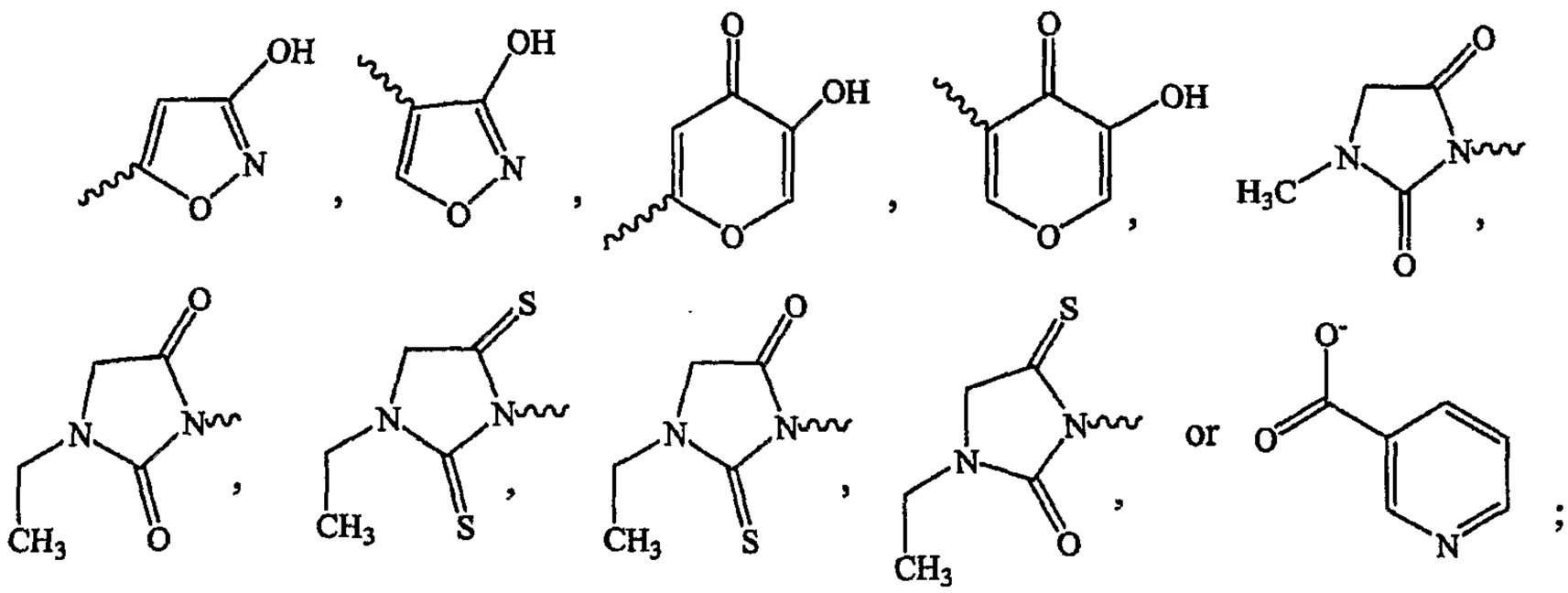


wherein:

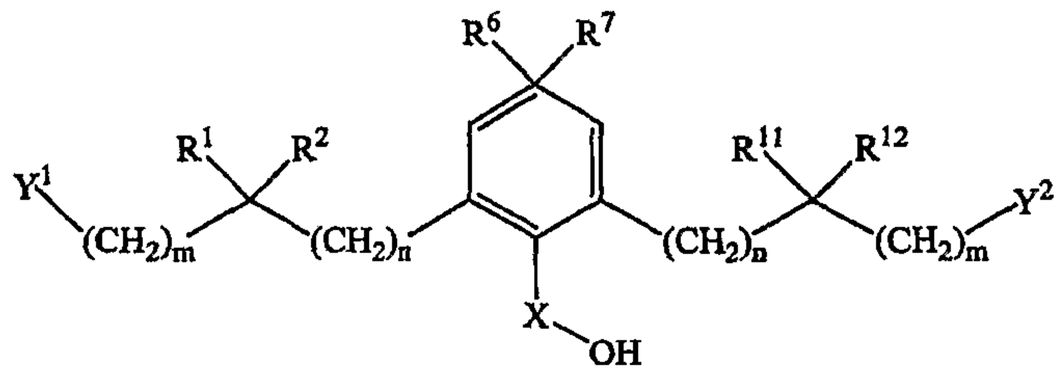
(i) R^3 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1–C_6$ alkoxy, or phenyl groups;

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl; and

(g) b is 0 or 1 or optionally the presence of one or more additional carbon-carbon bonds that when present complete one or more carbon-carbon double bonds.

In another embodiment, the invention encompasses compounds of formula **XXII**:



XXII

or a pharmaceutically acceptable salt, hydrate, solvate, or a mixture thereof, wherein:

(a) each occurrence of R^1 and R^2 is independently $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, benzyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group;

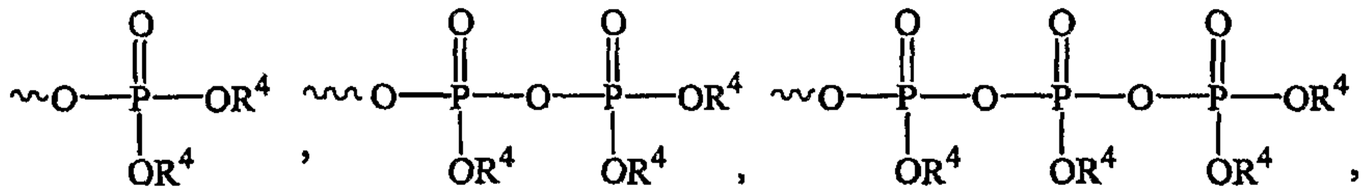
(b) each occurrence of R^{11} and R^{12} and the carbon to which they are both attached are taken together to form a $(C_3$-$C_7)$cycloakyl group;

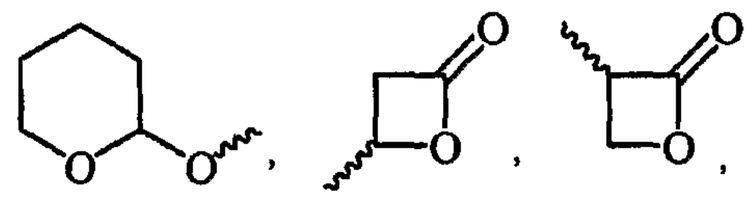
(c) each occurrence of n is independently an integer ranging from 1 to 7;

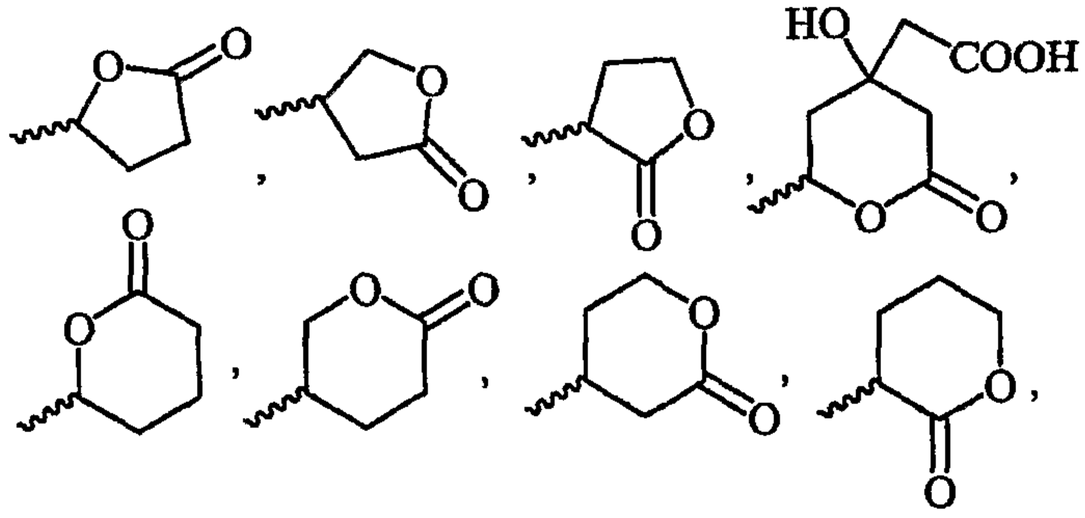
(d) X is $(CH_2)_z$ or Ph, wherein z is an integer from 0 to 4;

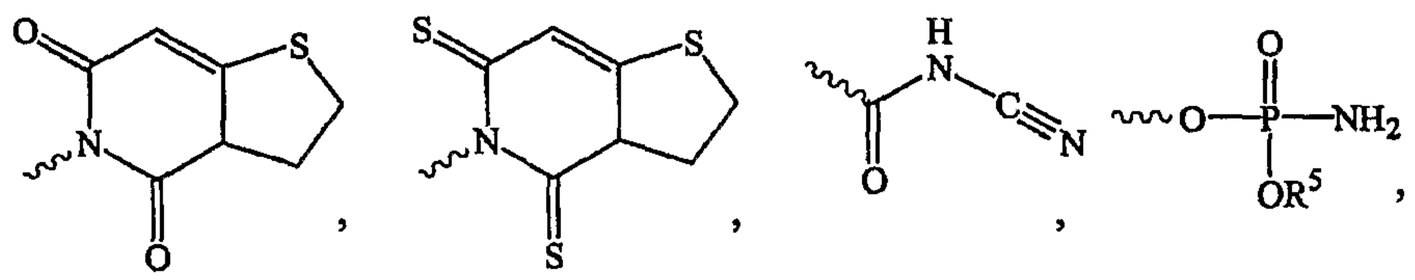
(e) each occurrence of m is independently an integer ranging from 0 to 4; and

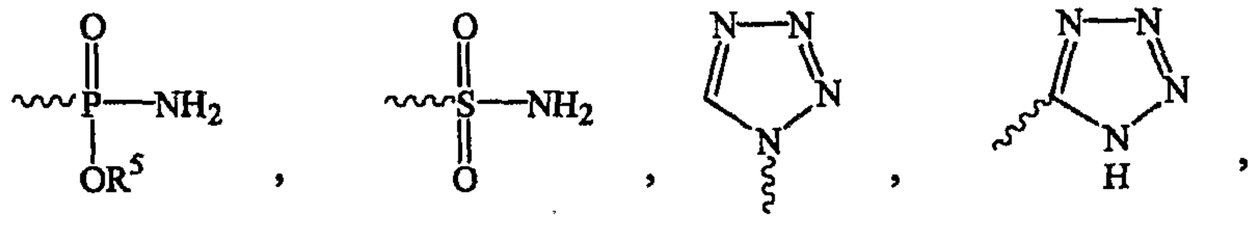
(f) each occurrence of Y^1 and Y^2 is independently $(C_1$–$C_6)$alkyl, CH_2OH, C(O)OH, $OC(O)R^3$, $C(O)OR^3$, SO_3H,

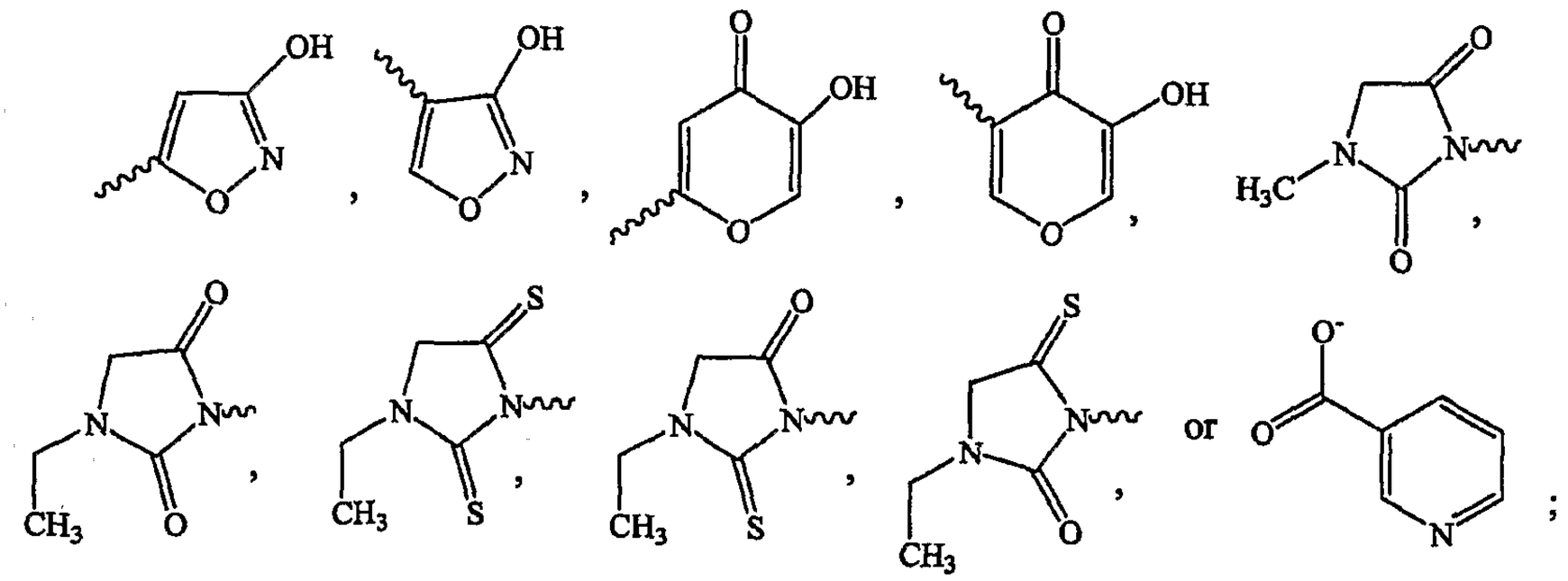












wherein:

(i) R^3 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $C_1–C_6$ alkoxy, or phenyl groups; and

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, or $(C_2–C_6)$alkynyl.

The present invention further provides pharmaceutical compositions comprising one or more compounds of the invention. Particular pharmaceutical compositions further comprise pharmaceutically acceptable vehicle, which can comprise a carrier, excipient, diluent, or a mixture thereof.

The present invention provides a method for treating or preventing aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, enhancing bile production, enhancing reverse lipid transport, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, modulating C reactive protein, obesity, oxysterol elimination in bile, pancreatitis, Parkinson's disease, a peroxisome proliferator activated receptor-associated disorder, phospholipid elimination in bile, renal disease, septicemia, metabolic syndrome disorders (*e.g.*, Syndrome X), and a thrombotic disorder, comprising administering to a patient in need of such treatment or prevention a therapeutically effective amount of a compound of the invention.

The present invention further provides a method for reducing the fat content of meat in livestock comprising administering to livestock in need of such fat-content

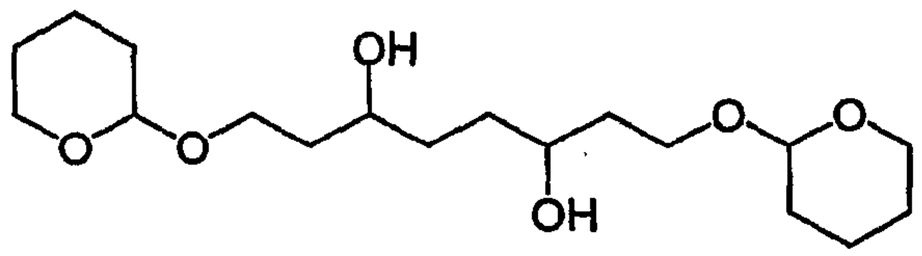
reduction a therapeutically effective amount of a compound of the invention or a pharmaceutical composition.

The present invention provides a method for reducing the cholesterol content of a fowl egg comprising administering to a fowl species a therapeutically effective amount of a compound of the invention.

The compounds of the invention are particularly useful when incorporated in a pharmaceutical composition comprising a carrier, excipient, diluent, or a mixture thereof. However, a compound of the invention need not be administered with excipients or diluents and can be delivered in a gel cap or drug delivery device.

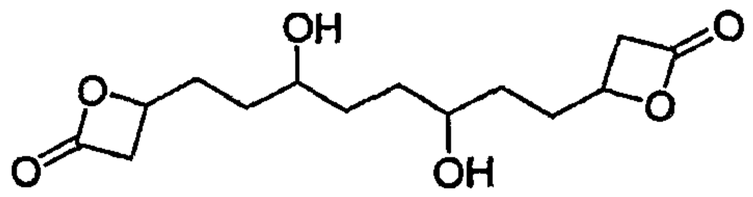
In certain embodiments of the invention, a compound of the invention is administered in combination with another therapeutic agent. The other therapeutic agent provides additive or synergistic value relative to the administration of a compound of the invention alone. Examples of other therapeutic agents include, but are not limited to, a lovastatin; a thiazolidinedione or fibrate; a bile-acid-binding-resin; a niacin; an anti-obesity drug; a hormone; a tyrophostine; a sulfonylurea-based drug; a biguanide; an α-glucosidase inhibitor; an apolipoprotein A-I agonist; apolipoprotein E; a cardiovascular drug; an HDL-raising drug; an HDL enhancer; or a regulator of the apolipoprotein A-I, apolipoprotein A-IV and/or apolipoprotein genes.

Illustrative examples of compounds of the invention are encompassed by formulas **I-XXII** and include those shown below, and pharmaceutically acceptable salts, hydrates, enantiomers, diastereomers, and geometric isomers thereof:



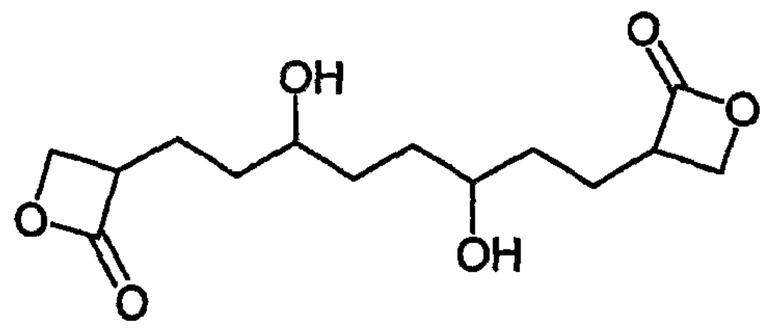
1-8-bis-(Tetrahydro-pyran-2-yloxy)-octane-3,6-diol

Compound 1



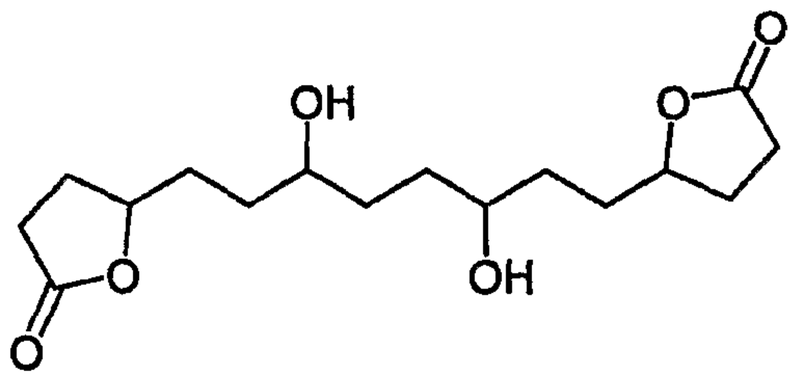
1,8-bis-(4-(Oxetan-2-one))-octane-3,6-diol

Compound 2



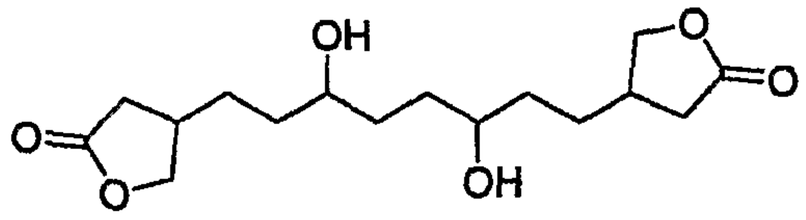
1,8-bis-(4-(Oxetan-2-one))-octane-3,6-diol

Compound 3



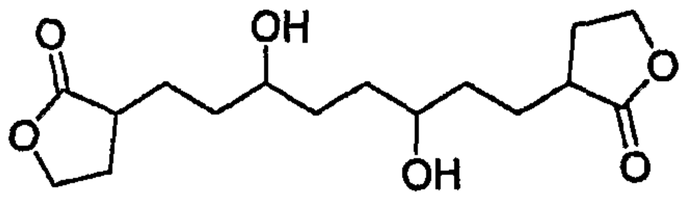
1,8-bis-(5-(Dihydro-furan-2-one))-octane-3,6-diol

Compound 4



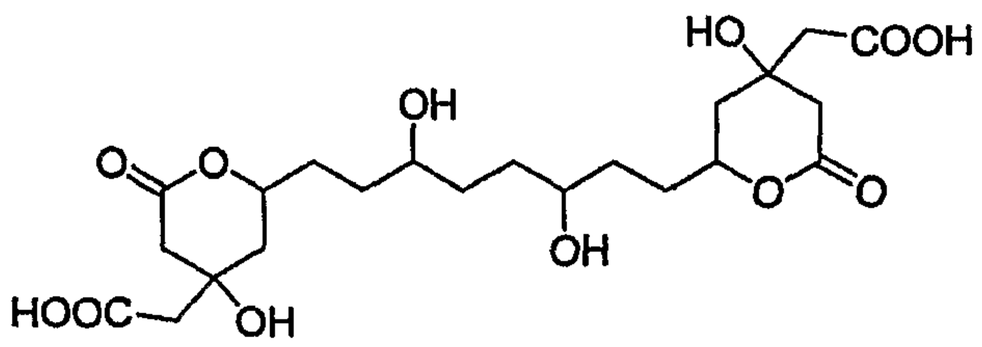
1,8-bis-(4-(Dihydro-furan-2-one))-octane-3,6-diol

Compound 5



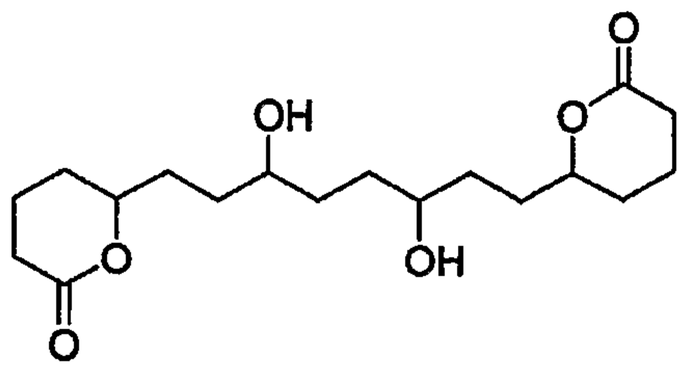
1,8-bis-(3-(Dihydro-furan-2-one))-octane-3,6-diol

Compound 6



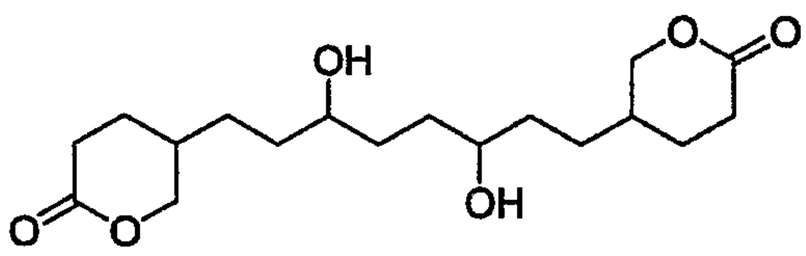
{2-[8-(4-Carboxymethyl-4-hydroxy-6-oxo-tetrahydro-pyran-2-yl)-3,6-dihydroxy-octyl]-4-hydroxy-6-oxo-tetrahydro-pyran-4-yl}-acetic acid

Compound 7



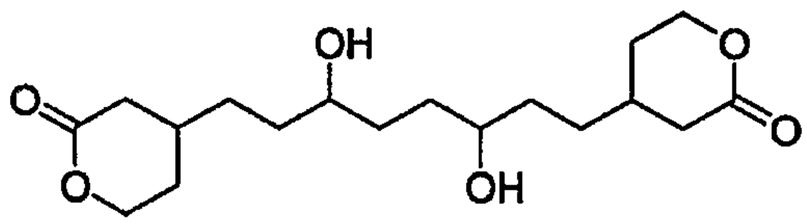
1,8-bis-(6-(Tetrahydro-pyran-2-one))-octane-3,6-diol

Compound 8



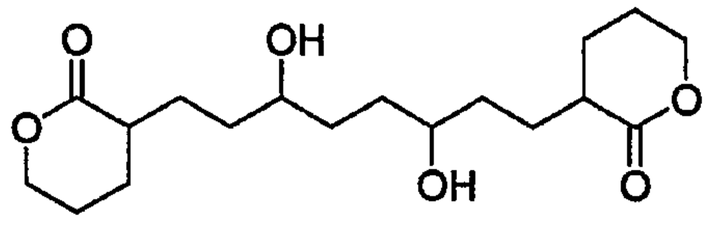
1,8-bis-(5-(Tetrahydro-pyran-2-one))-octane-3,6-diol

Compound 9



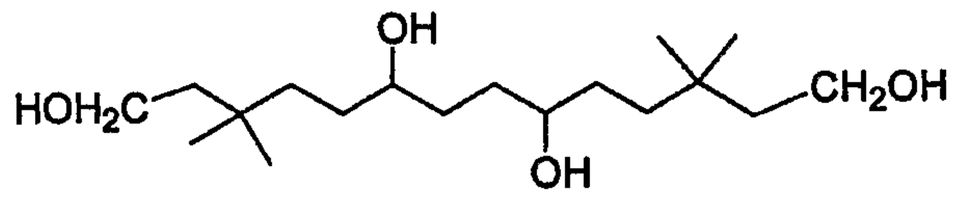
1,8-bis-(4-(Tetrahydro-pyran-2-one))-octane-3,6-diol

Compound 10



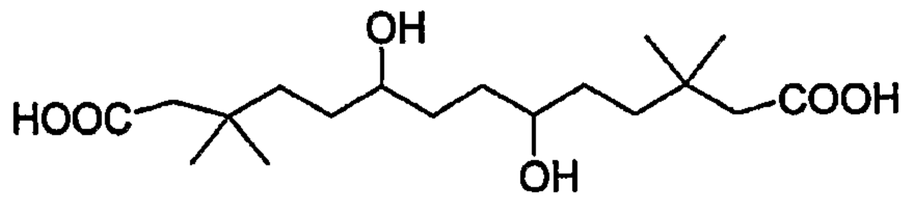
1,8-bis-(3-(Tetrahydro-pyran-2-one))-octane-3,6-diol

Compound 11



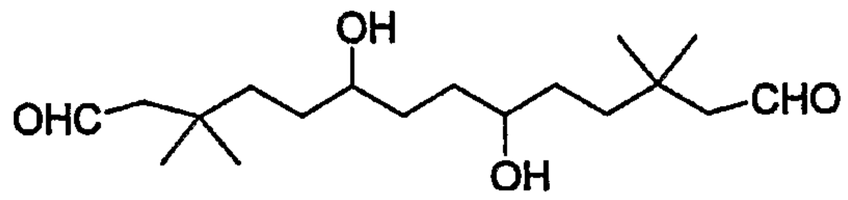
3,3,12,12-Tetramethyl-tetradecane-1,6,9,14-tetraol

Compound 12



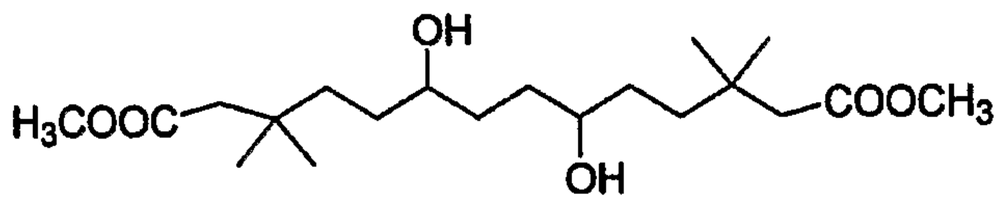
6,9-Dihydroxy-3,3,12,12-tetramethyl-tetradec anedioic acid

Compound 13



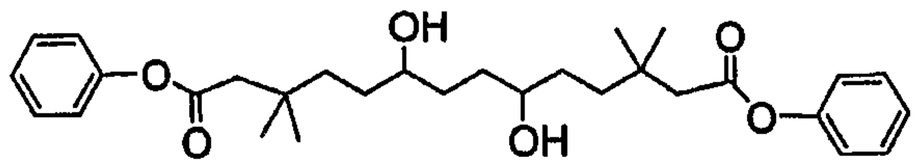
6,9-Dihydroxy-3,3,12,12-tetramethyl-tetradecanedial

Compound 14



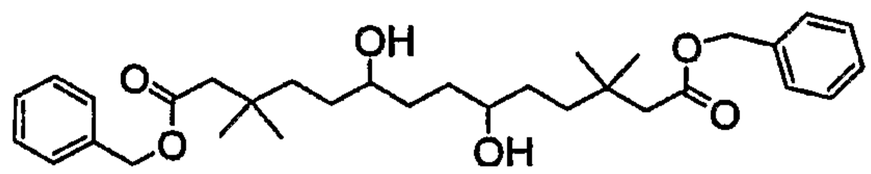
6,9-Dihydroxy-3,3,12,12-tetramethyl-tetradec anedioic acid dimethyl ester

Compound 15



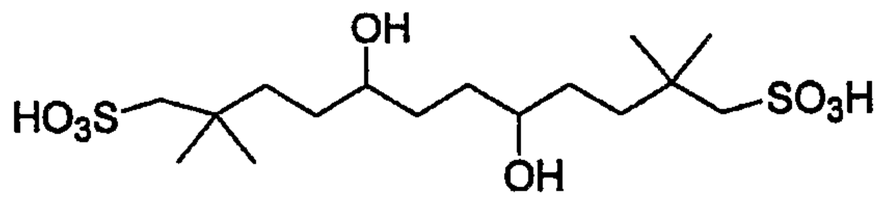
6,9-Dihydroxy-3,3,12,12-tetramethyl-tetradec anedioic acid diphenyl ester

Compound 16



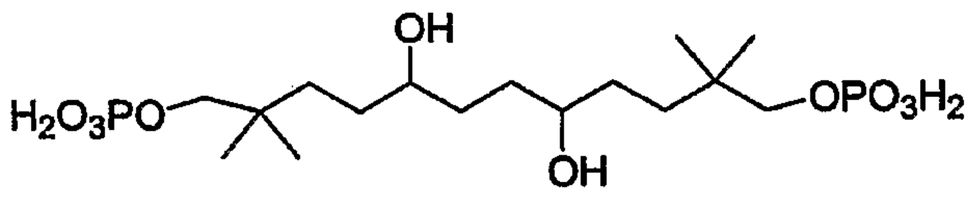
6,9-Dihydroxy-3,3,12,12-tetramethyl-tetradec anedioic acid dibenzyl ester

Compound 17



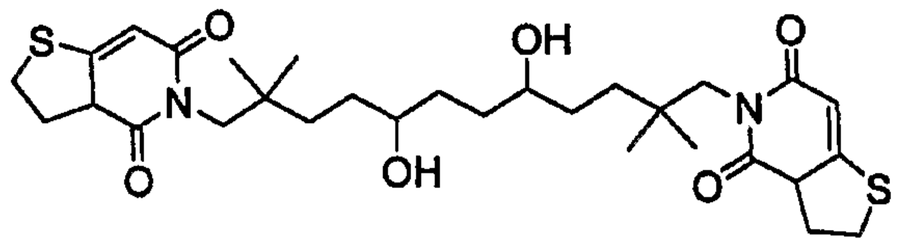
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecan e-1,12-disulfonic acid

Compound 18



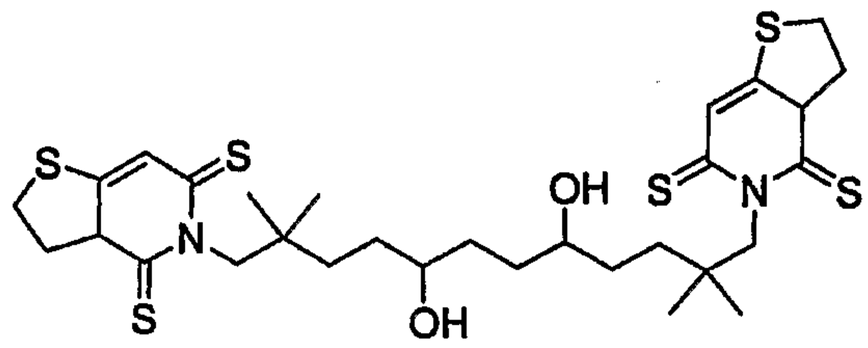
Phosphoric acid
mono-(5,8-dihydroxy-2,2,11,11-tetramethyl-1
2-phosphonooxy-dodecyl) ester

Compound 19



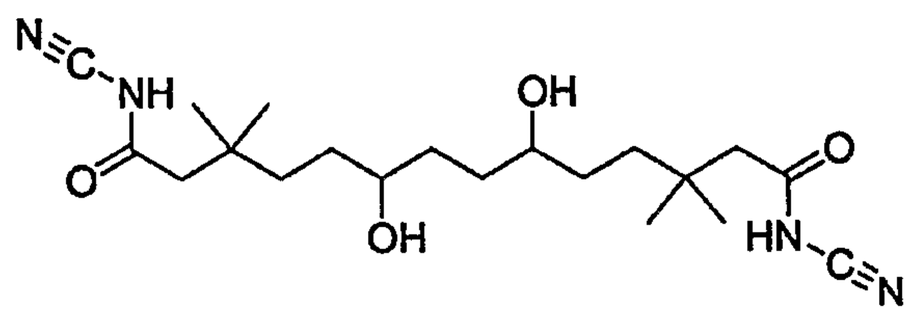
1,12-bis-(N-(3,3a-dihydro-2H-
thieno[3,2,c]pyridine-4,6-dione))-5,8-dihydroxy-2,2,11,11-tetramethyl-dodecane

Compound 20



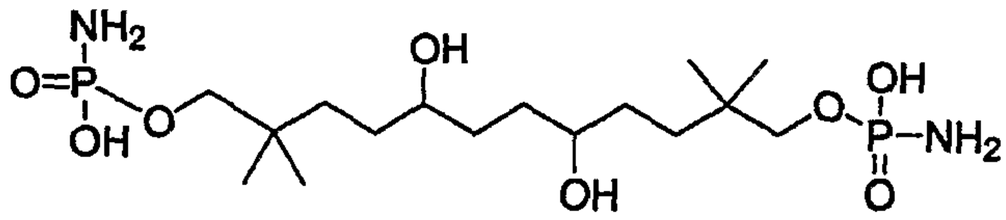
1,12-bis-(N-3,3a-dihydro-2H-
thieno[3,2,c]pyridine-4,6-dithioxo))-5,8-dihydroxy-2,2,11,11-tetramethyl-dodecane

Compound 21



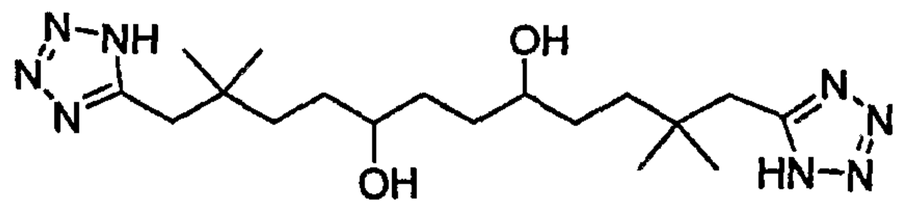
1,14-bis-(N-Cyanoamido)-6,9-dihydroxy-3,3,12,12-tetramethyl-tetradecane

Compound 22



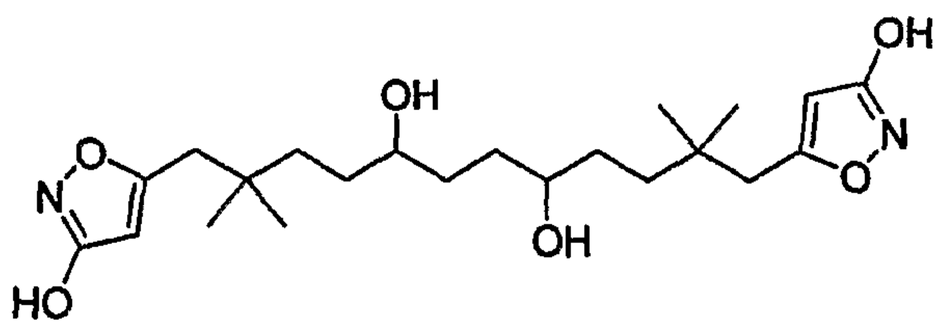
Phosphoramidic acidmono-
[12-(amino-hydroxy-phosphoryloxy)-
5,8-dihydroxy-2,2,11,11-tetramethyl-dodecyl]

Compound 23



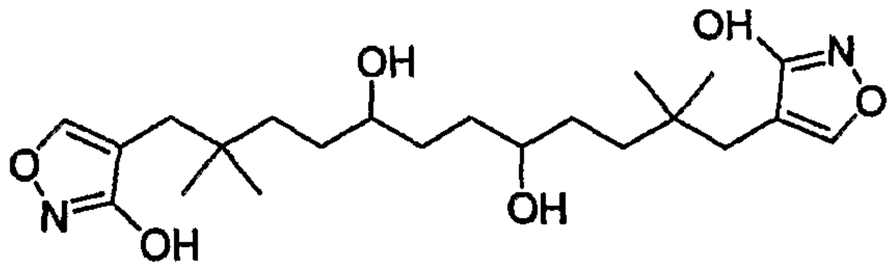
2,2,11,11-Tetramethyl-1,12-bis-(1H-tetrazol-5-yl)-dodecane-5,8-diol

Compound 24



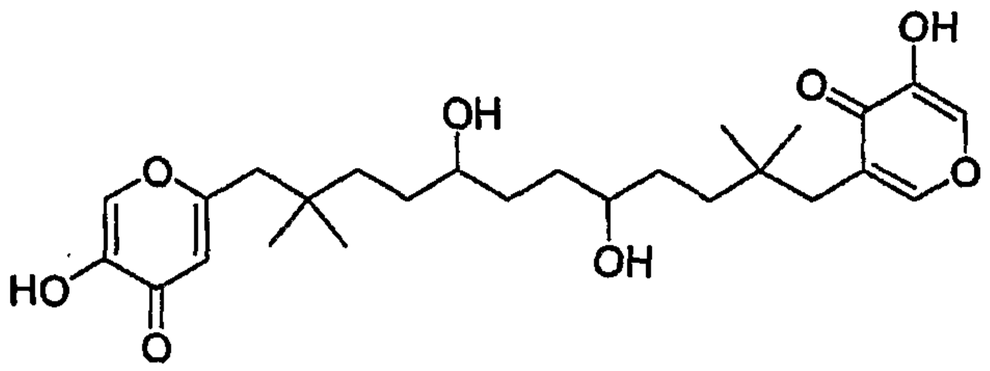
1,12-Bis-(3-hydroxy-isoxazol-5-yl)-2,2,11,11-tetramethyl-dodecane-5,8-diol

Compound 25



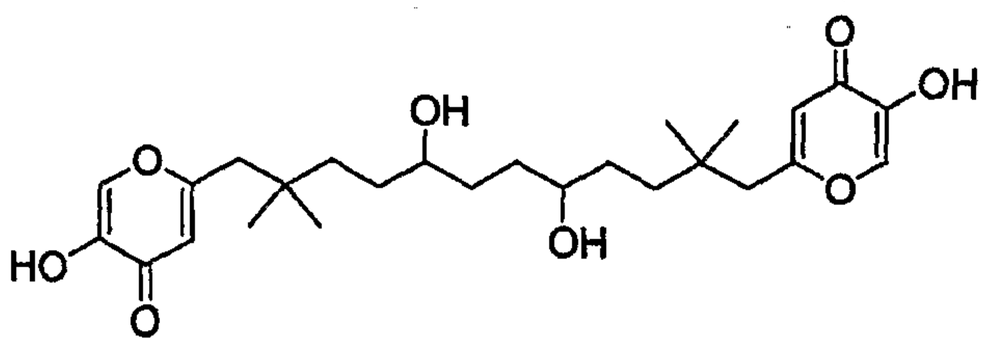
1,12-Bis-(3-hydroxy-isoxazol-4-yl)-2,2,11,11-
tetramethyl-dodecane-5,8-diol

Compound 26



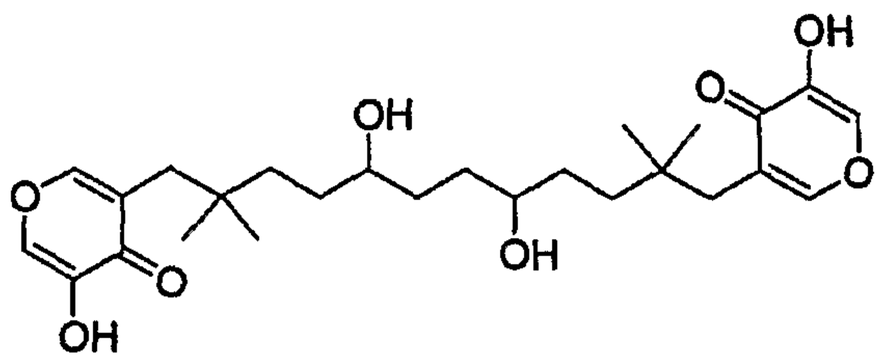
1-(6-(3-hydroxy-pyran-4-one)-12-(5-
(3-hydroxy-pyran-4-one)-2,2,11,11-tetramethyl-dodecane-5,8-diol

Compound 27



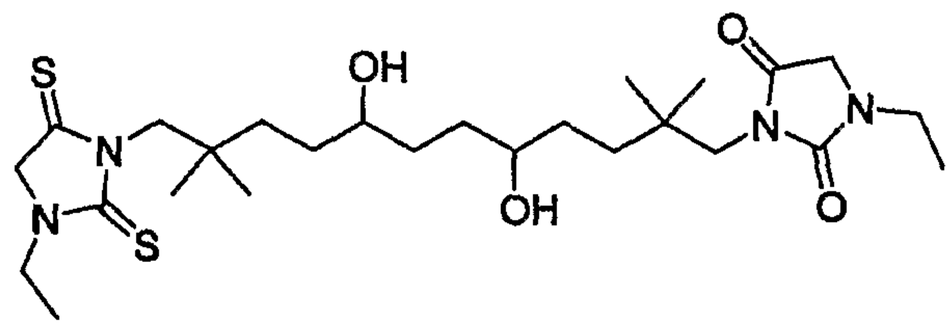
1,12-Bis-(6-(3-hydroxy-pyran-4-one)-2,2,11,11-tetramethy 1-dodecane-5,8-diol

Compound 28



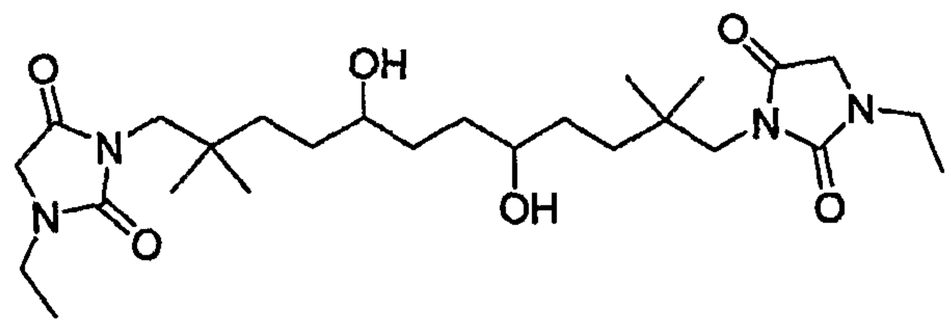
1,12-Bis-(5-(3-hydroxy-pyran-4-one)-2,2,11,11-tetramethy 1-dodecane-5,8-diol

Compound 29



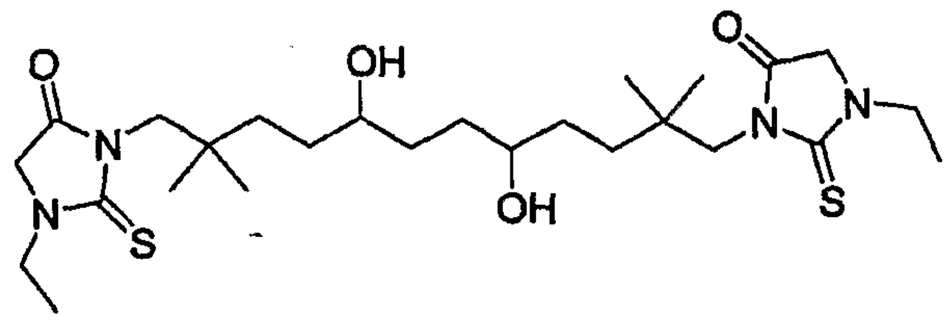
1-Ethyl-3-[12-(3-ethyl-2,5-dithioxo-imidazoli din-1-yl)-5,8-dihydroxy-2,2,11,11-tetramethyl -dodecyl]-imidazolidine-2,4-dione

Compound 30



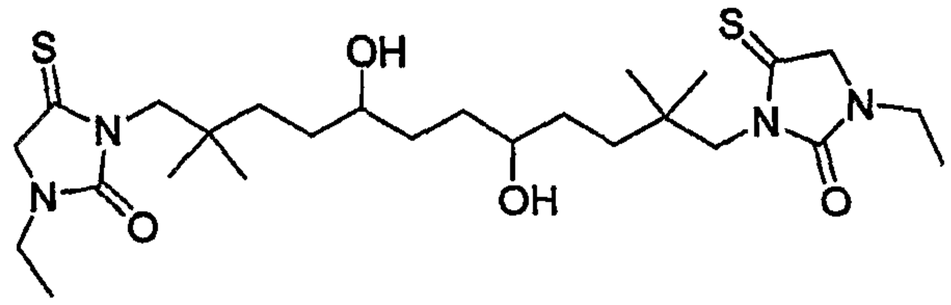
1,12-bis-(1-Ethyl-imidazolin-3-yl-2,4-dione)-2,2,11,11-tetramethyl-dodecane-5,8-diol

Compound 31



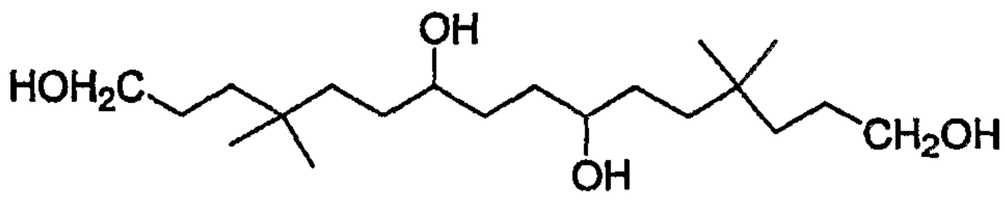
1,12-bis-(1-Ethyl-imidazolin-3-yl-2-thioxo-4-one)-2,2,11,11-tetramethyl-dodecane-5,8-diol

Compound 32



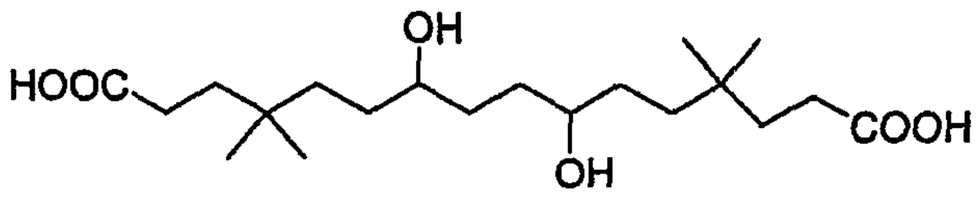
1,12-bis-(1-Ethyl-imidazolin-3-yl-4-thioxo-2-one)-2,2,11,11-tetramethyl-dodecane-5,8-diol

Compound 33



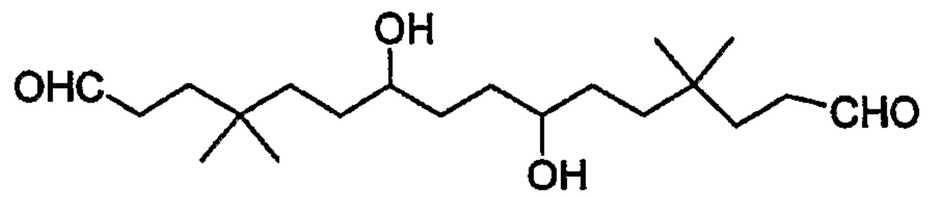
4,4,13,13-Tetramethyl-hexadecane-1,7,1016-5 etraol

Compound 34



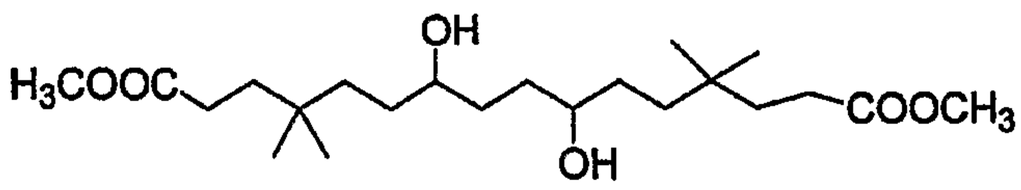
7,10-Dihydroxy-4,4,13,13-tetramethyl-hexadecanedioic acid

Compound 35



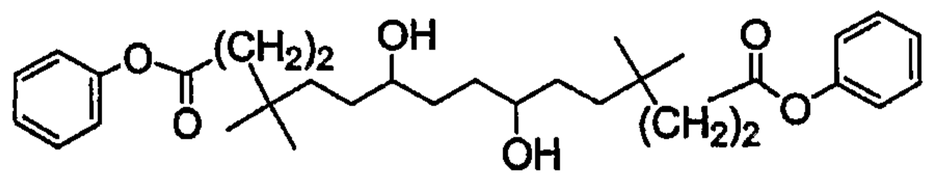
7,10-Dihydroxy-4,4,13,13-tetramethyl-hexade canedial

Compound 36



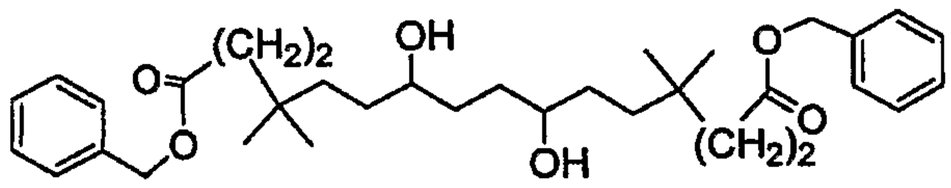
7,10-Dihydroxy-4,4,13,13-tetramethyl-hexadecanedioic acid dimethyl ester

Compound 37



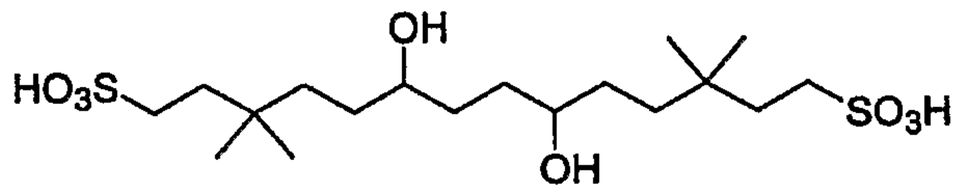
7,10-Dihydroxy-4,4,13,13-tetramethyl-hexadecanedioic acid diphenyl ester

Compound 38



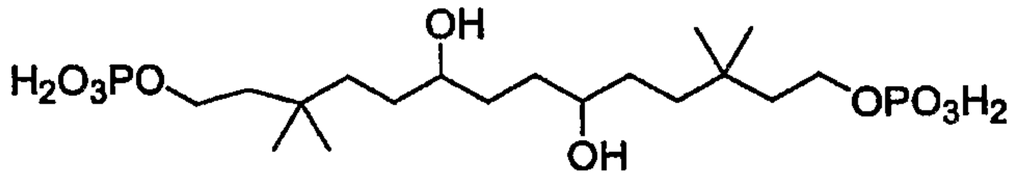
7,10-Dihydroxy-4,4,13,13-tetramethyl-hexadecanedioic acid dibenzyl ester

Compound 39



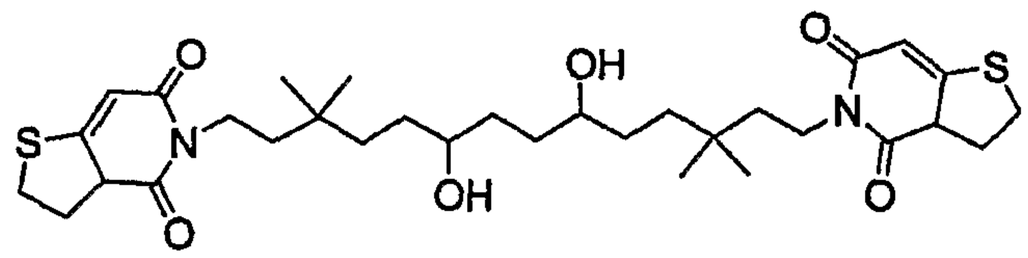
6,9-Dihydroxy-3,3,12,12-tetramethyl-tetradecane-1,14-disulfonic acid

Compound 40



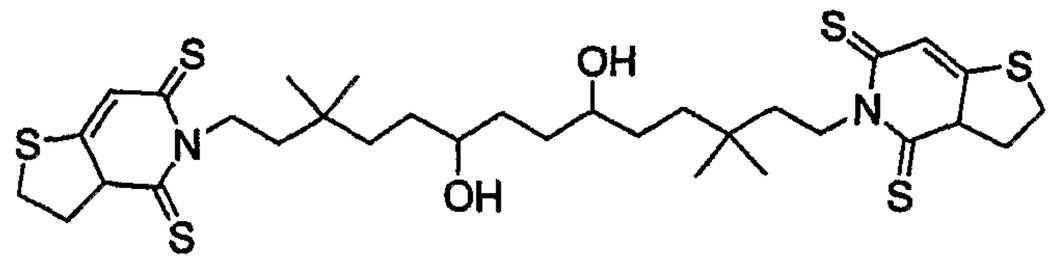
Phosphoric acid
mono-(6,9-dihydroxy-3,3,12,12-tetramethyl-1
4-phosphonooxy-tetradecyl) ester

Compound 41



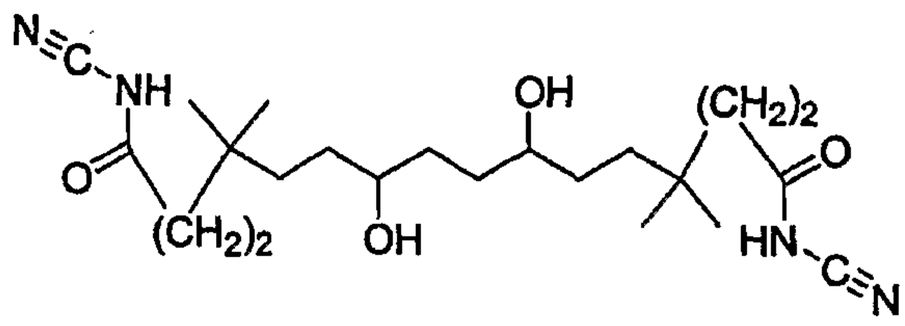
1,14-bis-(3,3a-Dihydro-2H-thieno[3,2,c]pyridine-4,6-dione)-3,3,12,12-tetramethyl-tetradecane-6,9-

Compound 42



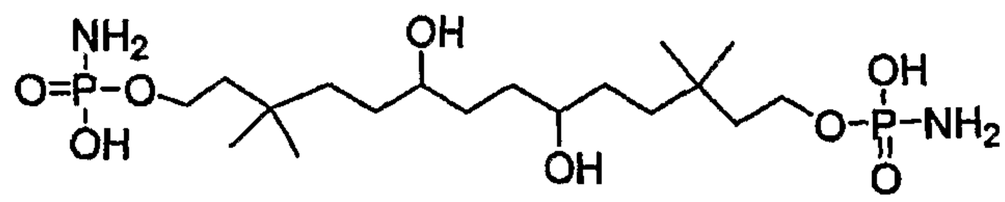
1,14-bis-(3,3a-Dihydro-2H-thieno[3,2,c]pyridine-4,6-dithioxo)-3,3,12,12-tetramethyl -tetradecane-6,9-diol

Compound 43



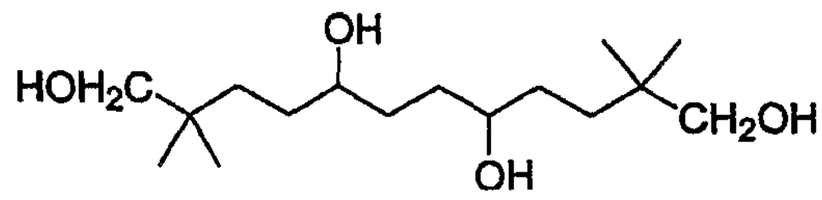
1,14-bis-(3,3a-Dihydro-2H-thieno[3,2,c]pyridine-4,6-dithioxo)-3,3,12,12-tetramethyl-tetradecane
-6,9-diol

Compound 44



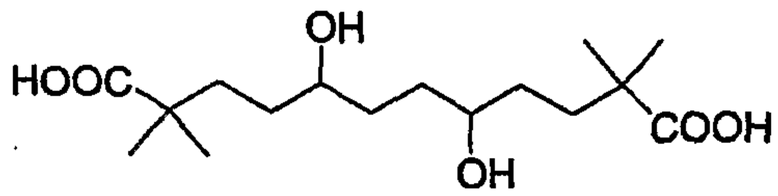
Phosphoramidic acid mono-[14-amino-hydroxy-phosphoryloxy)-6,9- dihydroxy-3,3,12,12-tetramethyl-tetradecyl]ester

Compound 45



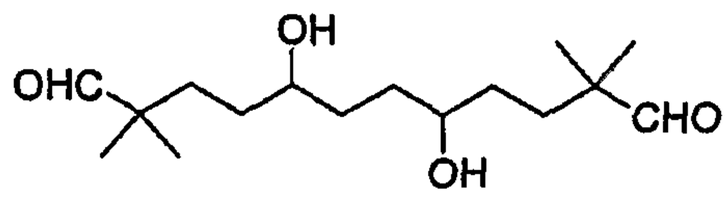
2,2,11,11-Tetramethyl-dodecane-
1,5,8,12-tetraol

Compound 46



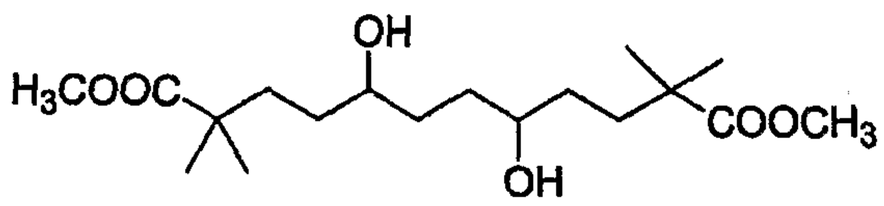
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedioic acid

Compound 47



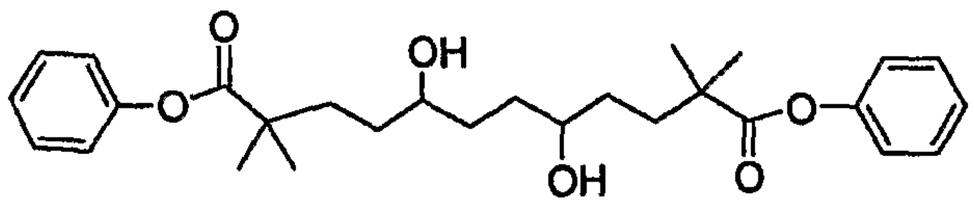
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedial

Compound 48



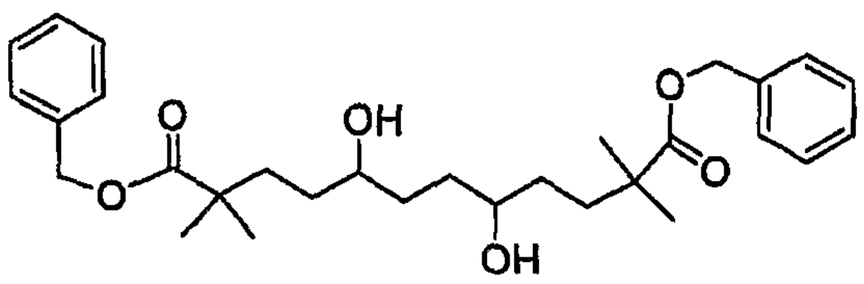
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedioic acid dimethyl ester

Compound 49



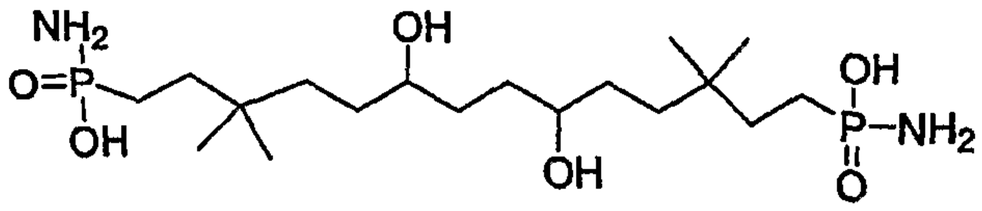
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedioic acid diphenyl ester

Compound 50



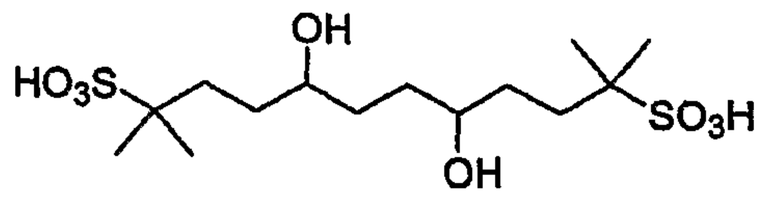
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedioic acid dibenzyl ester

Compound 51



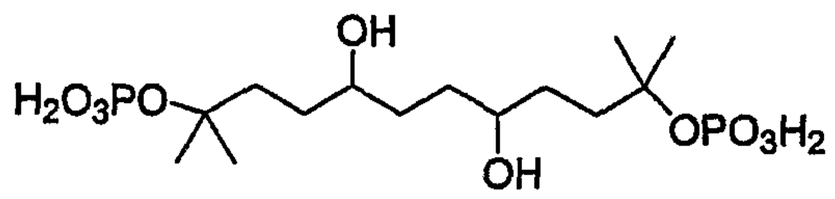
Phosphoramic acid mono-[14-(amino-hydroxy-phosphoryloxy)-6,9- dihydroxy-3,3,12,12-tetramethyl-tetradecyl] ester

Compound 52



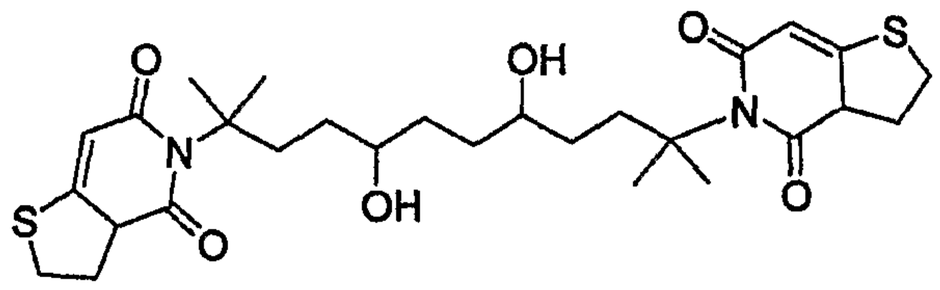
5,8-Dihydroxy-2,11-dimethyl-dodecane-2,11-disulfonic acid

Compound 53



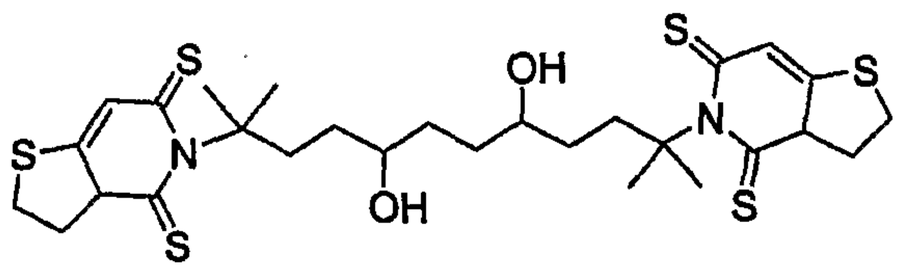
Phosphoric acid
mono-(4,7-dihydroxy-1,1,10-trimethyl-10-phosphonooxy-undecyl)ester

Compound 54



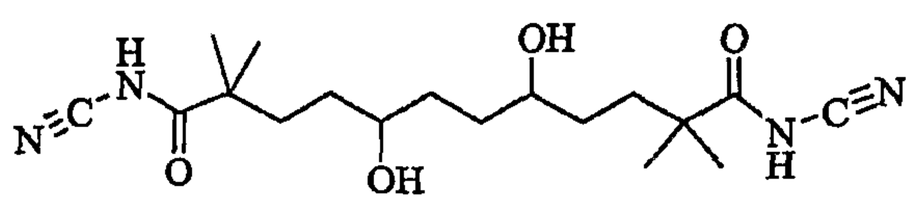
2,11-bix-(N-3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dione))-5,8-dihydroxy-1,12-dimethyl-dodecane

Compound 55



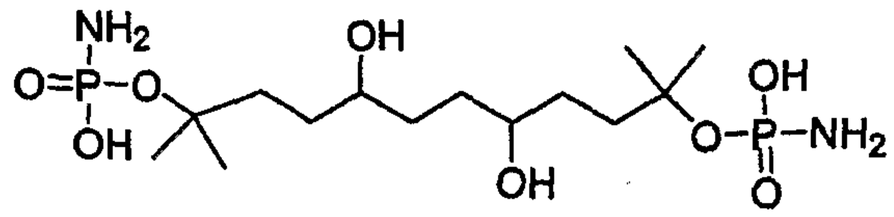
2,11-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dithioxo))-5,8-dihydroxy-1,12-dimethyl-dodecane

Compound 56



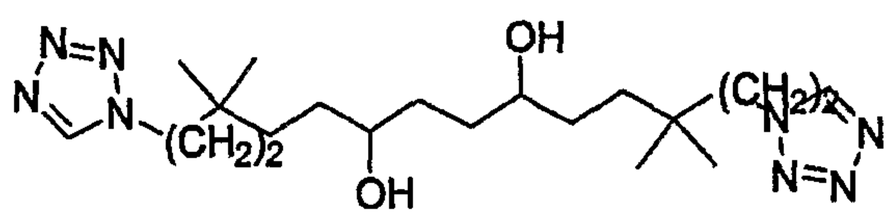
1,12-bis-(N-Cyanoamido)-5,8-dihydroxy-2,2,11,11-tetramethyl-dodecane

Compound 57



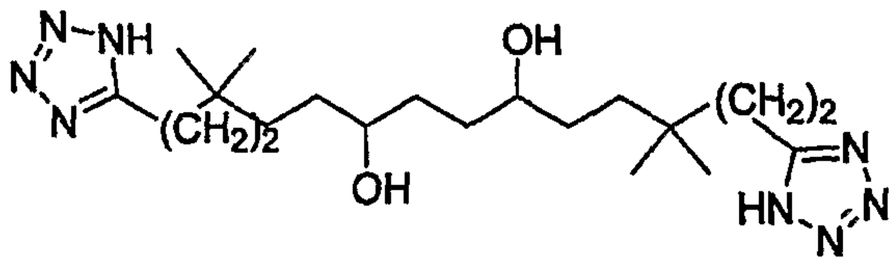
Phosphoramidic acid mono-[10-(amino-hydroxy phosphoryloxy)-4,7-dihydroxy-1,1,10-trimethyl-undecyl]ester

Compound 58



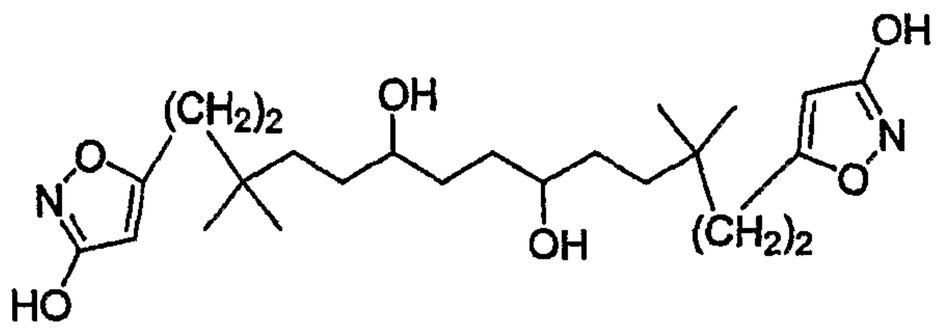
3,3,12,12 Tetramethyl-1,14-bis-tetrazol-1-yl tetradecane-6,9-diol

Compound 59



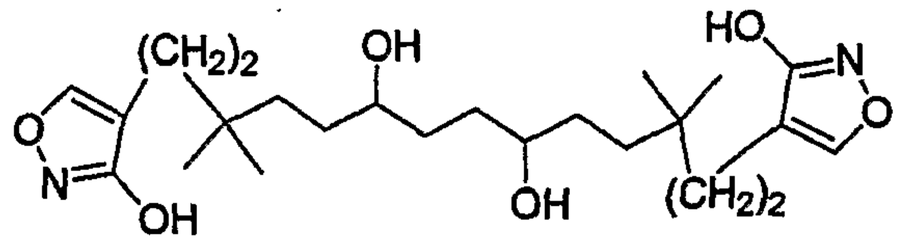
3,3,12,12-Tetramethyl-1,14-bis-(1H-tetrazol-5-yl) tetradecane-6,9-diol

Compound 60



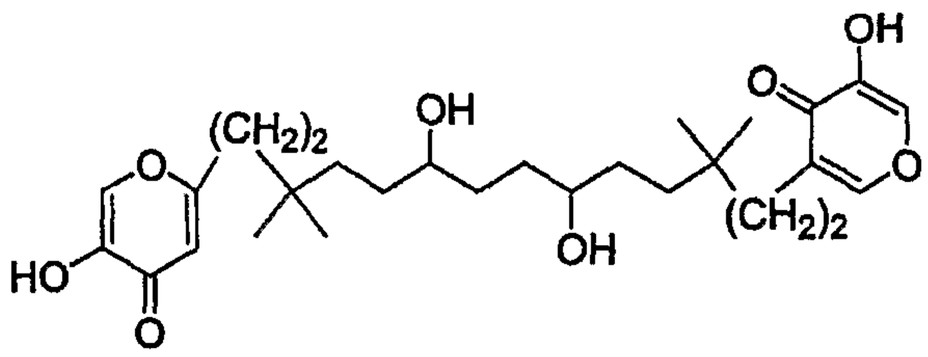
1,14-Bis-(3-hydroxy-isoxazol-5-yl)-3,3,12,12-tetramethyl-tetradecane-6,9-diol

Compound 61



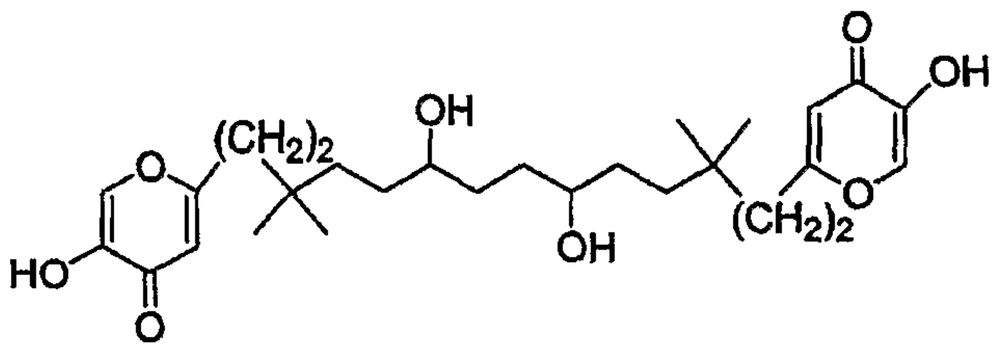
1,14-Bis-(3-hydroxy-isoxazol-4-yl)-3,3,12,12-tetramethyl-tetradecane-6,9-diol

Compound 62



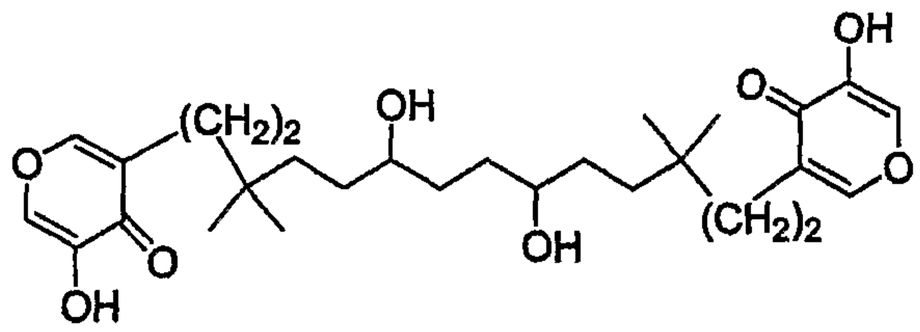
1-(6-(3-hydroxy-pyran-4-one)-14-(5-(3-hydroxy-pyran-4-one)-3,3,12,12-tetramethyl-tetradecane
6,9-diol

Compound 63



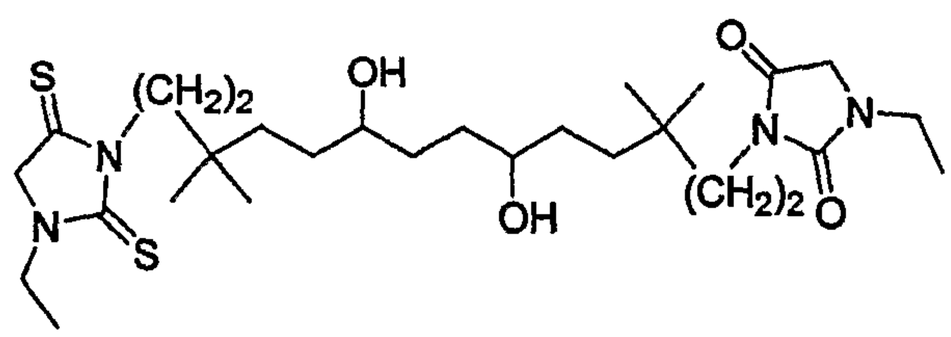
1,14-bis-(6-(3-hydroxy-pyran-4-one)-3,3,12,12-tetramethyl-tetradecane-6,9-diol

Compound 64



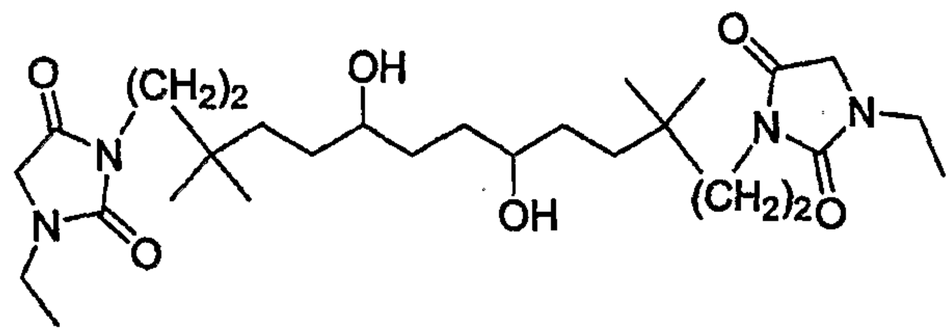
1,14-bis-(5-(3-hydroxy-pyran-4-one)-3,3,12,12-tetramethyl-tetradecane-6,9-diol

Compound 65



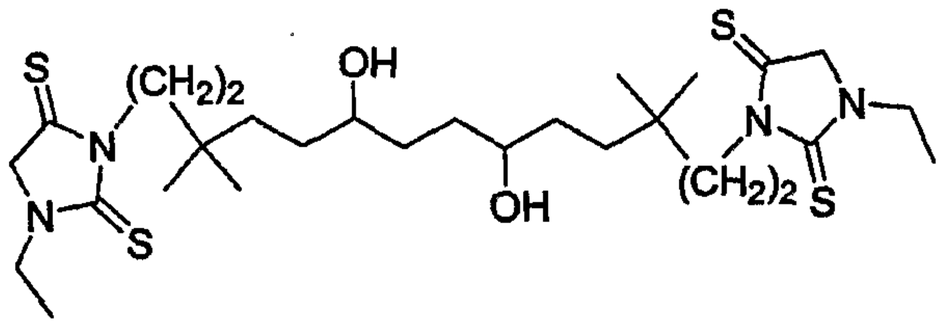
1-Ethyl-3-[14-(3-ethyl-2,5-dithioxo-imidazoli-din-1 yl)-6,9-dihydroxy-3,3,12,12-tetramethyl-tetradecyl] imidazolidine-2,4-dione

Compound 66



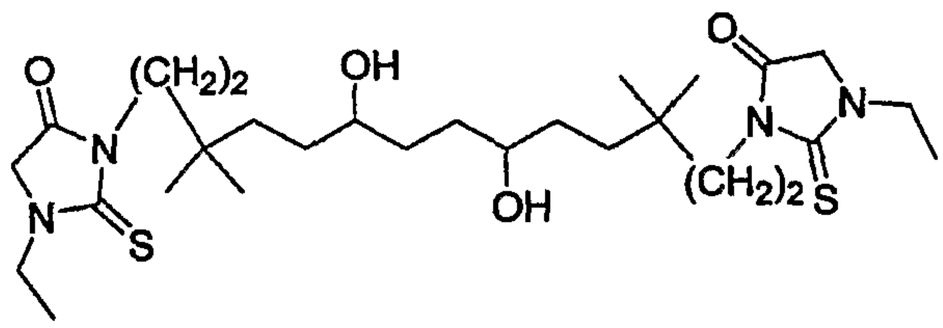
1,14-Bis-(1-Ethyl-imidazolin-3-yl-2,4-dione)-3,3,12,12-tetramethyl tetradecane-6,9-diol

Compound 67



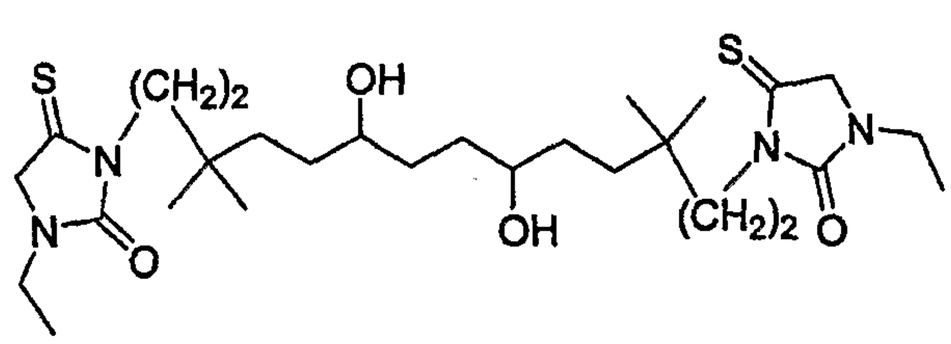
1,14-Bis-(1-Ethyl-imidazolin-3-yl-2,4-dithioxo) 3,3,12,12-tetramethyl-tetradecane-6,9-diol

Compound 68



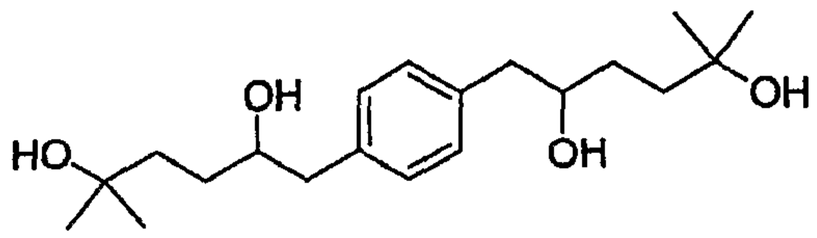
1,14-Bis-(1-Ethyl-imidazolin-3-yl-2-thioxo-4-one) 3,3,12,12-tetramethyl-tetradecane-6,9-diol

Compound 69



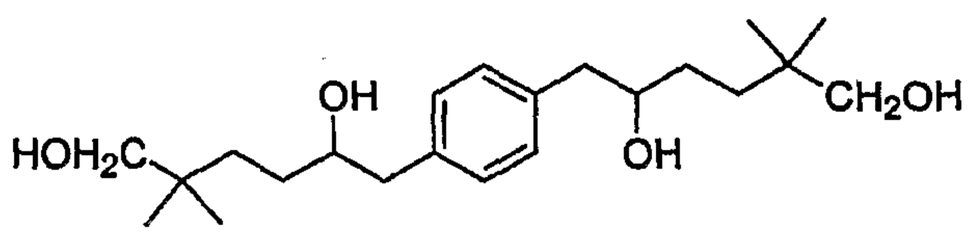
1,14-Bis-(1-Ethyl-imidazolin-3-yl-4-thioxo-2-one) 3,3,12,12-tetramethyl-tetradecane-6,9-diol

Compound 70



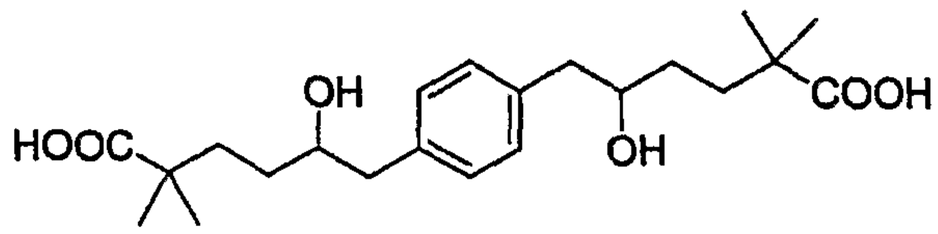
1-[4-(2,5-Dihydroxy-5-methyl-hexyl)-phenyl]-5-methyl-hexane-2,5-diol

Compound 71



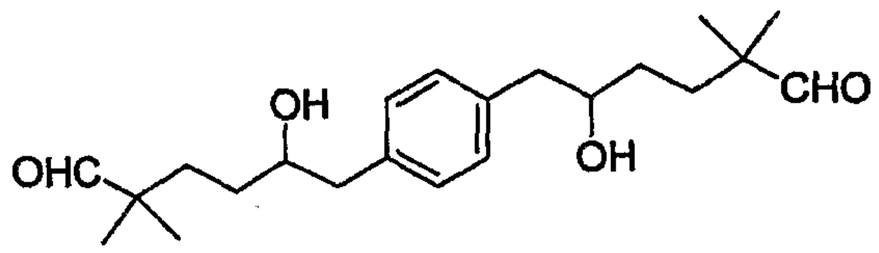
6-[4-(2,6-Dihydroxy-5,5-dimethyl-hexyl)-phenyl]-2,2-dimethyl-hexane-1,5-diol

Compound 72



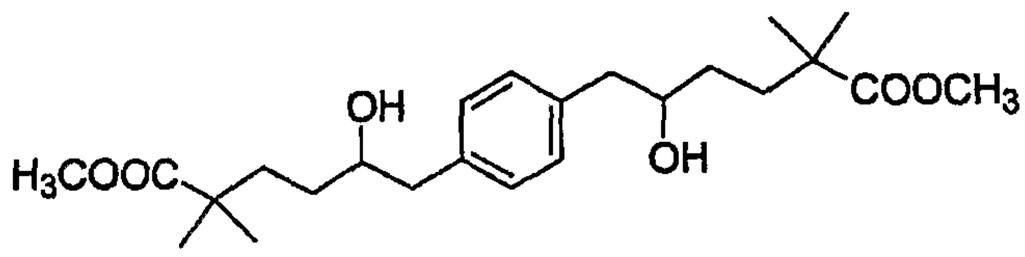
6-[4-(5-Carboxy-2-hydroxy-5-methyl-hexyl)-phenyl]-5-hydroxy-2,2-dimethyl-hexanoic-acid

Compound 73



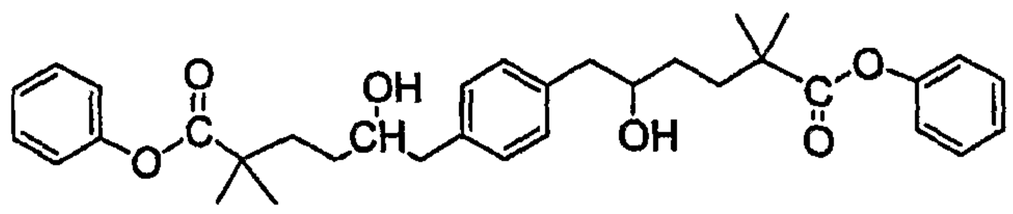
5-Hydroxy-6-[4-(2-hydroxy-5,5-dimethyl-6-oxo-hexyl)-phenyl]-2,2-dimethyl-hexanal

Compound 74



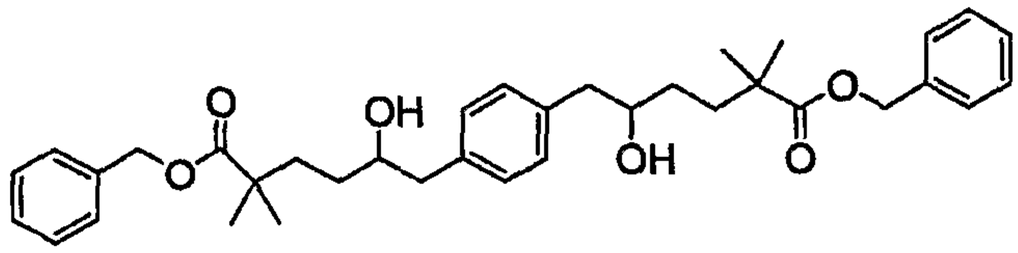
5-Hydroxy-6-[4-(2-hydroxy-5-methoxycarbonyl-5-methyl-hexyl)-phenyl]-2,2-dimethyl-hexanoic acid-methyl-ester

Compound 75



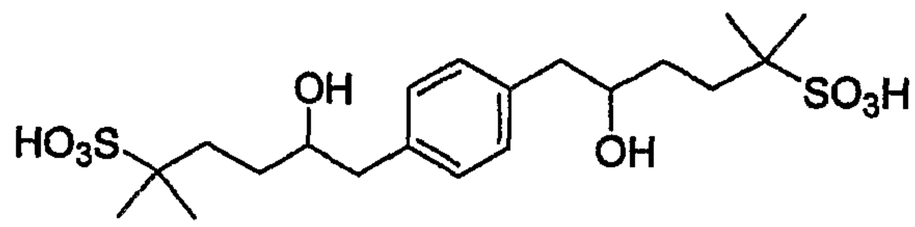
5-Hydroxy-6-[4-(2-hydroxy-5-methyl-5-phenoxycarbonyl-hexyl)-phenyl]-2,2-dimethyl hexanoic acid phenyl ester

Compound 76



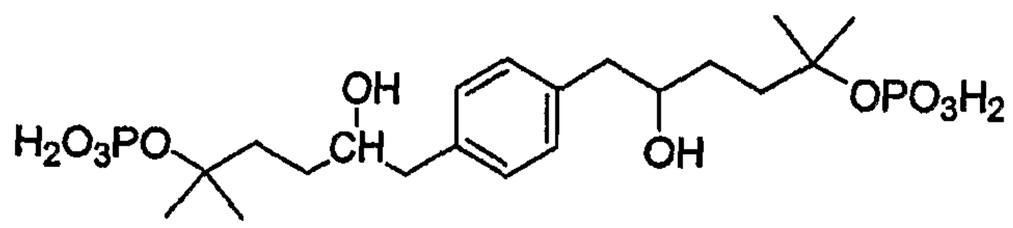
6-[4-(5-Benzyloxycarbonyl-2-hydroxy-5-methyl hexyl) phenyl]-5-hydroxy-2,2-dimethyl-hexanoic acid benzyl ester

Compound 77



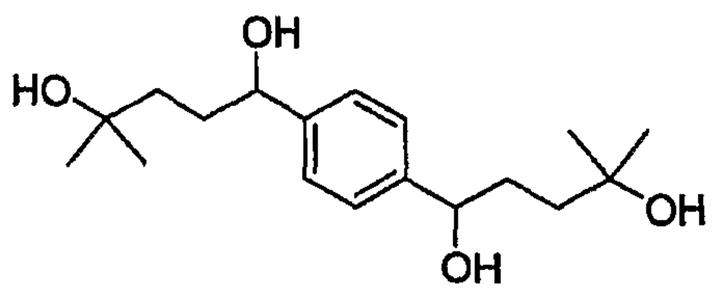
5-hydroxy-6-[4-(2-hydroxy-5-methyl-5-sulfo-hexyl) phenyl]-2-methyl-hexane-2-sulfonic acid

Compound 78



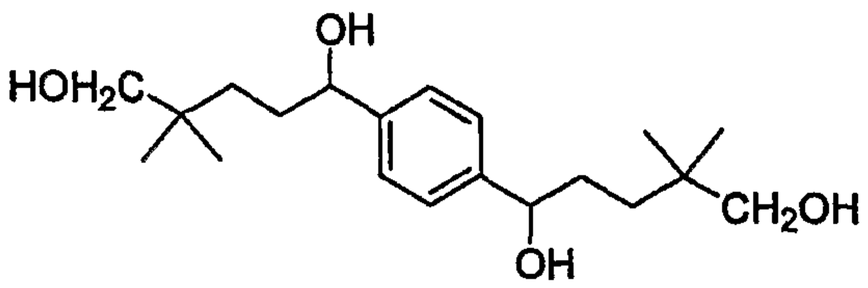
Phosphoric acid mono-{4-hydroxy-5-[4-(2-hydroxy-5-methyl-5-phosphonooxy-hexyl)-phenyl]-1,1-dimethyl-pentyl}ester

Compound 79



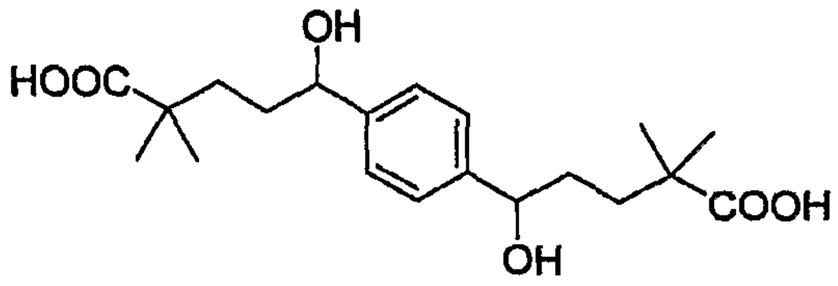
1-[4-(1,4-Dihydroxy-4-methyl-pentyl)-phenyl]-4- methyl-pentane-1,4-diol

Compound 80



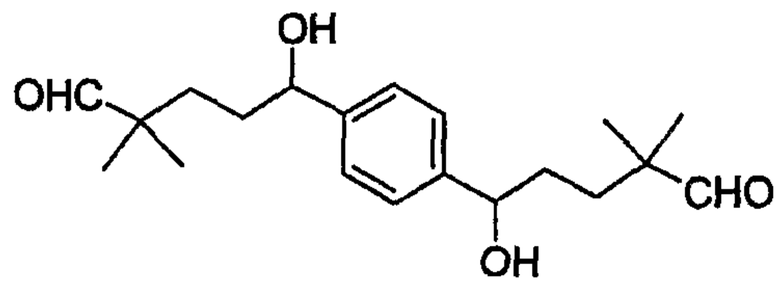
1-[4-(1,5 Dihydroxy-4,4-dimethyl-pentyl)-phenyl] 4,4-dimethyl-pentane-1,5-diol

Compound 81



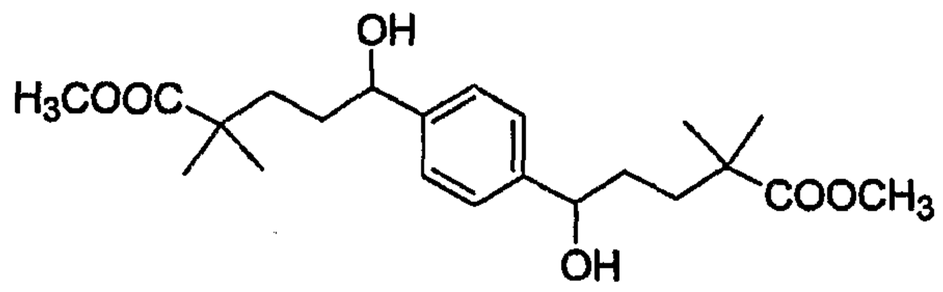
5-[4-(4-Carboxy-1-hydroxy-4-methyl-pentyl)-phenyl]-5-hydroxy-2,2-dimethyl-pentanoic acid

Compound 82



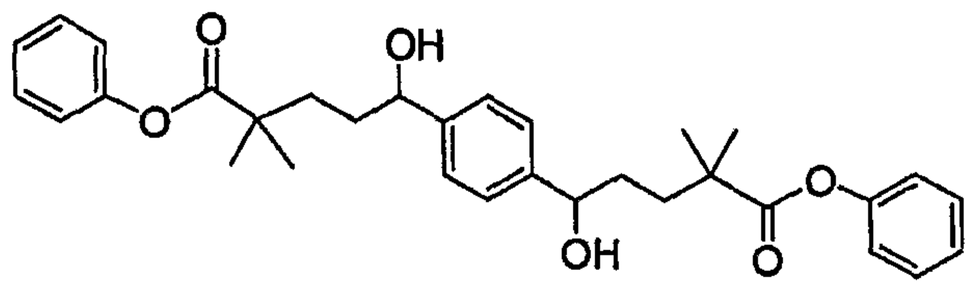
5-hydroxy-5-[4-(1-hydroxy-4,4-dimethyl-5-oxo pentyl)-phenyl]-2,2-dimethyl-pentanal

Compound 83



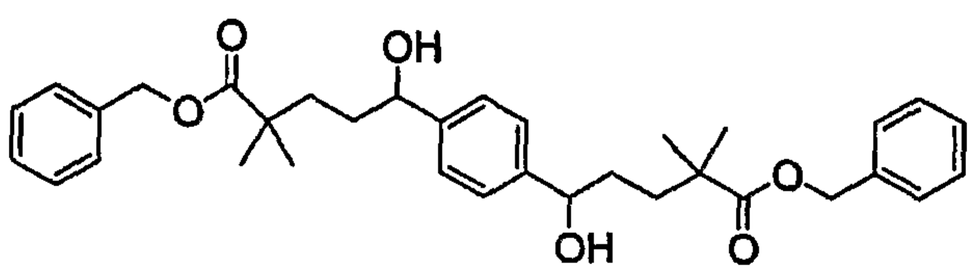
5-hydroxy-5-[4-(1-hydroxy-4-methoxycarbonyl-4-methyl-pentyl)-phenyl]-2,2-dimethyl-pentanoic acid methyl ester

Compound 84



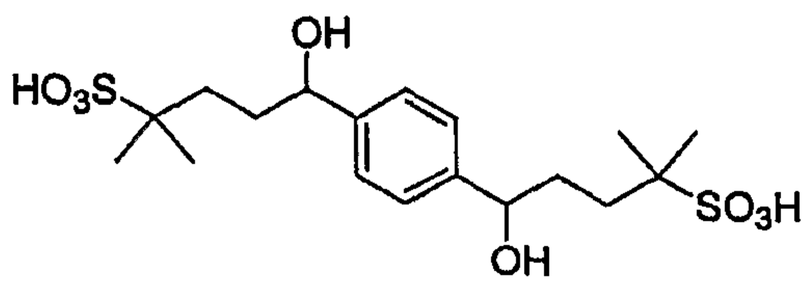
5-hydroxy-5-[4-(1-hydroxy-4-methyl-4-phenoxycarbonyl-pentyl)-phenyl]-2,2-dimethyl-pentanoic acid phenyl ester

Compound 85



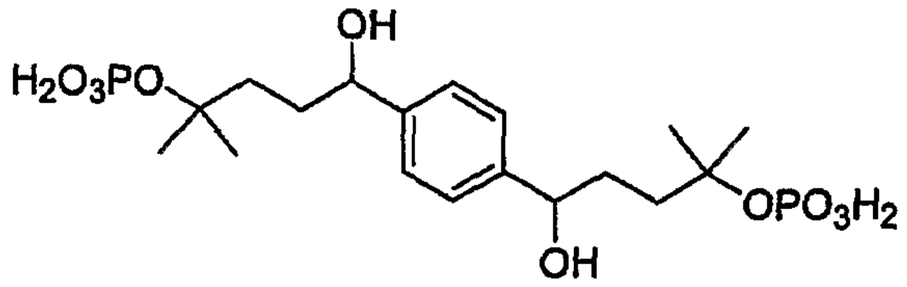
5-[4-(4-Benzyloxycarbonyl-1-hydroxy-4-methyl pentyl)-phenyl]--5-hydroxy-2,2-dimethyl-pentanoic acid benzyl ester

Compound 86



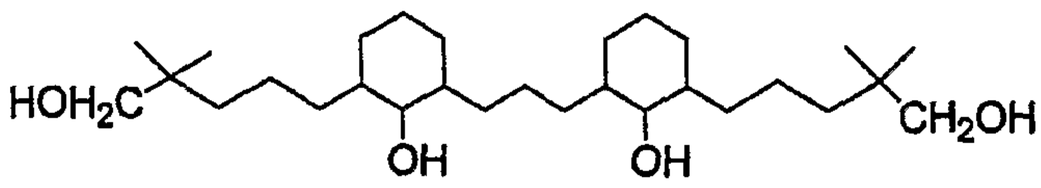
5-Hydroxy-5-[4-(1-hydroxy-4-methyl-4-sulfo-pentyl)-phenyl]-2-methyl-pentane-2-sulfonic acid

Compound 87



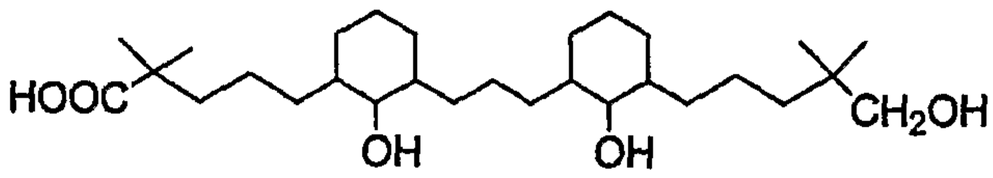
Phosphoric acid mono-{4-hydroxy-4-[4-(1-hydroxy 4-methyl-4-phosphonooxy-pentyl)-phenyl]-1,1-dimethyl-butyl}ester

Compound 88



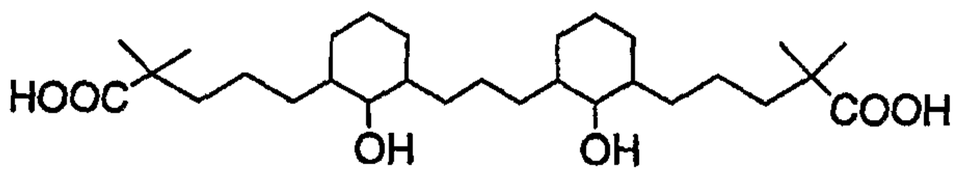
5-(2-hydroxy-3-{3-[2-hydroxy-3 (5-hydroxy-4,4-dimethyl-pentyl)-cyclohexyl]-propyl}-cyclohexyl)-2,2-dimethyl-pentanol

Compound 89



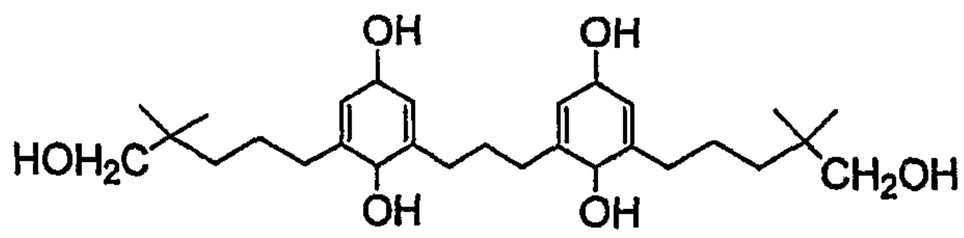
5-(2-Hydroxy-3-{3-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexyl]-propyl}-cyclohexyl)-2,2-dimethyl-pentanoic acid

Compound 90



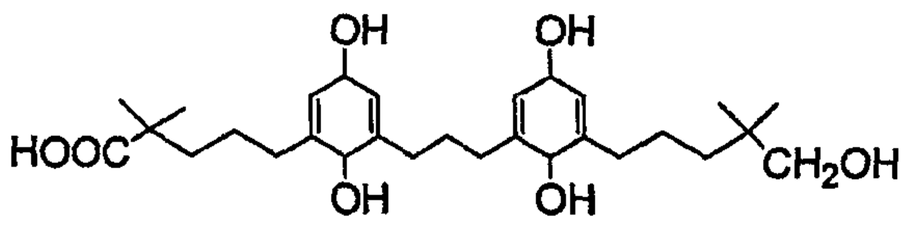
5-(3-{3-[3-(4-Carboxy-4-methyl-pentyl)-2-hydroxy-cyclohexyl]-propyl}-2-hydroxy-cyclohexyl)-2,2-dimethyl-pentanoic acid

Compound 91



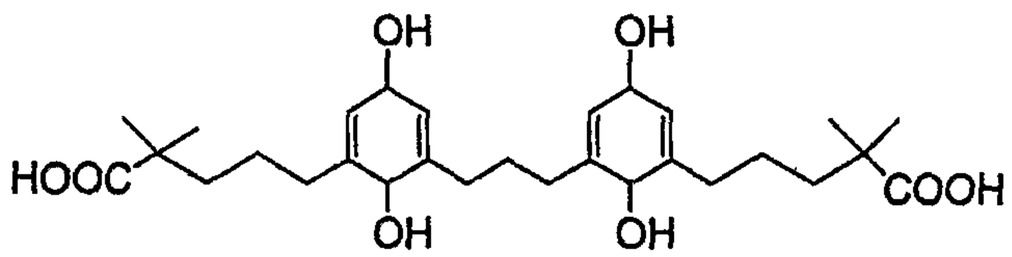
5-(5-3-[3,6-Dihydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexa-1,4-dienyl]- propyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanol

Compound 92



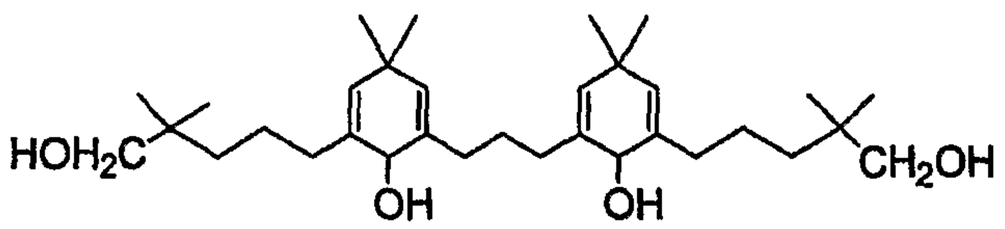
5-(5-{3-[3,6-Dihydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexa-1,4-dienyl]-propyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 93



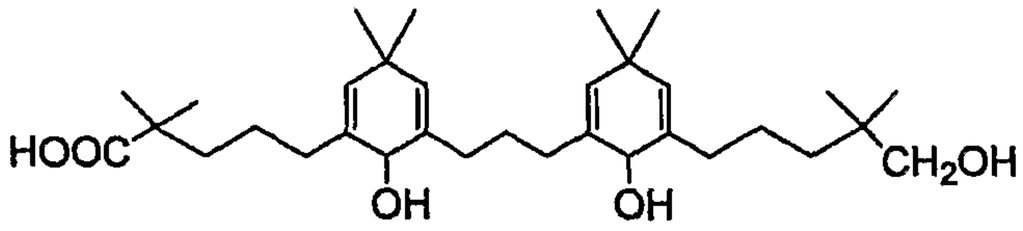
5-(5-{3-[5-(4-Carboxy-4-methyl-pentyl)-3,6-dihydroxy-cyclohexa -1,4-dienyl]- propyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 94



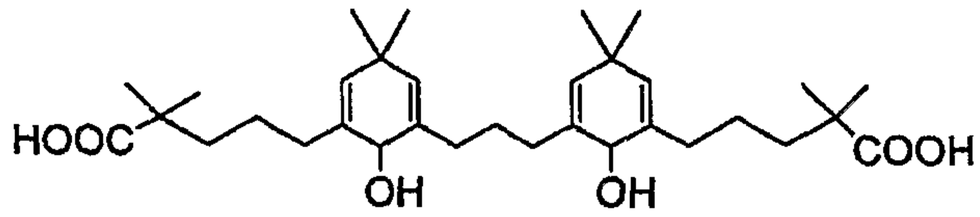
5-(6-Hydroxy-5-{3-[6-hydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-propyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanol

Compound 95



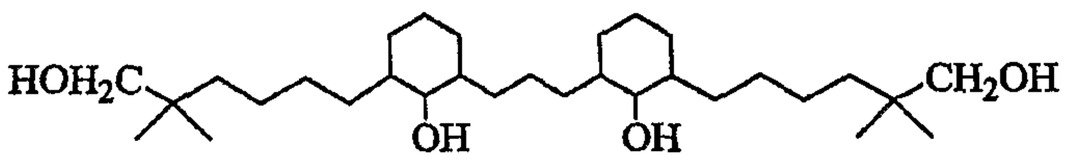
5-(6-Hydroxy-5-{3-[6-hydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-propyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 96



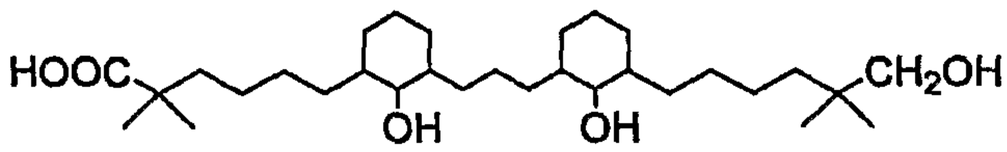
5-(5-{3-[5-(4-Carboxy-4-methyl-pentyl)-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl]-propyl}-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 97



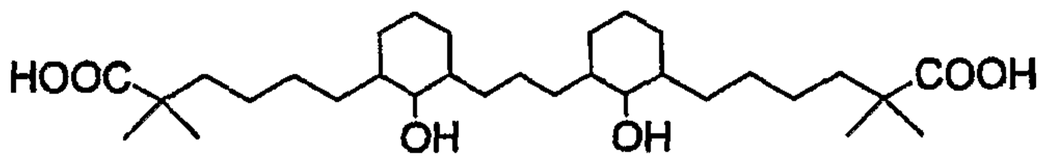
6-(2-Hydroxy-3-{3-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexyl]-propyl}-cyclohexyl)-2,2-dimethyl-hexanol

Compound 98



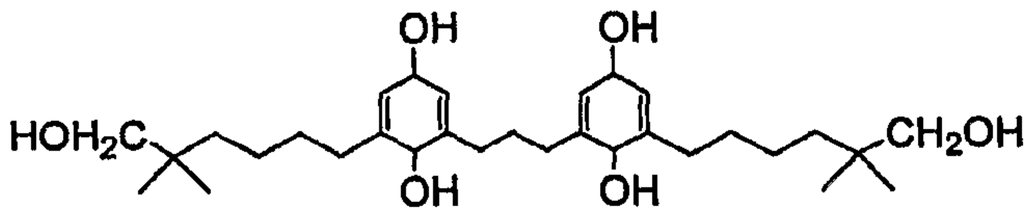
6-(2-Hydroxy-3-{3-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexyl]-propyl}-cyclohexyl)-2,2-dimethyl-hexanoic acid

Compound 99



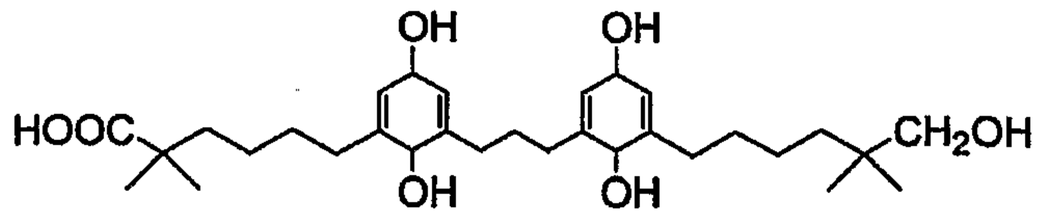
6-(3-{3-[3-(5-Carboxy-5-methyl-hexyl)-2-hydroxy-cyclohexyl]-propyl}-2-hydroxy-cyclohexyl)-2,2-dimethyl-hexanoic acid

Compound 100



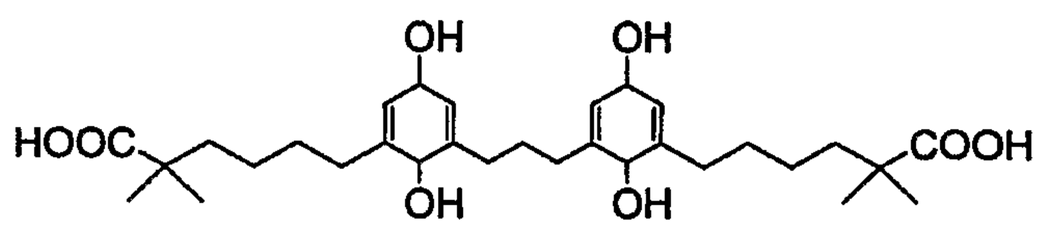
6-(5-{3-[3,6-Dihydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexa-1,4-dienyl]-propyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanol

Compound 101



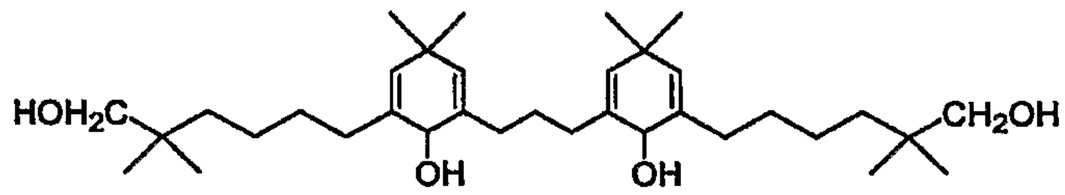
6-(5-{3-[3,6-Dihydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexa-1,4-dienyl]-propyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 102



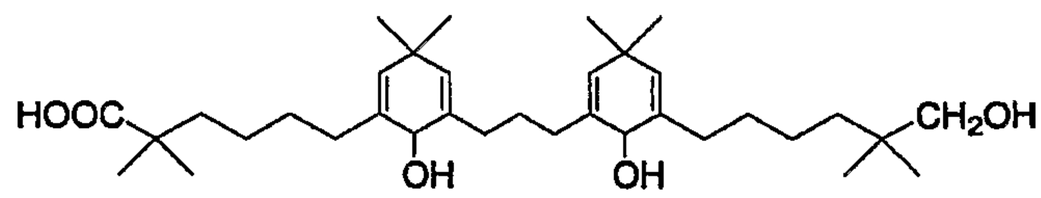
6-(5-{3-[5-(5-Carboxy-5-methyl-hexyl)-3,6-dihydroxy-cyclohexa-1,4-dienyl]-propyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 103



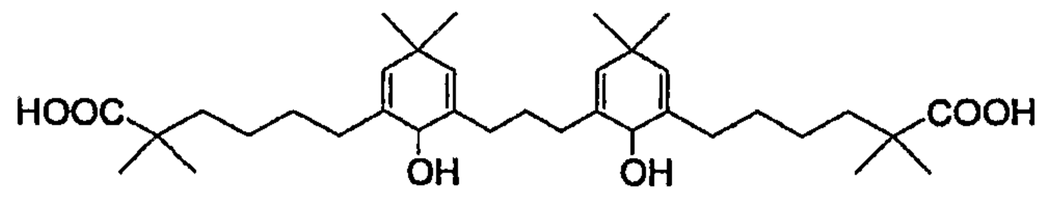
6-(6-Hydroxy-5-{3-[6-hydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-propyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanol

Compound 104



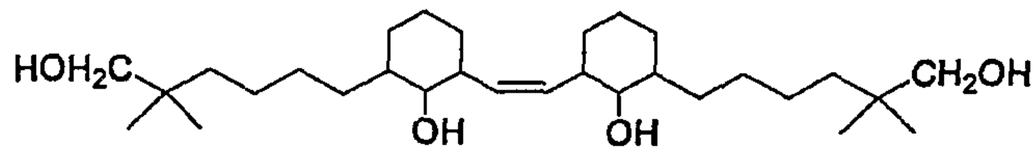
6-(6-Hydroxy-{3-[6-hydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-3,3-dimethyl-cyclohexa-1,4-dienyl] propyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 105



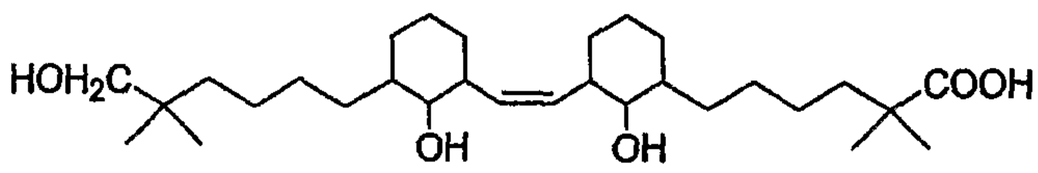
6-(5-{3-[5-(5-Carboxy-5-methyl-hexyl)-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl]-propyl}-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 106



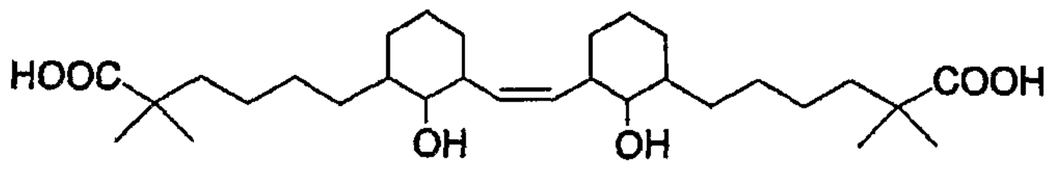
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexyl]-vinyl}-cyclohexyl)-2,2-dimethyl-hexanol

Compound 107



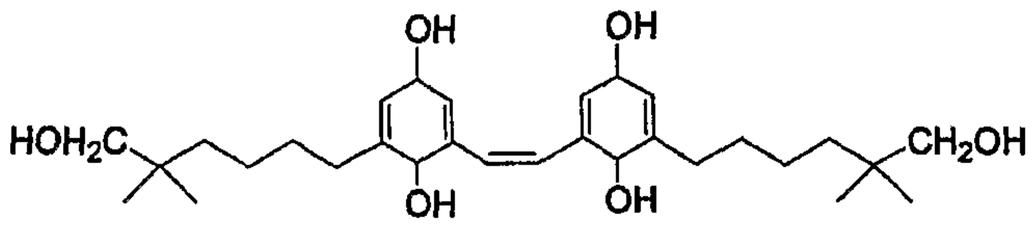
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexyl]-vinyl}-cyclohexyl)-2,2-dimethyl-hexanoic acid

Compound 108



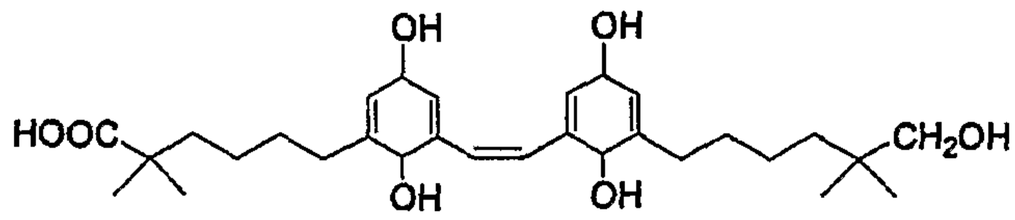
6-(3-{2-[3-(5-Carboxy-5-methyl-hexyl)-2-hydroxy-cyclohexyl]-vinyl}-2-hydroxy-cyclohexyl)-2,2-dimethyl-hexanoic acid

Compound 109



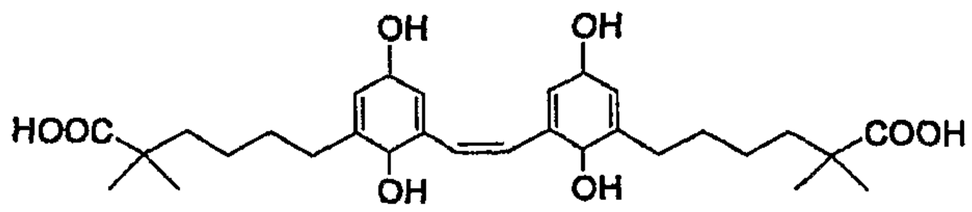
6-(5-{2-[3,6-Dihydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexa-1,4-dienyl]-vinyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanol

Compound 110



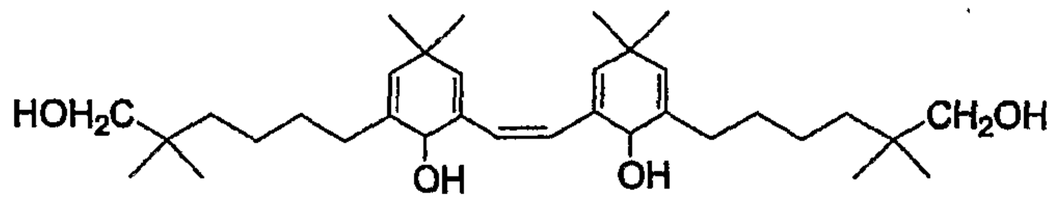
6-(5-{2-[3,6-Dihydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexa-1,4-dienyl]-vinyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 111



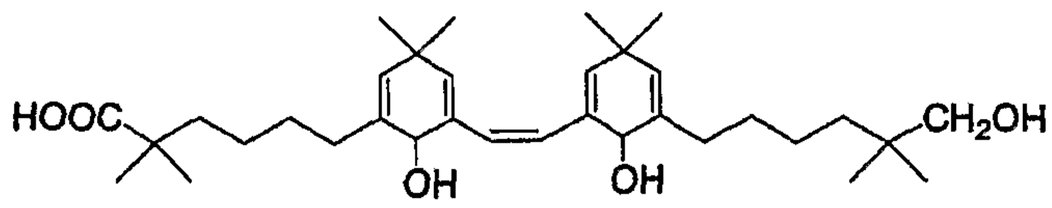
6-(5-{2-[5-(5-Carboxy-5-methyl-hexyl)-3,6-dihydroxy-cyclohexa-1,4-dienyl]-vinyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 112



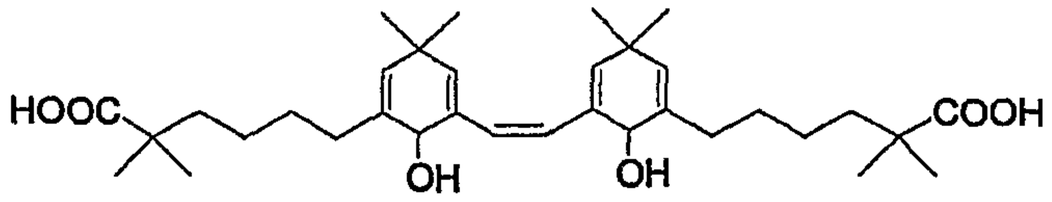
6-(6-Hydroxy-5-{2-[6-hydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-vinyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanol

Compound 113



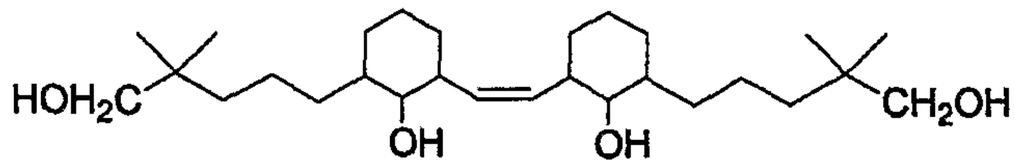
6-(6-Hydroxy-5-{2-[6-hydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-vinyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 114



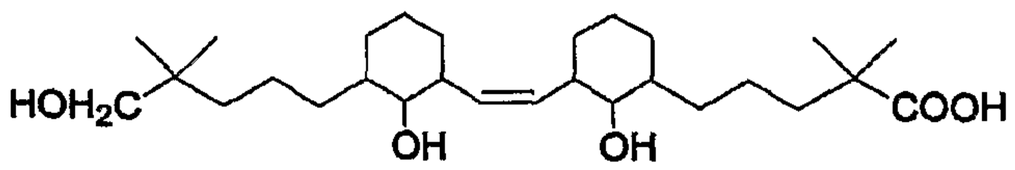
6-(5-{2-[5-(5-Carboxy-5-methyl-hexyl)-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl]-vinyl}-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 115



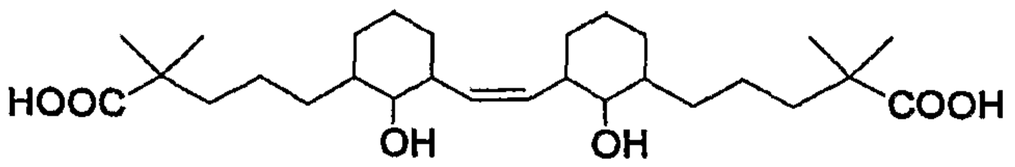
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexyl]-vinyl}-cyclohexyl)-2,2-dimethyl-pentanol

Compound 116



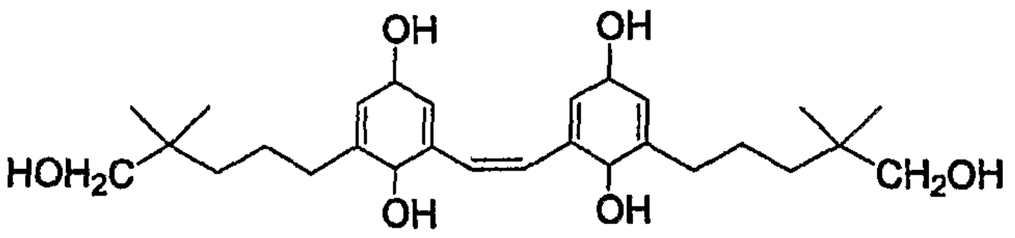
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexyl]-vinyl}-cyclohexyl)-2,2-dimethyl-pentanoic acid

Compound 117



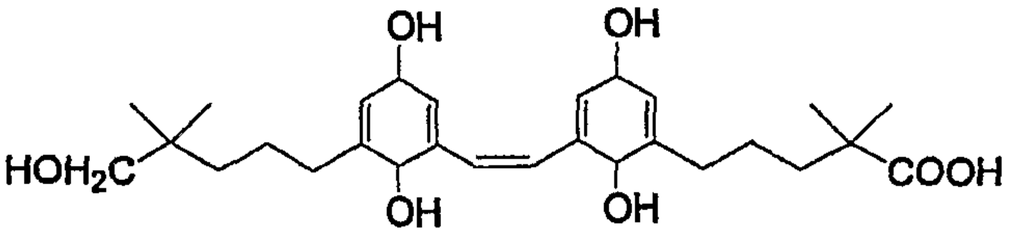
5-(3-{2-[3-(4-Carboxy-4-methyl-pentyl)-2-hydroxy-cyclohexyl]-vinyl}-2-hydroxy-cyclohexyl)-2,2-dimethyl-pentanoic acid

Compound 118



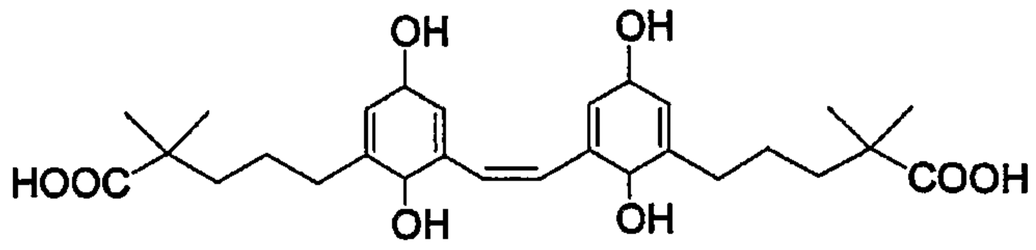
5-(5-{2-[3,6-Dihydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexa-1,4-dienyl]-vinyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanol

Compound 119



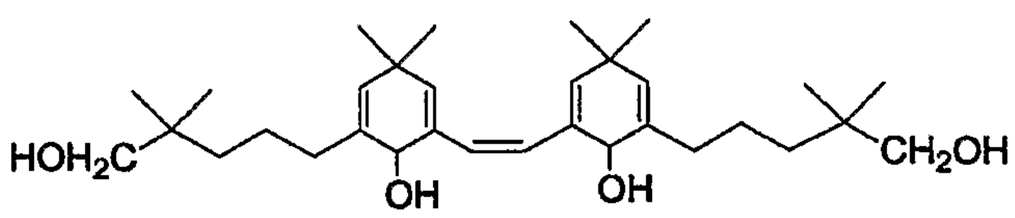
5-(5-{2-[3,6-Dihydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexa-1,4-dienyl]-vinyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 120



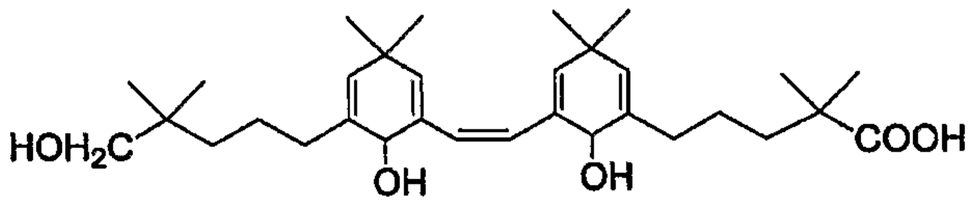
5-(5-{2-[5-(4-Carboxy-4-methyl-pentyl)-3,6-dihydroxy-cyclohexa-1,4-dienyl]-vinyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 121



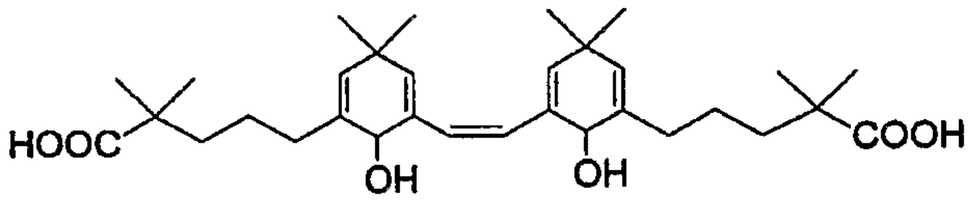
5-(6-Hydroxy-5-{2-[6-hydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-vinyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanol

Compound 122



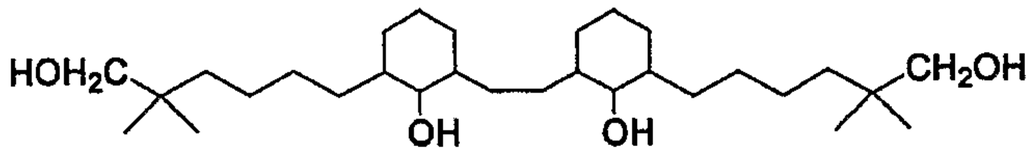
5-(6-Hydroxy-5-{2-[6-hydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-vinyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 123



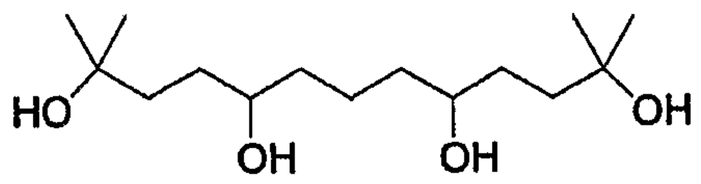
5-(5-{2-[5-(4-Carboxy-4-methyl-pentyl)-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl]-vinyl}-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 124



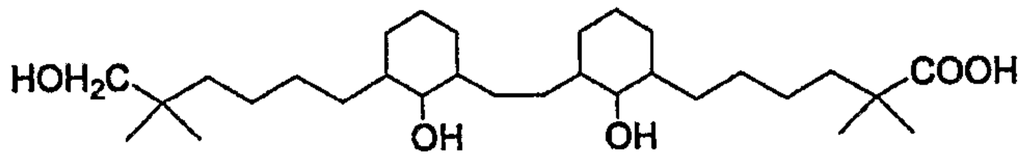
6-(2-Hydroxy-3-{3-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexyl]-ethyl}-cyclohexyl)-2,2-dimethyl-hexanol

Compound 125



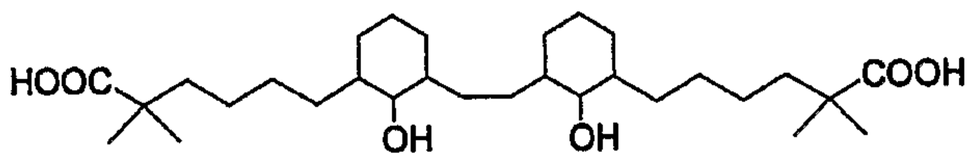
1) 2,12-Dimethyl-tridecane-2,5,9,12-tetraol

Compound 126



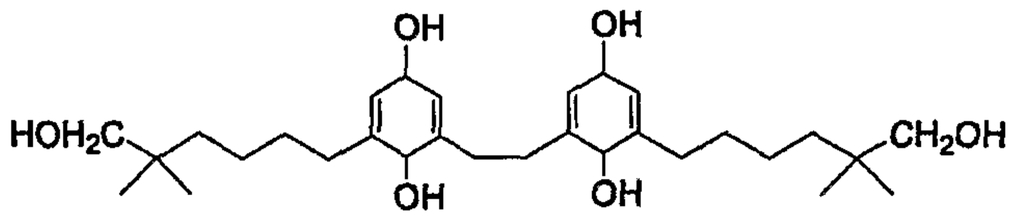
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexyl]-ethyl}-cyclohexyl)-2,2-dimethyl-hexanoic acid

Compound 127



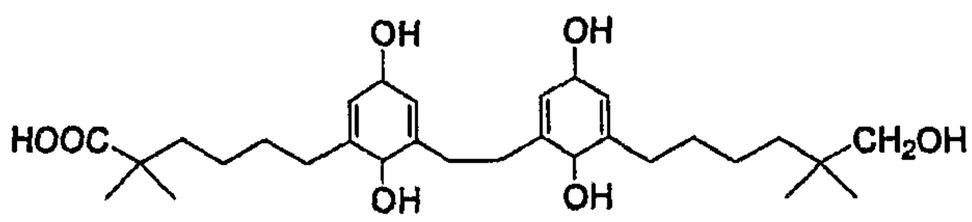
6-(3-{2-[3-(5-Carboxy-5-methyl-hexyl)-2-hydroxy-cyclohexyl]-ethyl}-2-hydroxy-cyclohexyl)-2,2-dimethyl-hexanoic acid

Compound 128



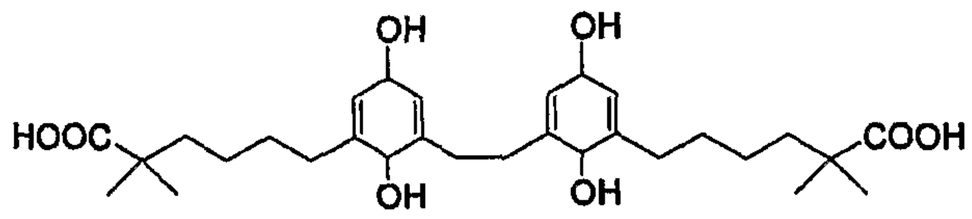
6-(5-{3-[3,6-Dihydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexa-1,4-dienyl]-ethyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanol

Compound 129



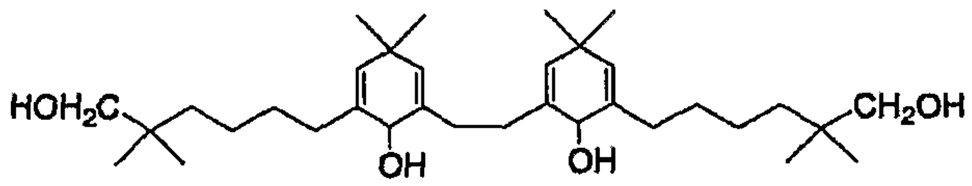
6-(5-{2-[3,6-Dihydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexa-1,4-dienyl]-ethyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 130



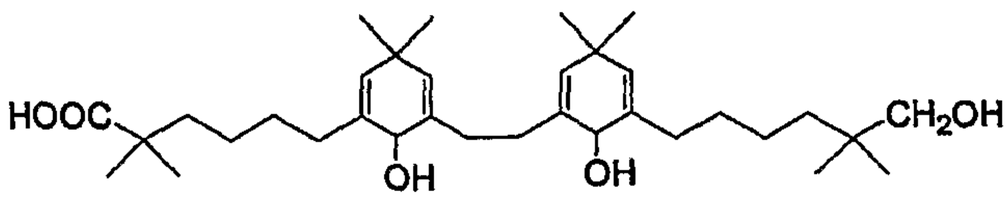
6-(5-{2-[5-(5-Carboxy-5-methyl-hexyl)-3,6-dihydroxy-cyclohexa-1,4-dienyl]-ethyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 131



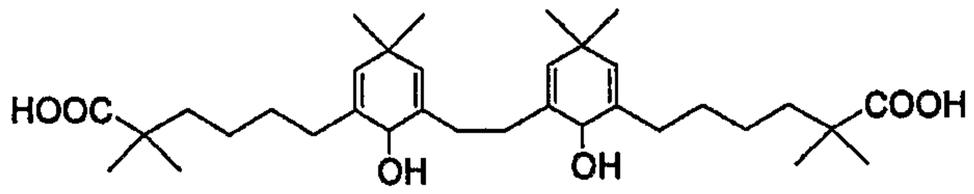
6-(6-Hydroxy-5-{2-[6-hydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-ethyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanol

Compound 132



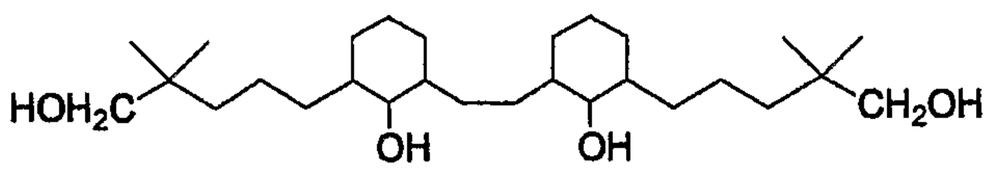
6-(6-Hydroxy-5-{2-[6-hydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-ethyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 133



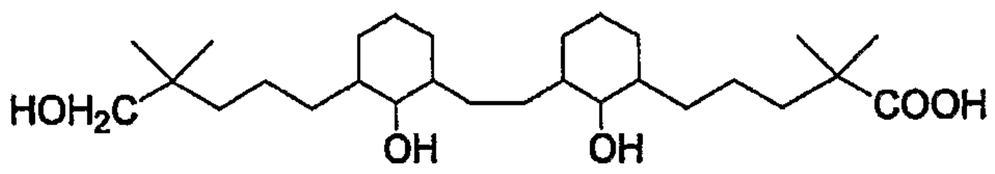
6-(5-{2-[5-(5-Carboxy-5-methyl-hexyl)-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl]-ethyl}-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 134



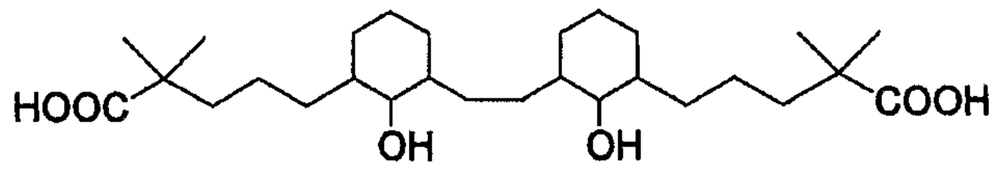
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexyl]-ethyl}-cyclohexyl)-2,2-dimethyl-pentanol

Compound 135



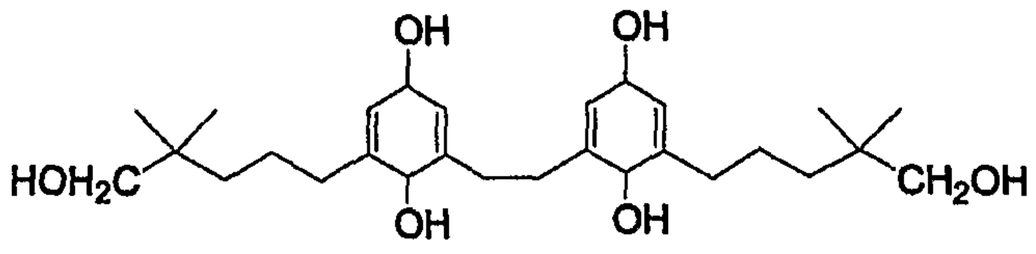
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexyl]-ethyl}-cyclohexyl)-2,2-dimethyl-pentanoic acid

Compound 136



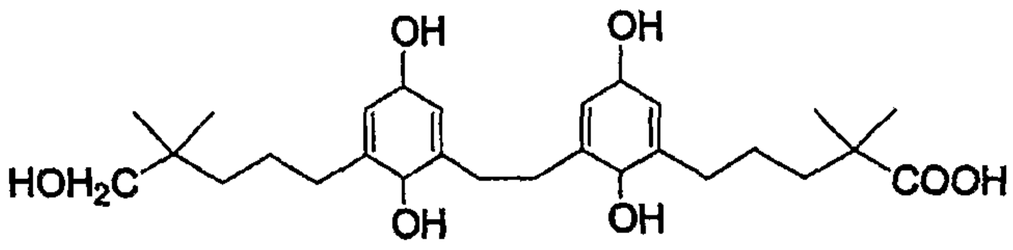
5-(3-{2-[3-(4-Carboxy-4-methyl-pentyl)-2-hydroxy-cyclohexyl]-ethyl}-2-hydroxy-cyclohexyl)-2,2-dimethyl-pentanoic acid

Compound 137



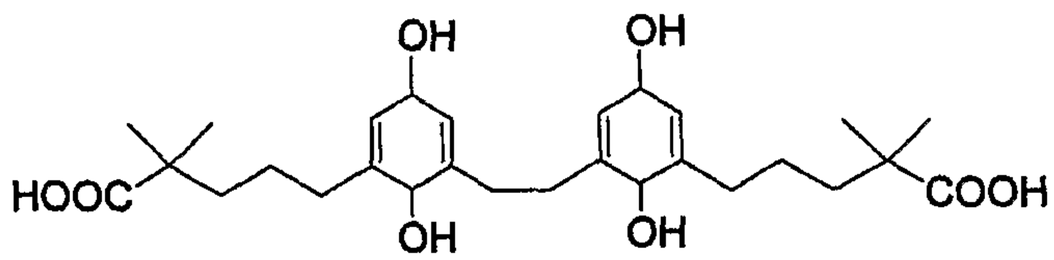
5-(5-{2-[3,6-Dihydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexa-1,4-dienyl]-ethyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanol

Compound 138



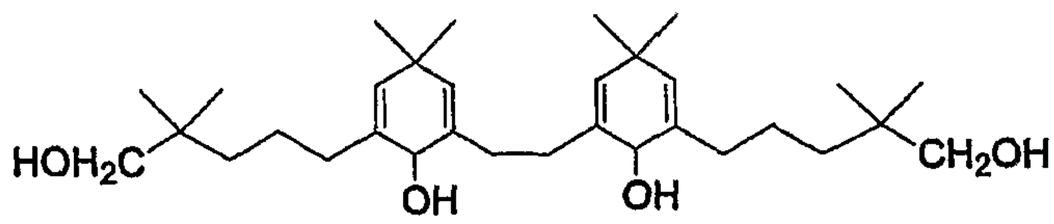
5-(5-{2-[3,6-Dihydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexa-1,4-dienyl]-ethyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 139



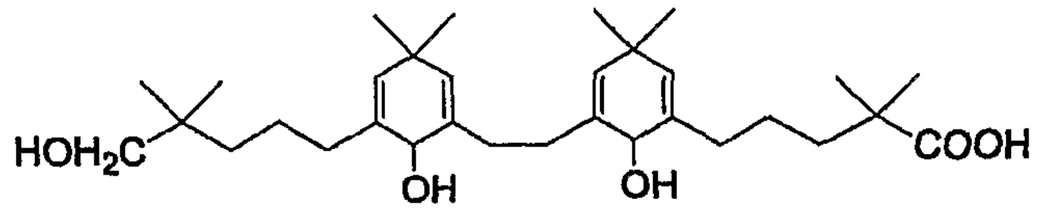
5-(5-{2-[5-(4-Carboxy-4-methyl-pentyl)-3,6-dihydroxy-cyclohexa-1,4-dienyl]-ethyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 140



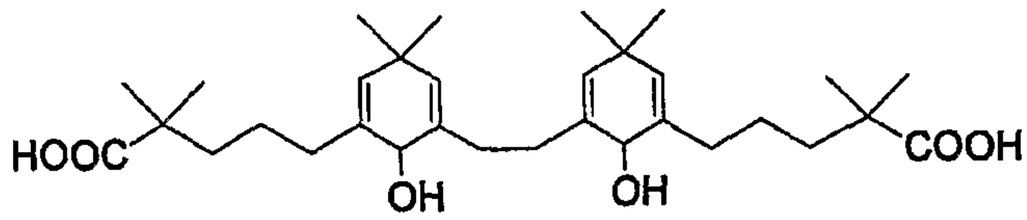
5-(6-Hydroxy-5-{2-[6-hydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-ethyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanol

Compound 141



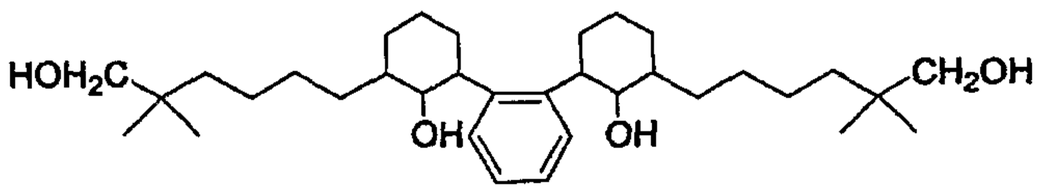
5-(6-Hydroxy-5-{2-[6-hydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-ethyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 142



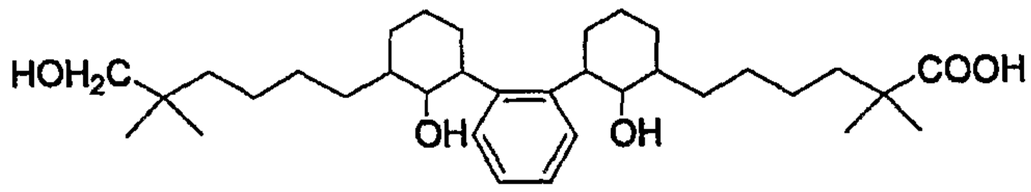
5-(5-{2-[5-(4-Carboxy-4-methyl-pentyl)-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl]-ethyl}-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 143



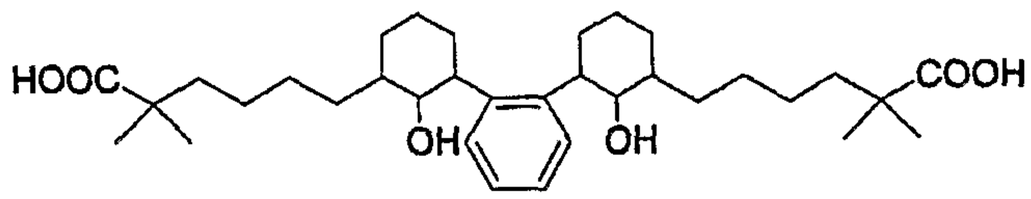
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexyl]-phenyl}-cyclohexyl)-2,2-dimethyl-hexanol

Compound 144



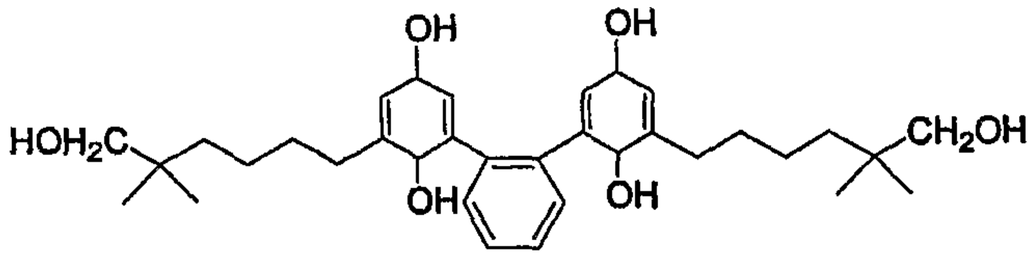
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexyl]-phenyl}-cyclohexyl)-2,2-dimethyl-hexanoic acid

Compound 145



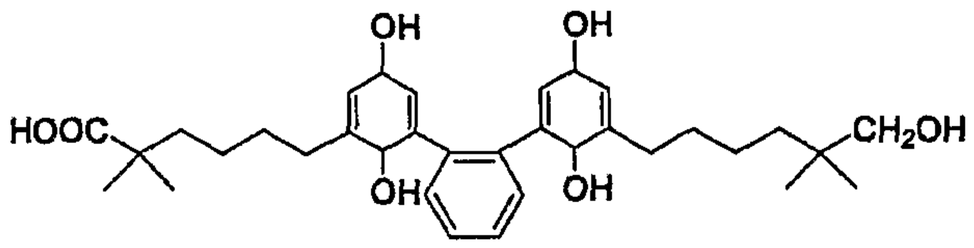
6-(3-{2-[3-(5-Carboxy-5-methyl-hexyl)-2-hydroxy-cyclohexyl]- phenyl}-2-hydroxy-cyclohexyl)-2,2-dimethyl-hexanoic acid

Compound 146



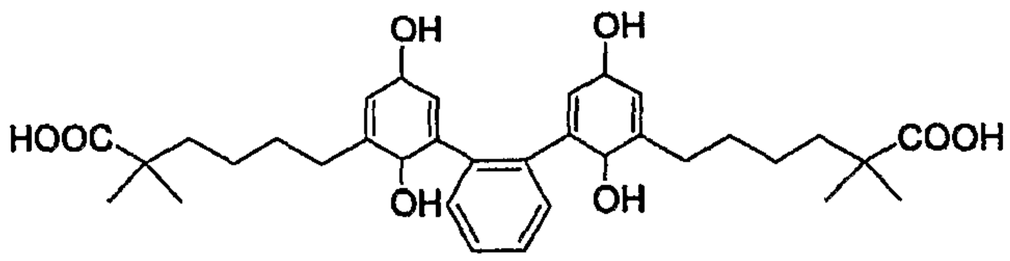
6-(5-{2-[3,6-Dihydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexa-1,4-dienyl]-phenyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanol

Compound 147



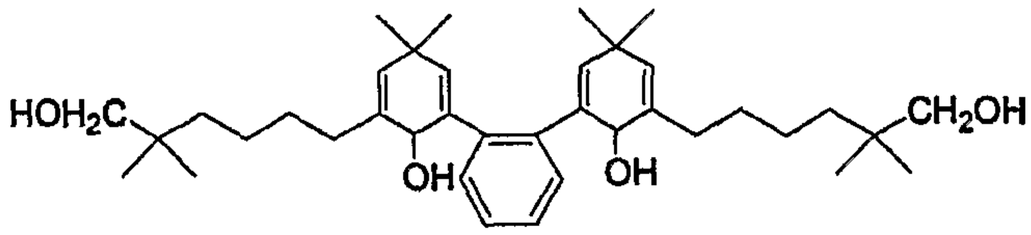
6-(5-{2-[3,6-Dihydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-cyclohexa-1,4-dienyl]-phenyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 148



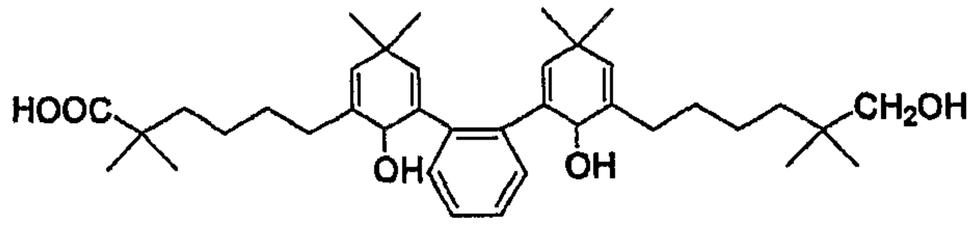
6-(5-{2-[5-(5-Carboxy-5-methyl-hexyl)-3,6-dihydroxy-cyclohexa-1,4-dienyl]-phenyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 149



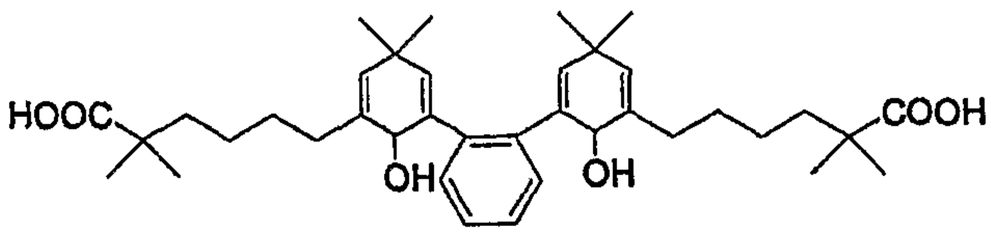
6-(6-Hydroxy-5-{2-[6-hydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-phenyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanol

Compound 150



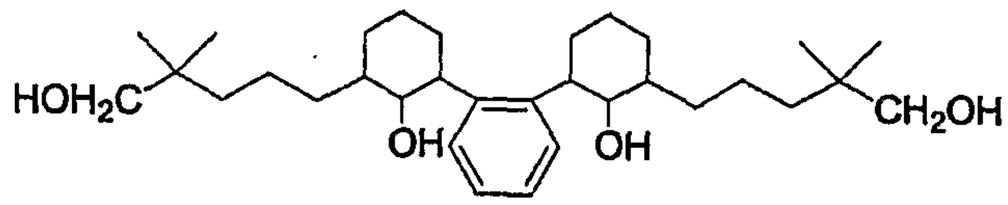
6-(6-Hydroxy-5-{2-[6-hydroxy-5-(6-hydroxy-5,5-dimethyl-hexyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-phenyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 151



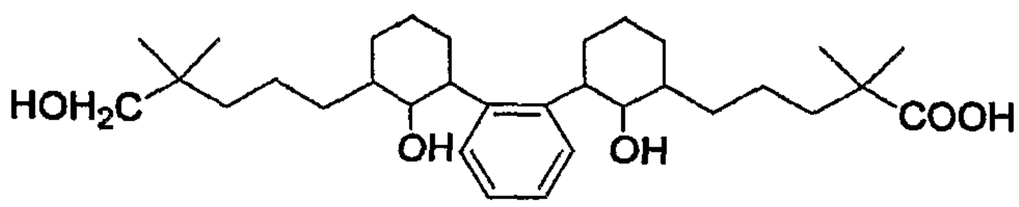
6-(5-{2-[5-(5-Carboxy-5-methyl-hexyl)-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl]-phenyl}-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-hexanoic acid

Compound 152



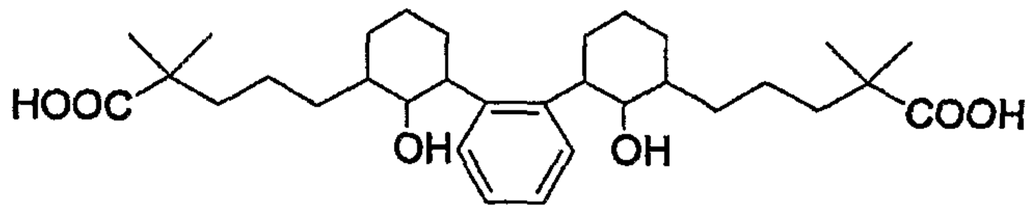
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexyl]-phenyl}-cyclohexyl)-2,2-dimethyl-pentanol

Compound 153



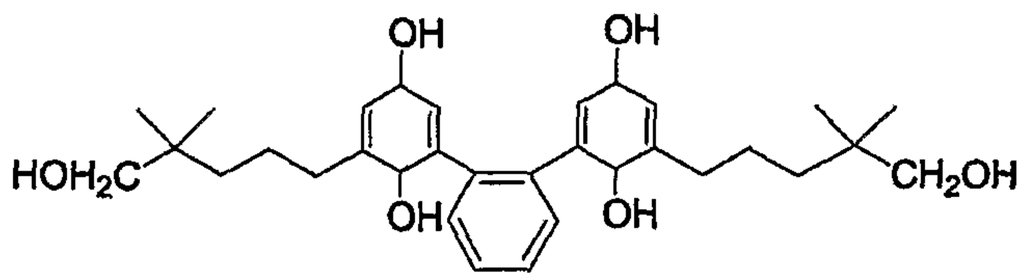
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexyl]-phenyl}-cyclohexyl)-2,2-dimethyl-pentanoic acid

Compound 154



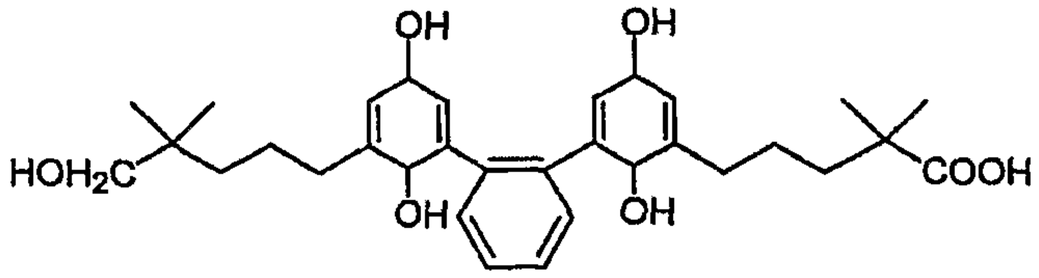
5-(3-{2-[3-(4-Carboxy-4-methyl-pentyl)-2-hydroxy-cyclohexyl]-phenyl}-2-hydroxy-cyclohexyl)-2,2-dimethyl-pentanoic acid

Compound 155



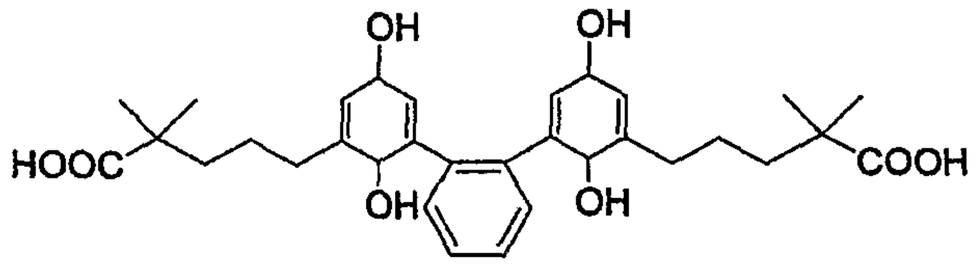
5-(5-{2-[3,6-Dihydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexa-1,4-dienyl]-phenyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanol

Compound 156



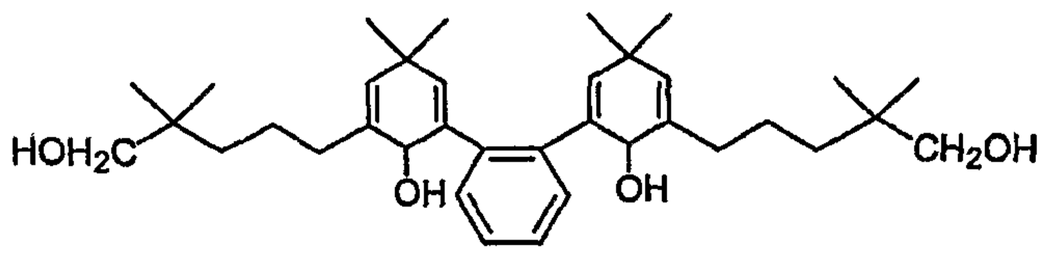
5-(5-{2-[3,6-Dihydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-cyclohexa-1,4-dienyl]-phenyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 157



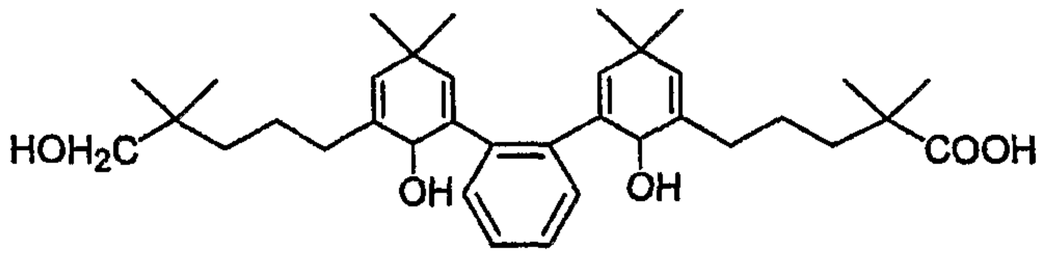
5-(5-{2-[5-(4-Carboxy-4-methyl-pentyl)-3,6-dihydroxy-cyclohexa-1,4-dienyl]-phenyl}-3,6-dihydroxy-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 158



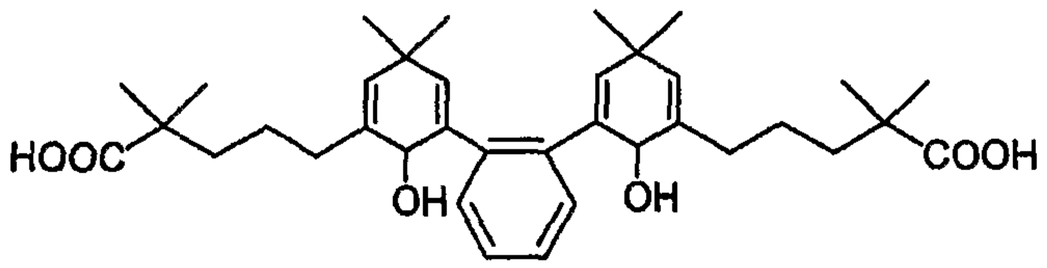
5-(6-Hydroxy-5-{2-[6-hydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-phenyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanol

Compound 159



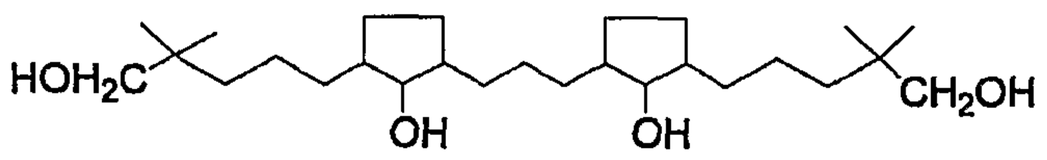
5-(6-Hydroxy-5-{2-[6-hydroxy-5-(5-hydroxy-4,4-dimethyl-pentyl)-3,3-dimethyl-cyclohexa-1,4-dienyl]-phenyl}-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 160



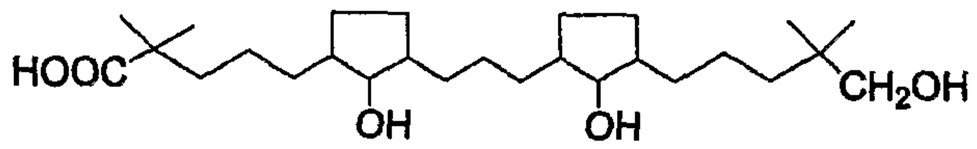
5-(5-{2-[5-(4-Carboxy-4-methyl-pentyl)-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl]-phenyl}-6-hydroxy-3,3-dimethyl-cyclohexa-1,4-dienyl)-2,2-dimethyl-pentanoic acid

Compound 161



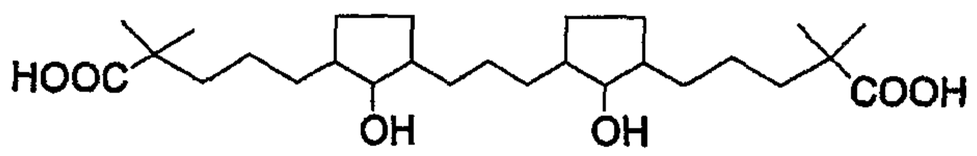
5-(2-Hydroxy-3-{3-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopentyl]-propyl}-cyclopentyl)-2,2-dimethyl-pentanol

Compound 162



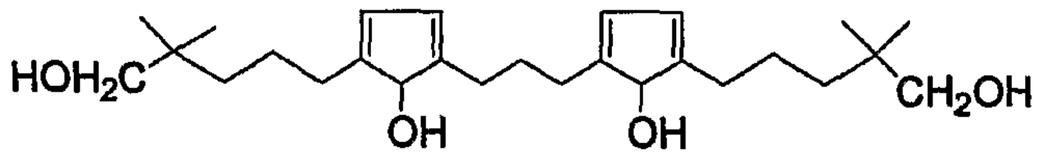
5-(2-Hydroxy-3-{3-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopentyl]-propyl}-cyclopentyl)-2,2-dimethyl-pentanoic acid

Compound 163



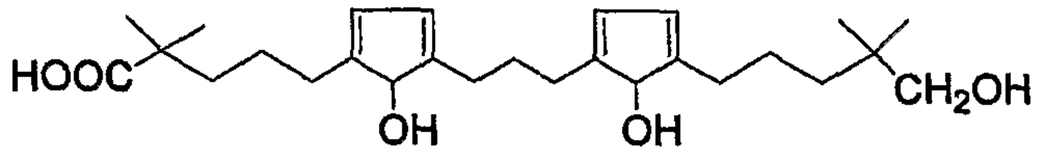
5-(3-{3-[3-(4-Carboxy-4-methyl-pentyl)-2-hydroxy-cyclopentyl]-propyl}-2-hydroxy-cyclopentyl)-2,2-dimethyl-pentanoic acid

Compound 164



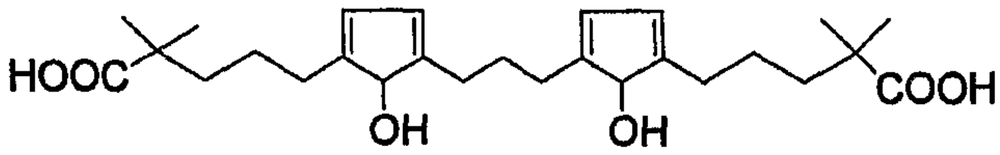
5-(5-Hydroxy-4-{3-[5-hydroxy-4-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopenta-1,3-dienyl]-propyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanol

Compound 165



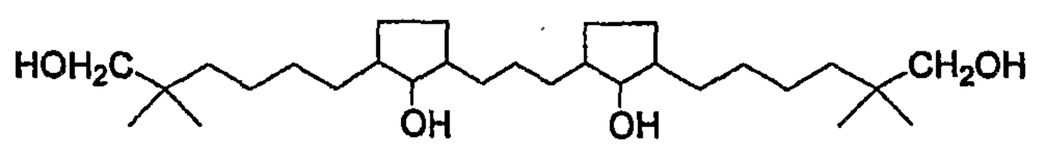
5-(5-Hydroxy-4-{3-[5-hydroxy-4-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopenta-1,3-dienyl]-propyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanoic acid

Compound 166



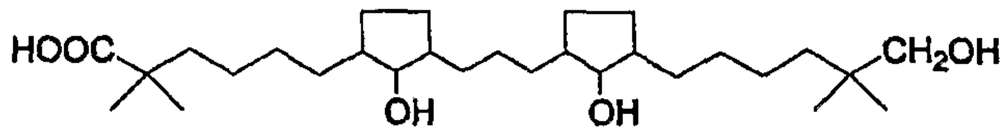
5-(4-{3-[4-(4-Carboxy-4-methyl-pentyl)-5-hydroxy-cyclopenta-1,3-dienyl]-propyl}-5-hydroxy-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanoic acid

Compound 167



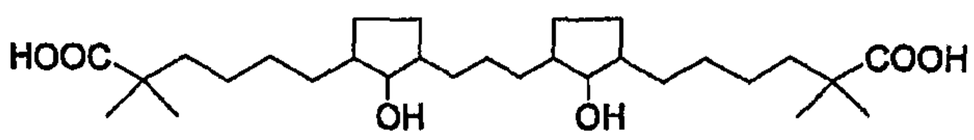
6-(2-Hydroxy-3-{3-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopentyl]-propyl}-cyclopentyl)-2,2-dimethyl-hexanol

Compound 168



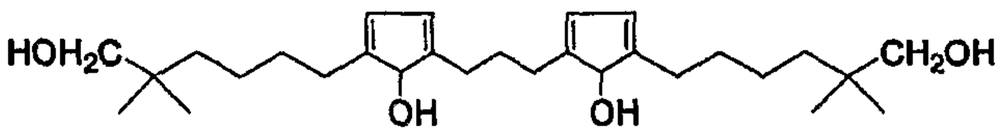
6-(2-Hydroxy-3-{3-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopentyl]-propyl}-cyclopentyl)-2,2-dimethyl-hexanoic acid

Compound 169



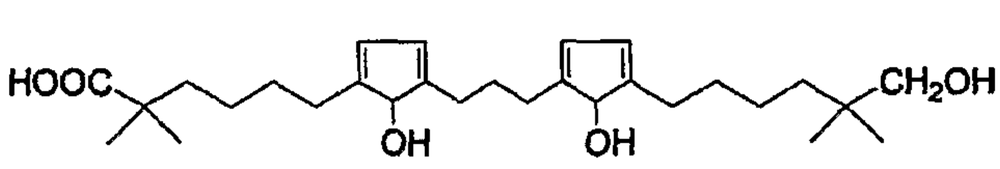
6-(3-{3-[3-(5-Carboxy-5-methyl-hexyl)-2-hydroxy-cyclopentyl]-propyl}-2-hydroxy-cyclopentyl)-2,2-dimethyl-hexanoic acid

Compound 170



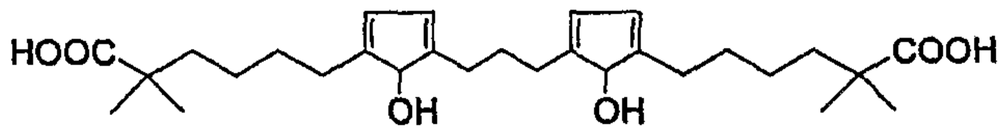
6-(5-Hydroxy-4-{3-[5-hydroxy-4-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopenta-1,3-dienyl]-propyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-hexanol

Compound 171



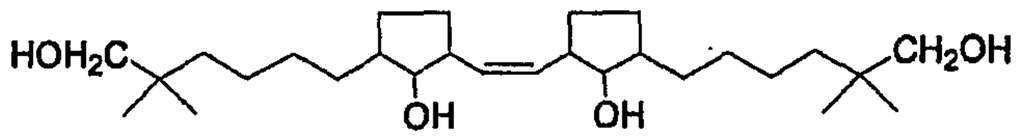
6-(5-Hydroxy-4-{3-[5-hydroxy-4-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopenta-1,3-dienyl]-propyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-hexanoic acid

Compound 172



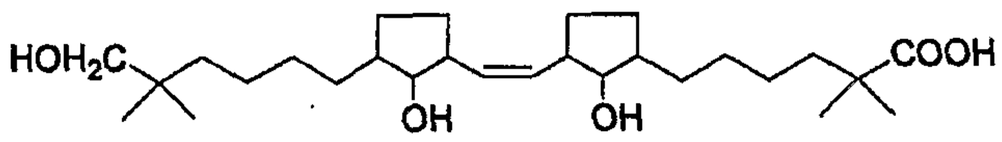
6-(4-{3-[4-(5-Carboxy-5-methyl-hexyl)-5-hydroxy-cyclopenta-1,3-dienyl]-propyl}-5-hydroxy-cyclopenta-1,3-dienyl)-2,2-dimethyl-hexanoic acid

Compound 173



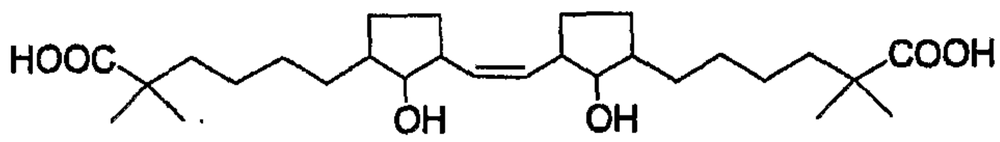
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopentyl]-vinyl}-cyclopentyl)-2,2-dimethyl-hexanol

Compound 174



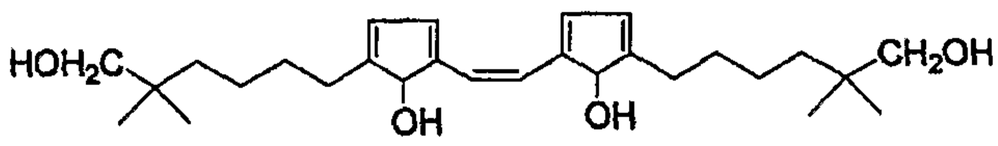
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopentyl]-vinyl}-cyclopentyl)-2,2-dimethyl-hexanoic acid

Compound 175



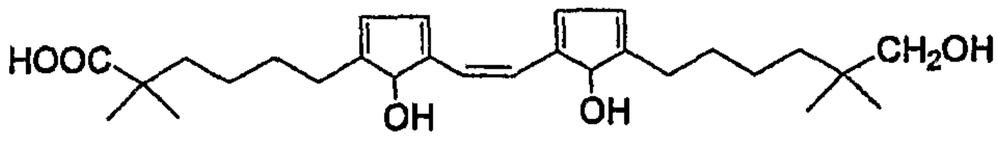
6-(3-{2-[3-(5-Carboxy-5-methyl-hexyl)-2-hydroxy-cyclopentyl]-vinyl}-2-hydroxy-cyclopentyl)-2,2-dimethyl-hexanoic acid

Compound 176



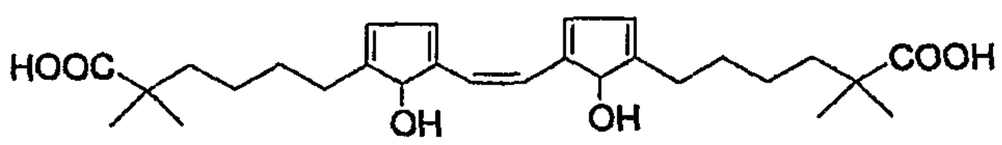
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopentyl]-vinyl}-cyclopentyl)-2,2-dimethyl-hexanol

Compound 177



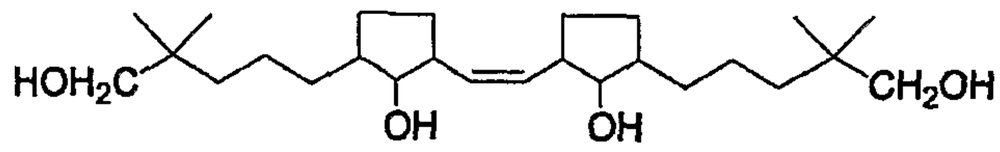
6-(5-Hydroxy-4-{2-[5-hydroxy-4-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopenta-1,3-dienyl]-vinyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-hexanoic acid

Compound 178



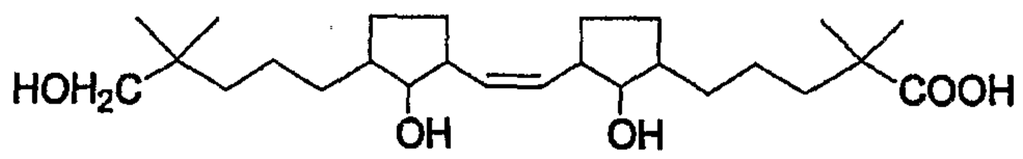
6-(4-{2-[4-(5-Carboxy-5-methyl-hexyl)-5-hydroxy-cyclopenta-1,3-dienyl]-vinyl}-5-hydroxy-cyclopenta-1,3-dienyl)-2,2-dimethyl-hexanoic acid

Compound 179



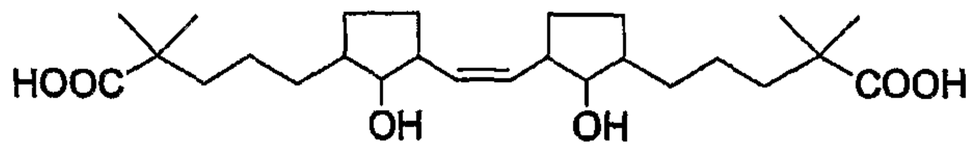
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopentyl]-vinyl}-cyclopentyl)-2,2-dimethyl-pentanol

Compound 180



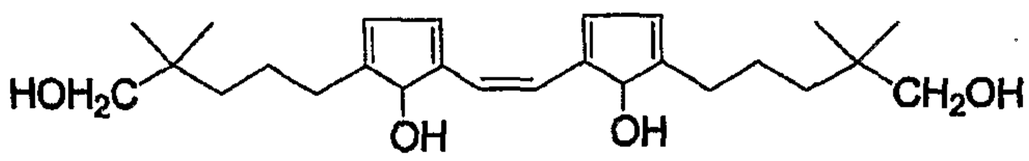
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopentyl]-vinyl}-cyclopentyl)-2,2-dimethyl-pentanoic acid

Compound 181



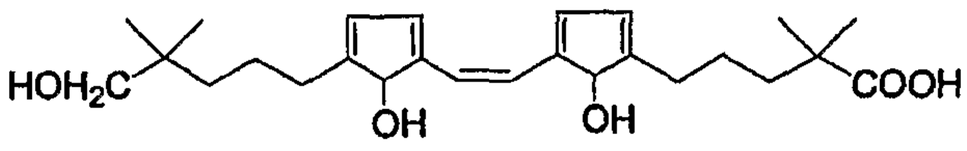
5-(3-{2-[3-(4-Carboxy-4-methyl-pentyl)-2-hydroxy-cyclopentyl]-vinyl}-2-hydroxy-cyclopentyl)-2,2-dimethyl-pentanoic acid

Compound 182



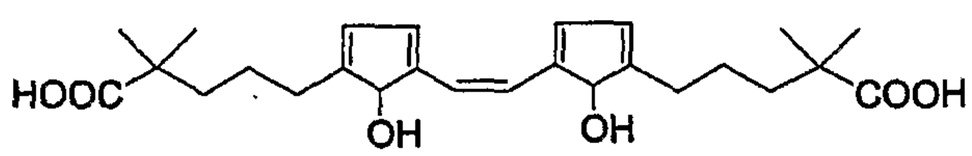
5-(5-Hydroxy-4-{2-[5-hydroxy-4-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopenta-1,3-dienyl]-vinyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanol

Compound 183



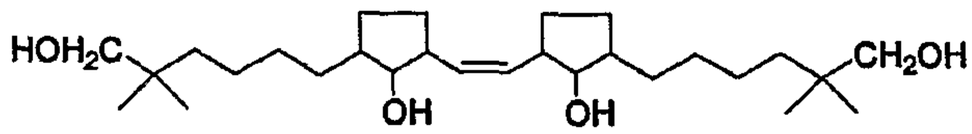
5-(5-Hydroxy-4-{2-[5-hydroxy-4-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopenta-1,3-dienyl]-vinyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanoic acid

Compound 184



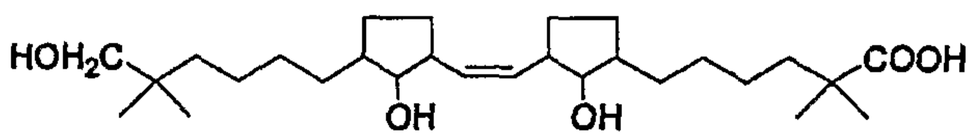
5-(4-{2-[4-(4-Carboxy-4-methyl-pentyl)-5-hydroxy-cyclopenta-1,3-dienyl]-vinyl}-5-hydroxy-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanoic acid

Compound 185



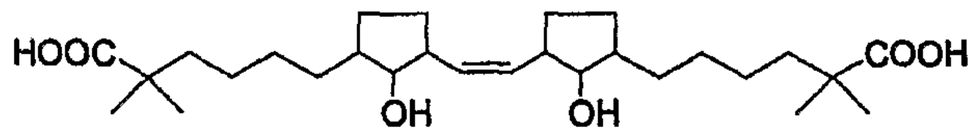
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopentyl]-vinyl}-cyclopentyl)-2,2-dimethyl-hexanol

Compound 186



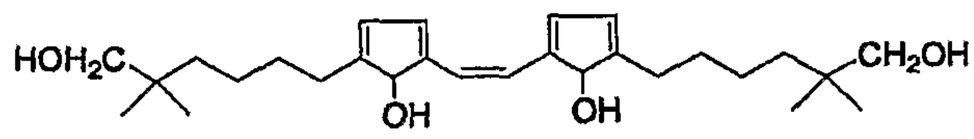
6-(2-Hydroxy-3-{2-[2-hydroxy-3-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopentyl]-vinyl}-cyclopentyl)-2,2-dimethyl-hexanoic acid

Compound 187



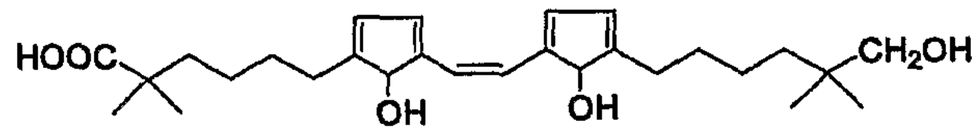
6-(3-{2-[3-(5-Carboxy-5-methyl-hexyl)-2-hydroxy-cyclopentyl]-vinyl}-2-hydroxy-cyclopentyl)-2,2-dimethyl-hexanoic acid

Compound 188



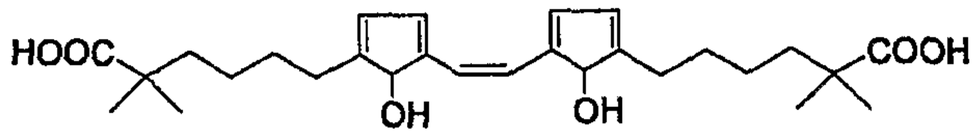
6-(5-Hydroxy-4-{2-[5-hydroxy-4-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopenta-1,3-dienyl]-vinyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-hexanol

Compound 189



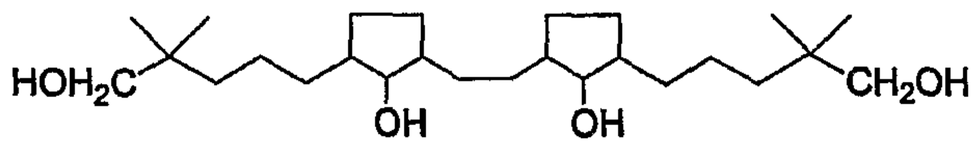
6-(5-Hydroxy-4-{2-[5-hydroxy-4-(6-hydroxy-5,5-dimethyl-hexyl)-cyclopenta-1,3-dienyl]-vinyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-hexanoic acid

Compound 190



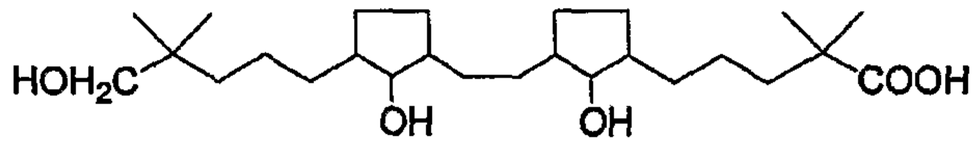
6-(4-{2-[4-(5-Carboxy-5-methyl-hexyl)-5-hydroxy-cyclopenta-1,3-dienyl]-vinyl}-5-hydroxy-cyclopenta-1,3-dienyl)-2,2-dimethyl-hexanoic acid

Compound 191



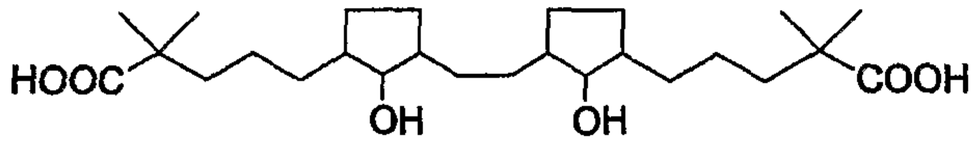
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopentyl]-ethyl}-cyclopentyl)-2,2-dimethyl-pentanol

Compound 192



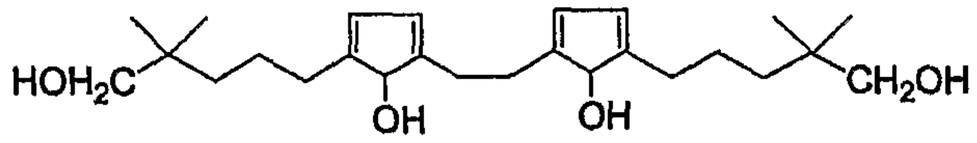
5-(2-Hydroxy-3-{2-[2-hydroxy-3-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopentyl]-ethyl}-cyclopentyl)-2,2-dimethyl-pentanoic acid

Compound 193



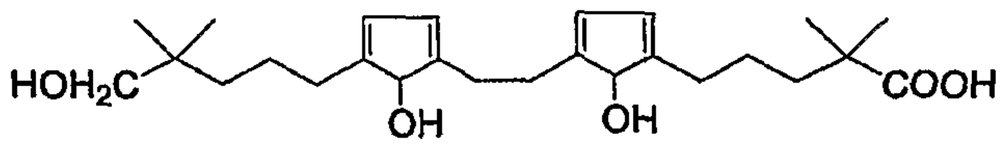
5-(3-{2-[3-(4-Carboxy-4-methyl-pentyl)-2-hydroxy-cyclopentyl]-ethyl}-2-hydroxy-cyclopentyl)-2,2-dimethyl-pentanoic acid

Compound 194



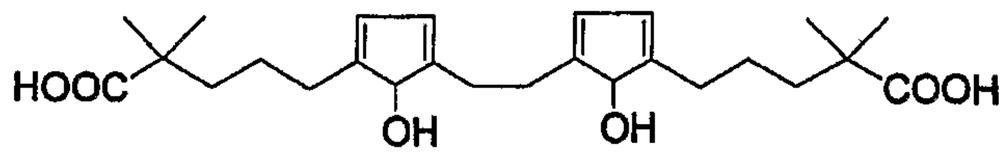
5-(5-Hydroxy-4-{2-[5-hydroxy-4-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopenta-1,3-dienyl]-ethyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanol

Compound 195



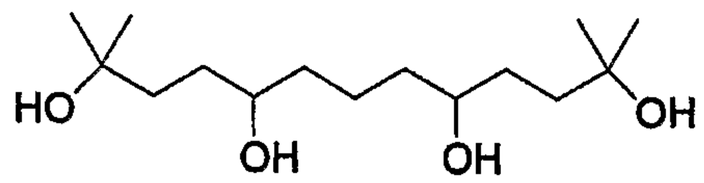
5-(5-Hydroxy-4-{2-[5-hydroxy-4-(5-hydroxy-4,4-dimethyl-pentyl)-cyclopenta-1,3-dienyl]-ethyl}-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanoic acid

Compound 196



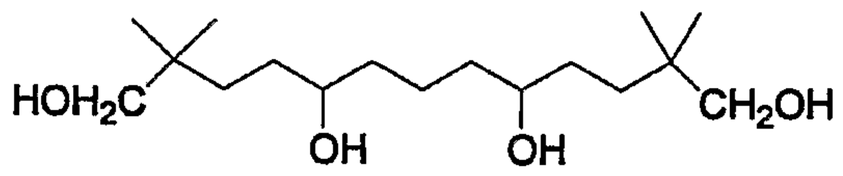
5-(4-{2-[4-(4-Carboxy-4-methyl-pentyl)-5-hydroxy-cyclopenta-1,3-dienyl]-ethyl}-5-hydroxy-cyclopenta-1,3-dienyl)-2,2-dimethyl-pentanoic acid

Compound 197



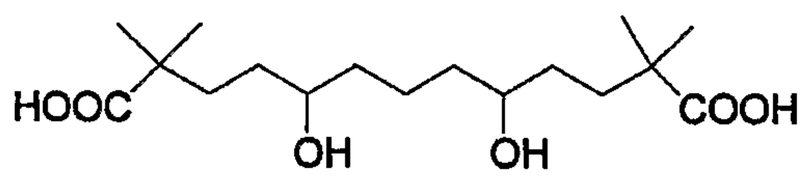
2,12-Dimethyl-tridecane-2,5,9,12-tetraol

Compound 198



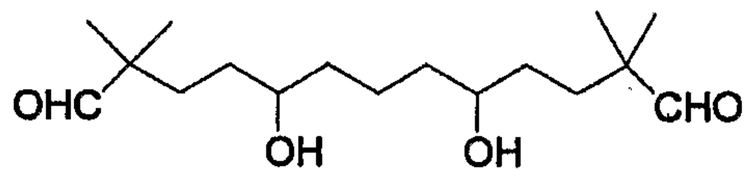
2,2,12,12-Tetramethyl-tridecane-1,5,9,13-tetraol

Compound 199



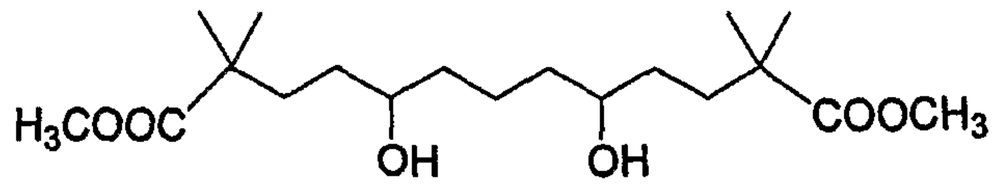
5,9-Dihydroxy-2,2,12,12-tetramethyl-tridecanedioic acid

Compound 200



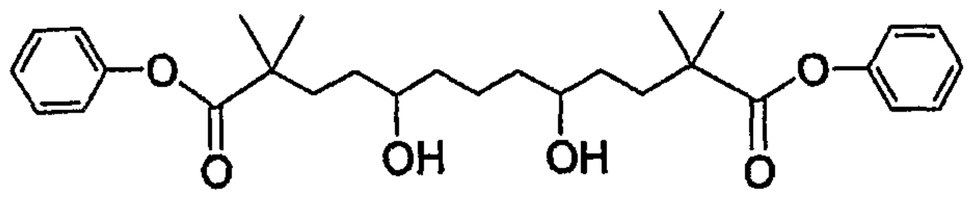
5,9-Dihydroxy-2,2,12,12-tetramethyl-tridecanedial

Compound 201



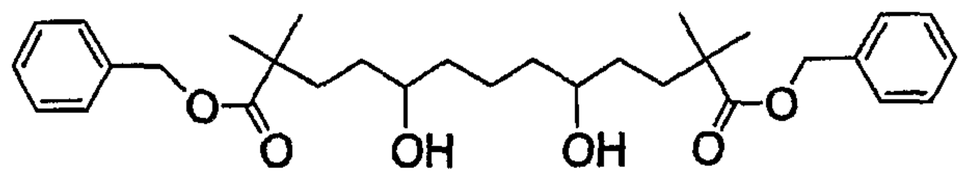
5,9-Dihydroxy-2,2,12,12-tetramethyl-tridecanedioic acid dimethyl ester

Compound 202



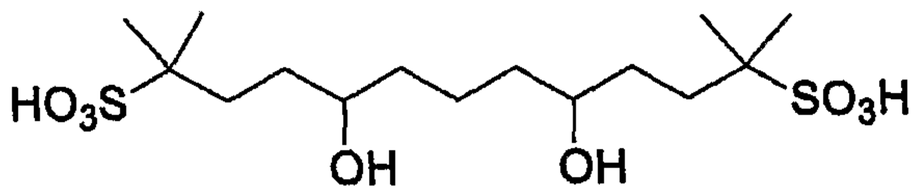
5,9-Dihydroxy-2,2,12,12-tetramethyl-tridecanedioic acid diphenyl ester

Compound 203



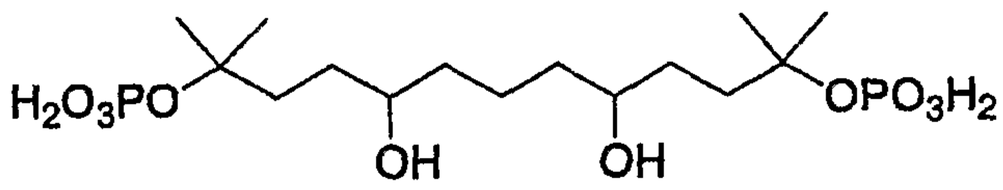
5,9-Dihydroxy-2,2,12,12-tetramethyl-tridecanedioic acid dibenzyl ester

Compound 204



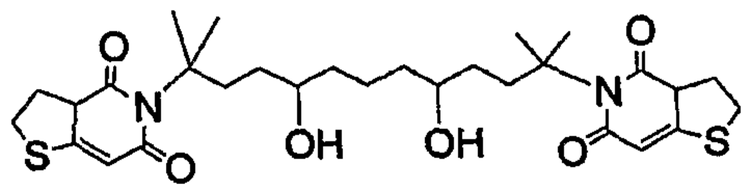
5,9-Dihydroxy-2,12-dimethyl-tridecane-2,12-disulfonic acid

Compound 205



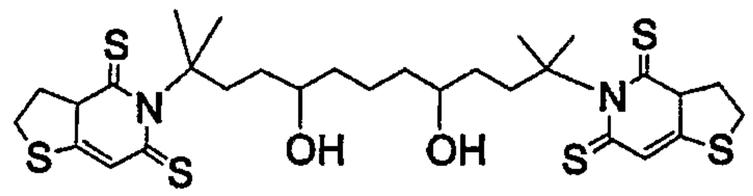
Phosphoric acid mono-(4,8-dihydroxy-1,1,11-trimethyl-11-phosphonooxy-dodecyl) ester

Compound 206



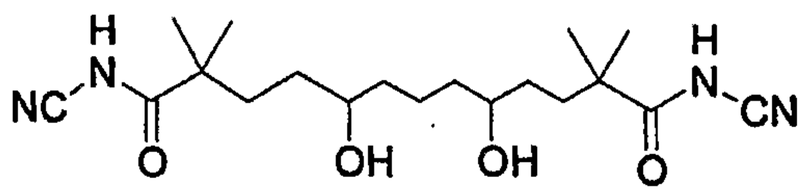
2,12-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dione))-5,9-dihydroxy-2,12-dimethyl-tridecane

Compound 207



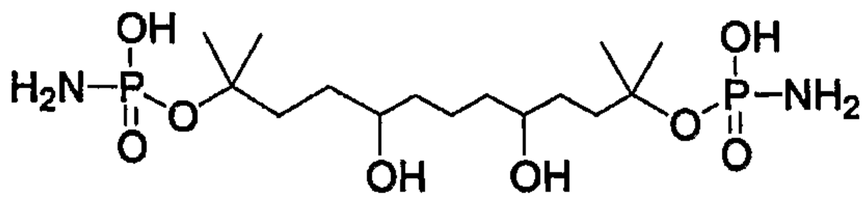
2,12-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dithioxo))-5,9-dihydroxy-2,12-dimethyl-tridecane

Compound 208



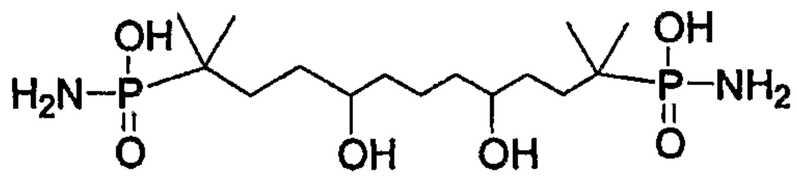
1,14-bis-(N-Cyanoamido)-5,9-dihydroxy-2,2,12,12-tetramethyl-tridecane

Compound 209



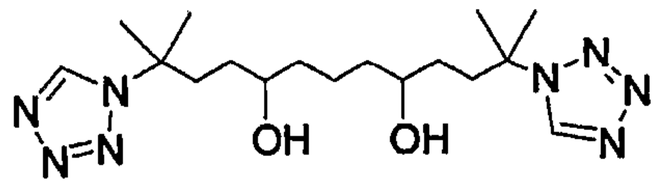
Phosphoramidic acid mono-[11-(amino-hydroxy-phosphoryloxy)-4,8-dihydroxy-1,1,11-trimethyl-dodecyl] ester

Compound 210



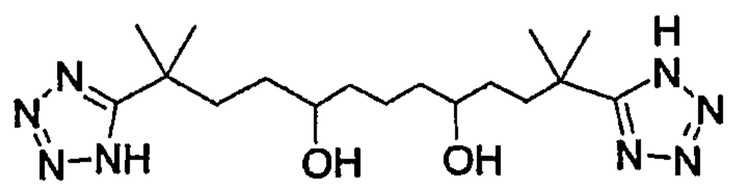
Phosphoramic acid mono-[11-(amino-hydroxy-phosphoryloxy)-4,8-dihydroxy-1,1,11-trimethyl-dodecyl] ester

Compound 211



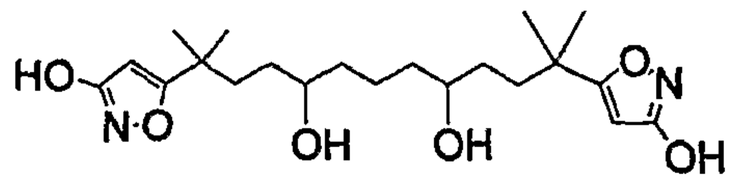
2,12-Dimethyl-2,12-bis-tetrazol-1-yl-tridecane-5,9-diol

Compound 212



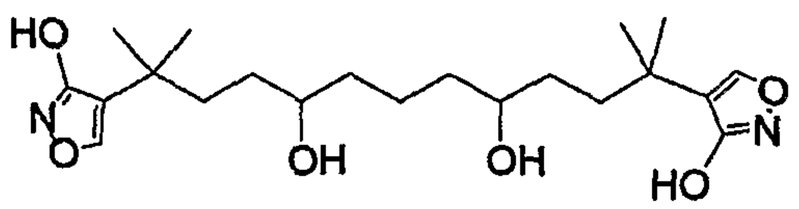
2,12-Dimethyl-2,12-bis-(1H-tetrazol-5-yl)-tridecane-5,9-diol

Compound 213



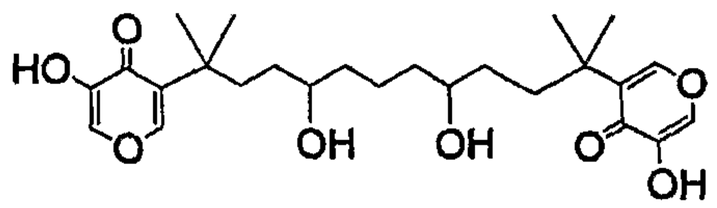
2,12-Bis-(3-hydroxy-isoxazol-5-yl)-2,12-dimethyl-tridecane-5,9-diol

Compound 214



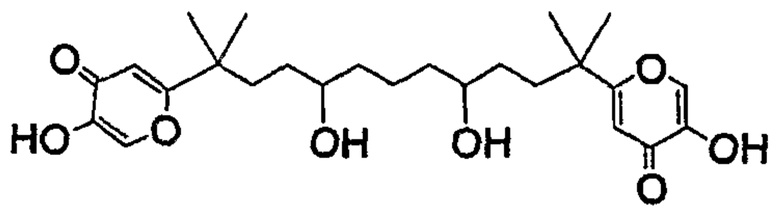
2,12-Bis-(3-hydroxy-isoxazol-4-yl)-2,12-dimethyl-tridecane-5,9-diol

Compound 215



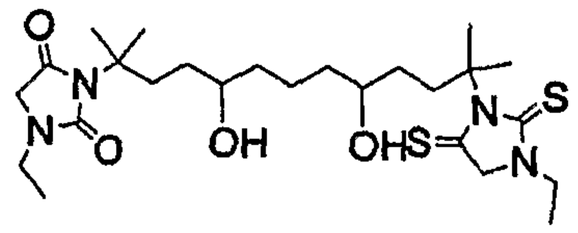
1,12-Bis-(5-(3-hydroxy-pyran-4-one)-2,12-dimethyl-tridecane-5,9-diol

Compound 216



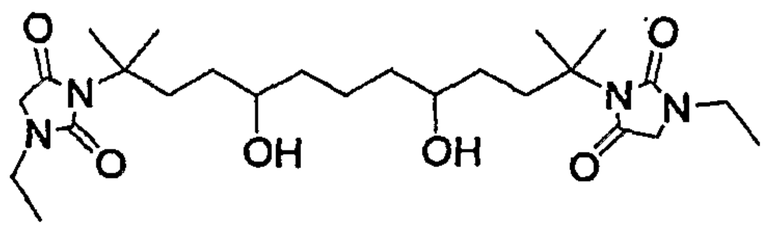
1,12-Bis-(6-(3-hydroxy-pyran-4-one)-2,12-dimethyl-tridecane-5,9-diol

Compound 217



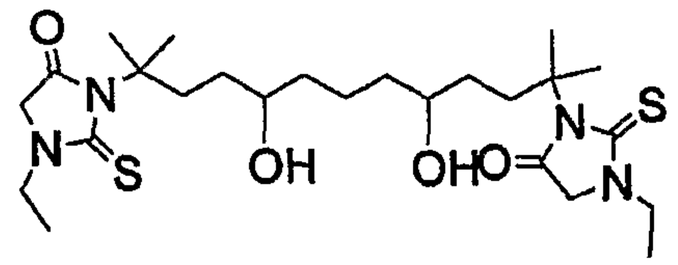
1-Ethyl-3-[11-(3-ethyl-2,5-dithioxo-imidazolidin-1-yl)-4,8-dihydroxy-1,1,11-trimethyl-dodecyl]-imidazolidine-2,4-dione

Compound 218



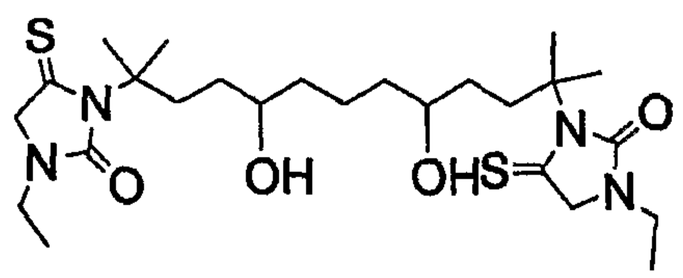
1,12-Bis-(1-Ethyl-imidazolin-3-yl-2,4-dione)-2,12-tetramethyl-tridecane-5,9-diol

Compound 219



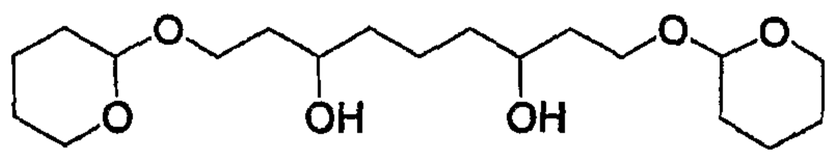
1,12-Bis-(1-Ethyl-imidazolin-3-yl-2-thioxo-4-one)-2,12-tetramethyl-tridecane-5,9-diol

Compound 220



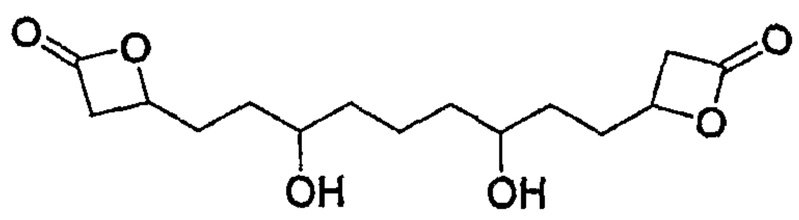
1,12-Bis-(1-Ethyl-imidazolin-3-yl-5-thioxo-4-one)-2,12-tetramethyl-tridecane-5,9-diol

Compound 221



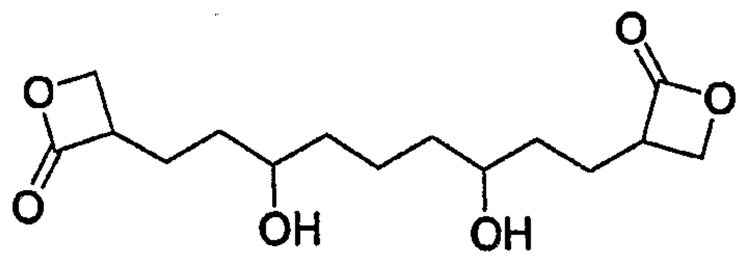
1,9-Bis-(tetrahydro-pyran-2-yloxy)-nonane-3,7-diol

Compound 222



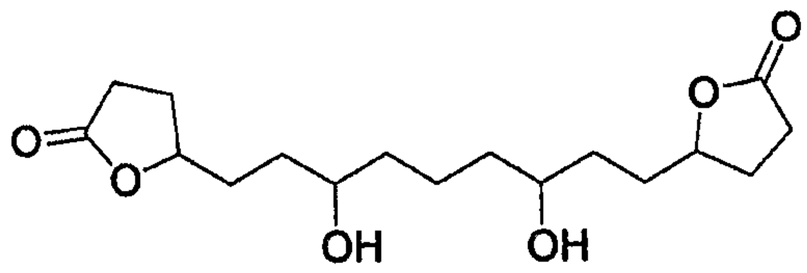
1,9-bis-(4-(Oxetan-2-one))-nonane-3,7-diol

Compound 223



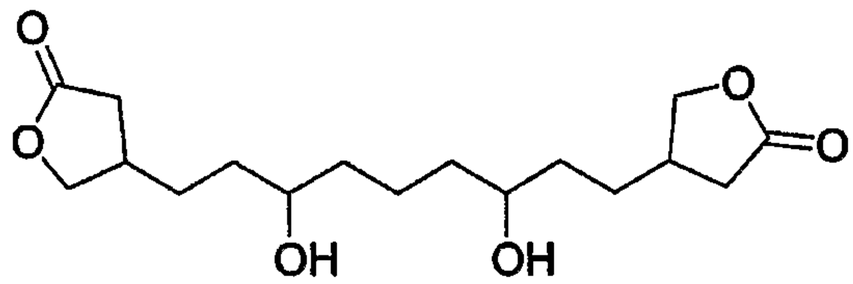
1,9-bis-(3-(Oxetan-2-one))-nonane-3,7-diol

Compound 224



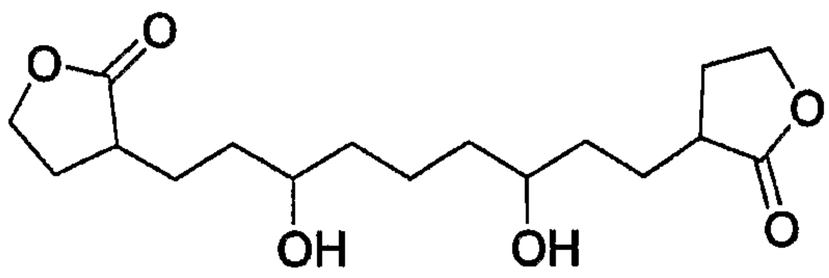
1,9-bis-(5-(Dihydro-furan-2-one))-nonane-3,7-diol

Compound 225



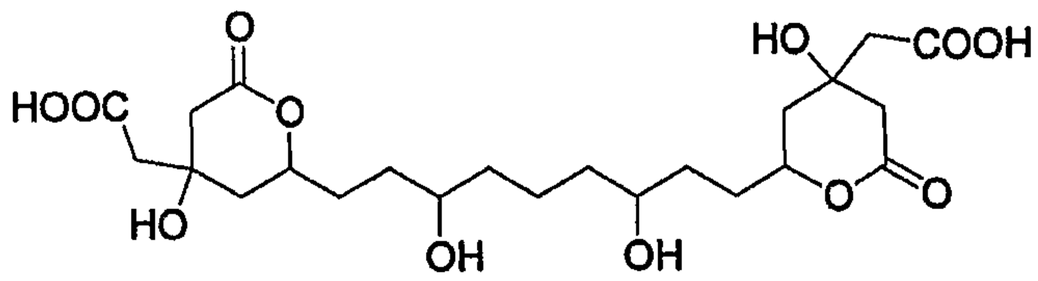
1,9-bis-(4-(Dihydro-furan-2-one))-nonane-3,7-diol

Compound 226



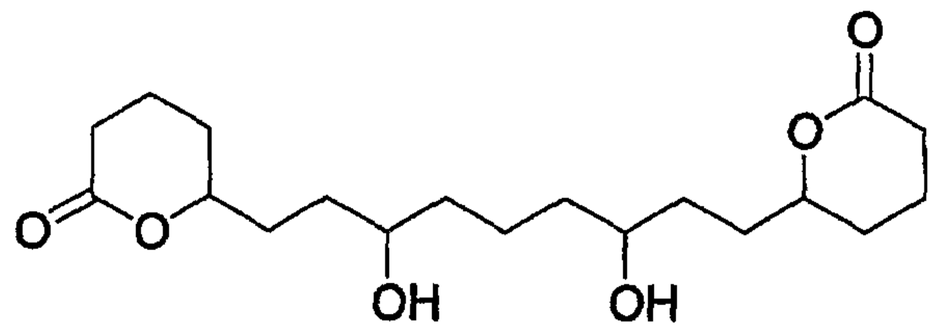
1,9-bis-(3-(Dihydro-furan-2-one))-nonane-3,7-diol

Compound 227



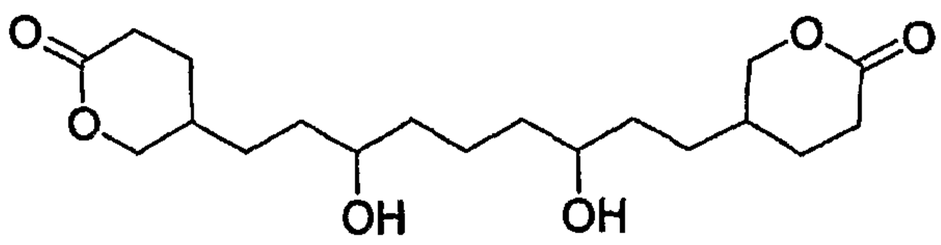
{2-[9-(4-Carboxymethyl-4-hydroxy-6-oxo-tetrahydro-pyran-2-yl)-3,7-dihydroxy-nonyl]-4-hydroxy-6-oxo-tetrahydro-pyran-4-yl}-acetic acid

Compound 228



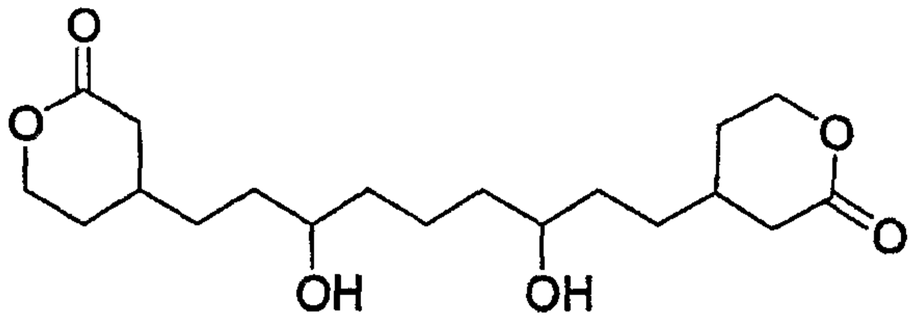
1,9-bis-(6-(Tetrahydro-pyran-2-one))-nonane-3,7-dio

Compound 229



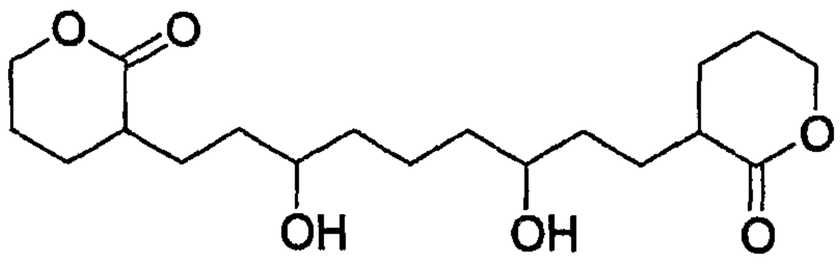
1,9-bis-(5-(Tetrahydro-pyran-2-one))-nonane-3,7-diol

Compound 230



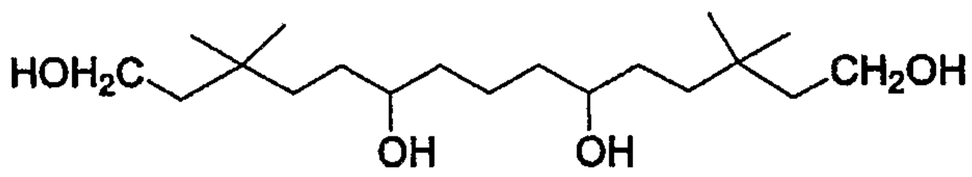
1,9-bis-(4-(Tetrahydro-pyran-2-one))-nonane-3,7-diol

Compound 231



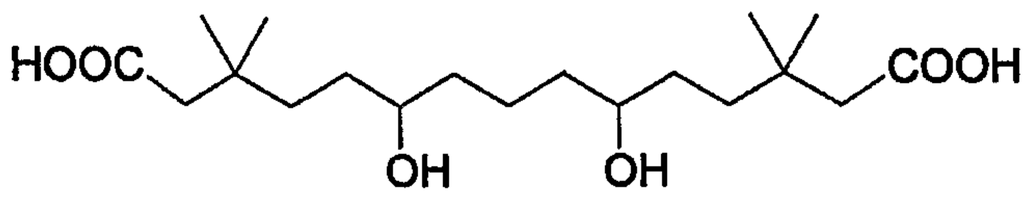
1,9-bis-(6-(Tetrahydro-pyran-2-one))-nonane-3,7-diol

Compound 232



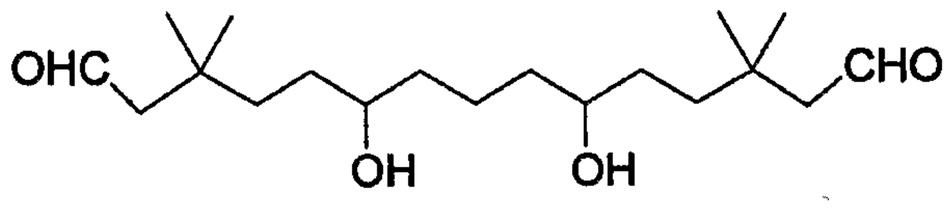
3,3,13,13-Tetramethyl-pentadecane-1,6,10,15-tetraol

Compound 233



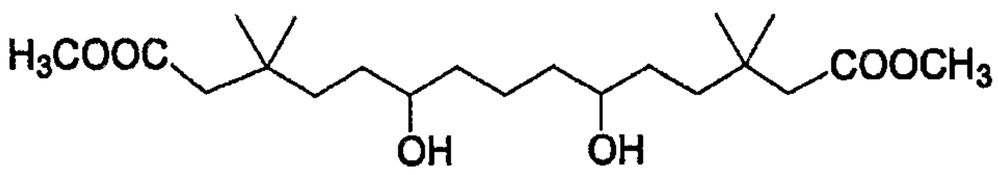
6,10-Dihydroxy-3,3,13,13-tetramethyl-pentadecanedioic acid

Compound 234



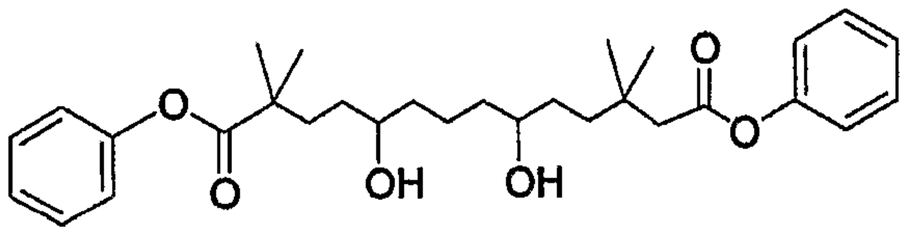
6,10-Dihydroxy-3,3,13,13-tetramethyl-pentadecanedial

Compound 235



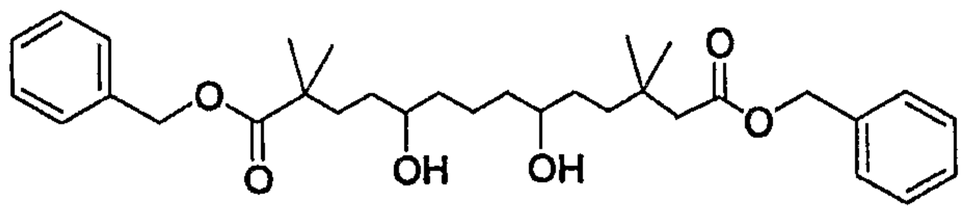
6,10-Dihydroxy-3,3,13,13-tetramethyl-pentadecanedioic acid dimethyl ester

Compound 236



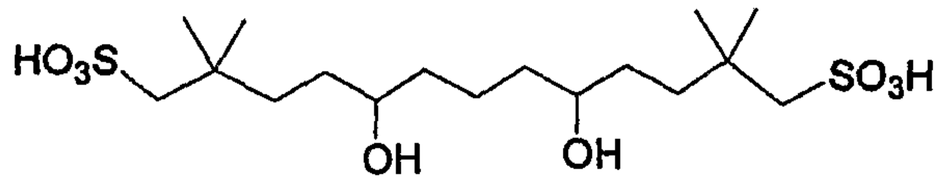
5,9-Dihydroxy-2,2,12,12-tetramethyl-tetradecanedioic acid diphenyl ester

Compound 237



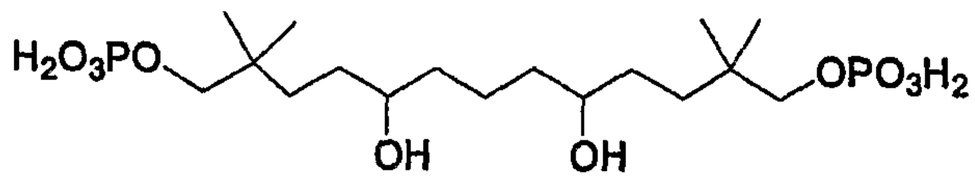
5,9-Dihydroxy-2,2,12,12-tetramethyl-tetradecanedioic acid dibenzyl ester

Compound 238



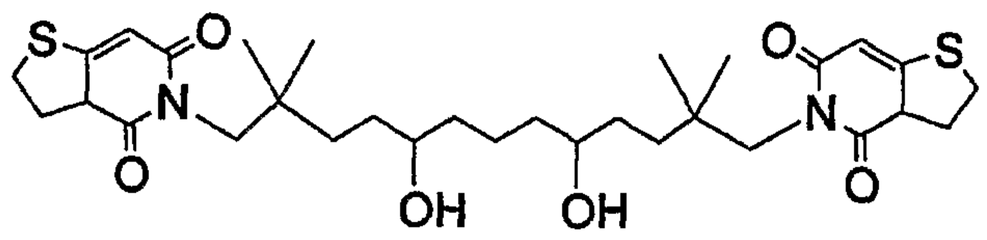
5,9-Dihydroxy-2,2,12,12-tetramethyl-tridecane-1,13-disulfonic acid

Compound 239



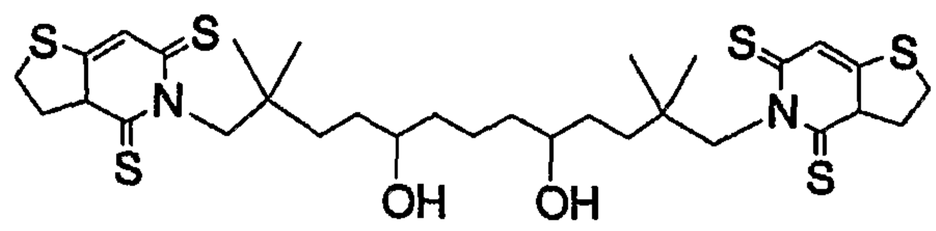
Phosphoric acid mono-(5,9-dihydroxy-2,2,12,12-tetramethyl-13-phosphonooxy-tridecyl) ester

Compound 240



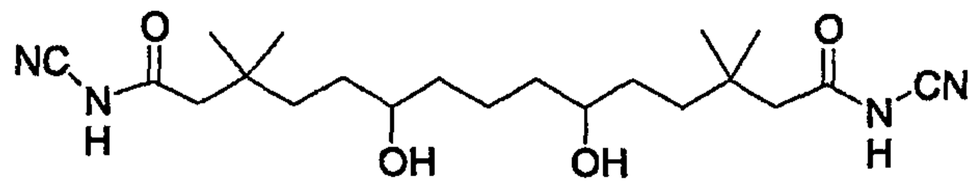
1,13-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dione))-5,9-dihydroxy-2,2,12,12-tetramethyl-tridecane

Compound 241



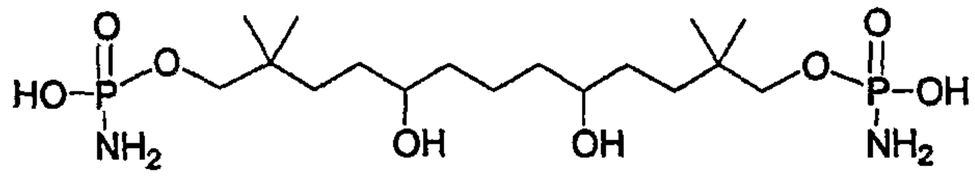
1,13-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dithioxo))-5,9-dihydroxy-2,2,12,12-tetramethyl-tridecane

Compound 242



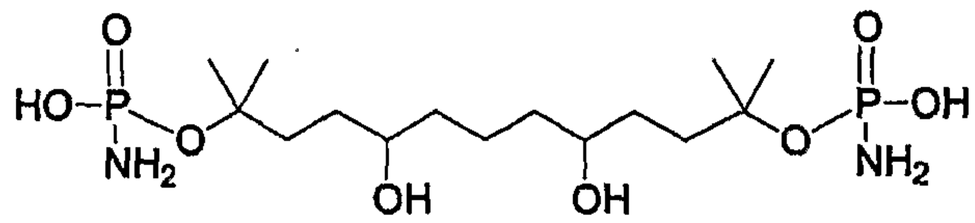
1,15-bis-(N-Cyanoamido)-6,10-dihydroxy-3,3,13,13-tetramethyl-pentadecane

Compound 243



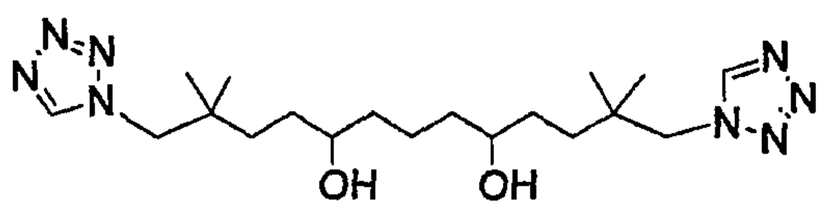
Phosphoramidic acid mono-[13-(amino-hydroxy-phosphoryloxy)-5,9-dihydroxy-2,2,12,12-tetramethyl-tridecyl] ester

Compound 244



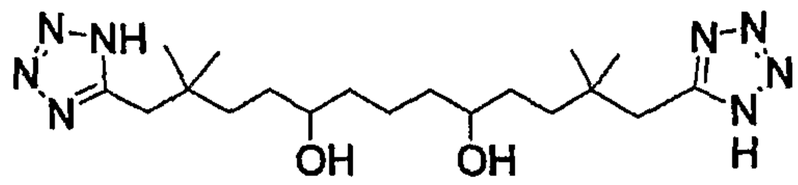
Phosphoramidic acid mono-[11-(amino-hydroxy-phosphoryloxy)-4,8-dihydroxy-1,1,11-trimethyl-dodecyl] ester

Compound 245



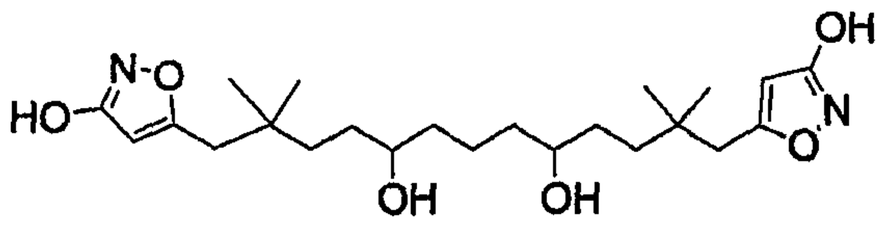
2,2,12,12-Tetramethyl-1,13-bis-tetrazol-1-yl-tridecane-5,9-diol

Compound 246



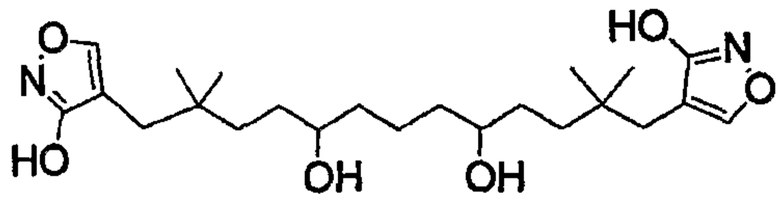
2,2,12,12-Tetramethyl-1,13-bis-(1H-tetrazol-5-yl)-tridecane-5,9-diol

Compound 247



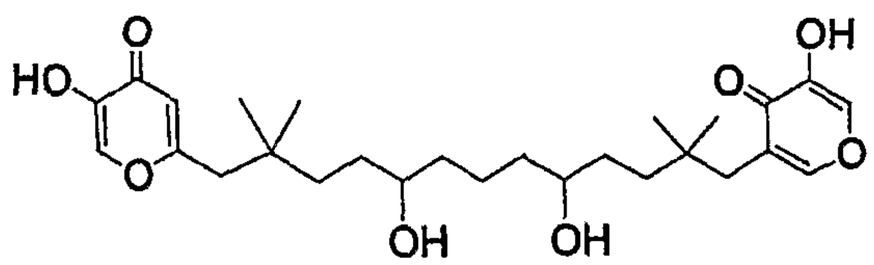
1,13-Bis-(3-hydroxy-isoxazol-5-yl)-2,2,12,12-tetramethyl-tridecane-5,9-diol

Compound 248



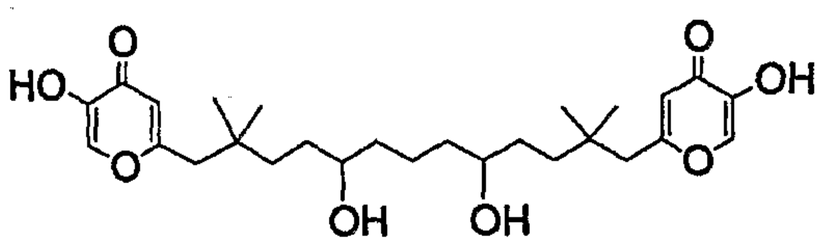
1,13-Bis-(3-hydroxy-isoxazol-4-yl)-2,2,12,12-tetramethyl-tridecane-5,9-diol

Compound 249



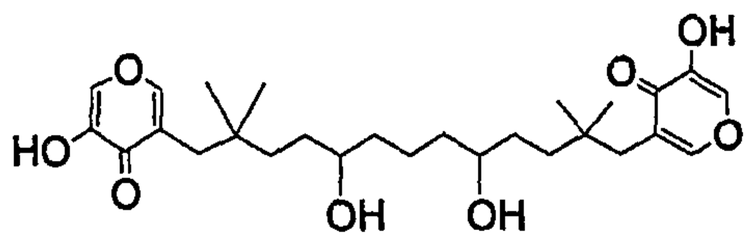
1-(6-(3-hydroxy-pyran-4-one)-13-(5-(3-hydroxy-pyran-4-one)- 2,2,12,12-tetramethyl-tridecane-5,9-diol

Compound 250



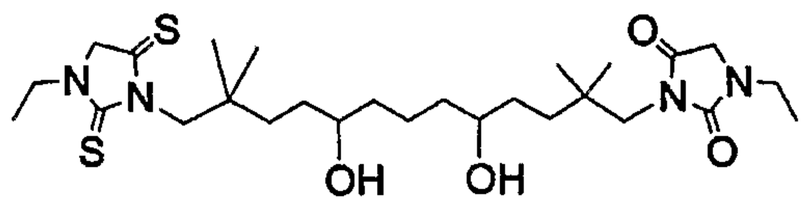
1, 13-bis-(6-(3-hydroxy-pyran-4-one)-2,2,12,12-tetramethyl-tridecane-5,9-diol

Compound 251



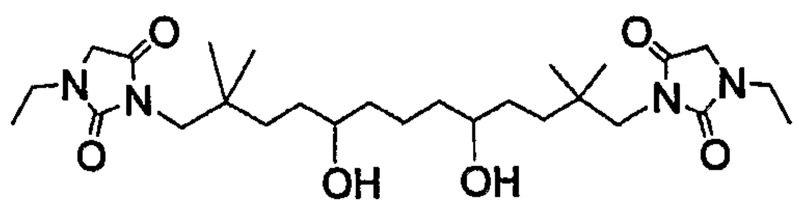
1, 13-bis-(5-(3-hydroxy-pyran-4-one)-2,2,12,12-tetramethyl-tridecane-5,9-diol

Compound 252



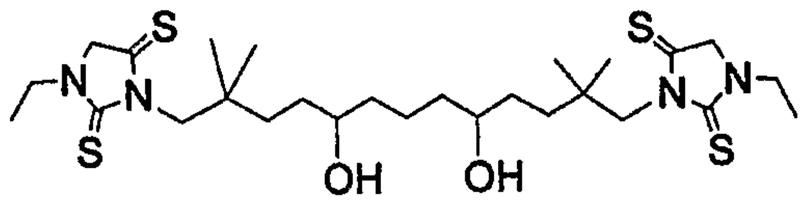
1-Ethyl-3-[13-(3-ethyl-2,5-dithioxo-imidazolidin-1-yl)-5,9-dihydroxy-2,2,12,12-tetramethyl-tridecyl]-imidazolidine-2,4-dione

Compound 253



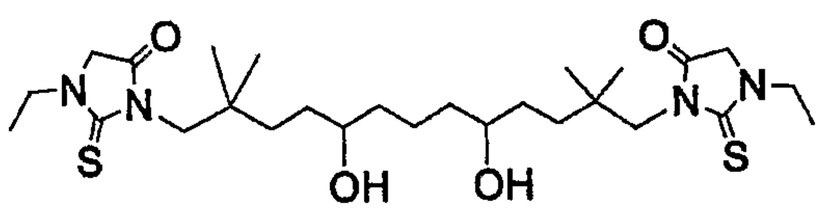
1,13-bis-(1-Ethyl-imidazolin-3-yl-2,4-dione)-2,2,12,12-tetramethyl-dodecane-5,9-diol

Compound 254



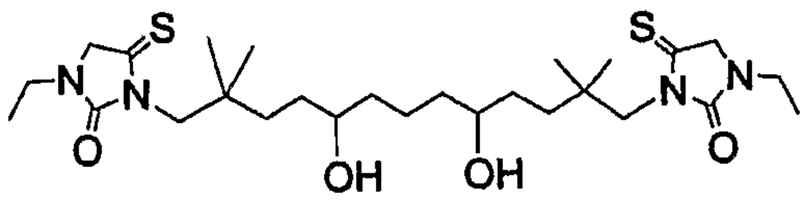
1,13-bis-(1-Ethyl-imidazolin-3-yl-2,4-dithioxo)-2,2,12,12-tetramethyl-dodecane-5,9-diol

Compound 255



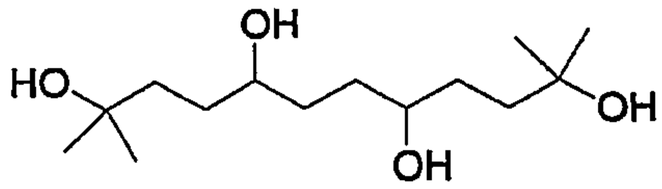
1,13-bis-(1-Ethyl-imidazolin-3-yl-2-thioxo-4-one)-2,2,12,12-tetramethyl-dodecane-5,9-diol

Compound 256



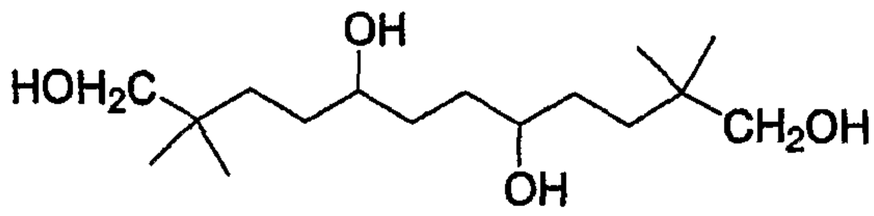
1,13-bis-(1-Ethyl-imidazolin-3-yl-4-thioxo-2-one)-2,2,12,12-tetramethyl-dodecane-5,9-diol

Compound 257



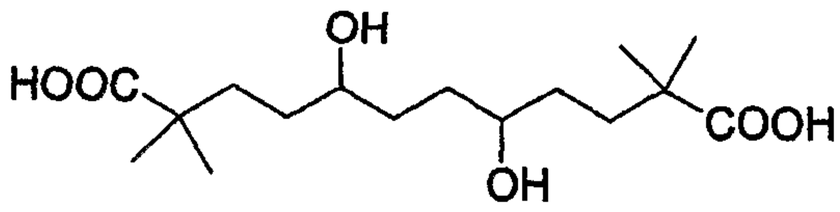
2,11-Dimethyl-dodecane-2,5,8,11-tetraol

Compound 258



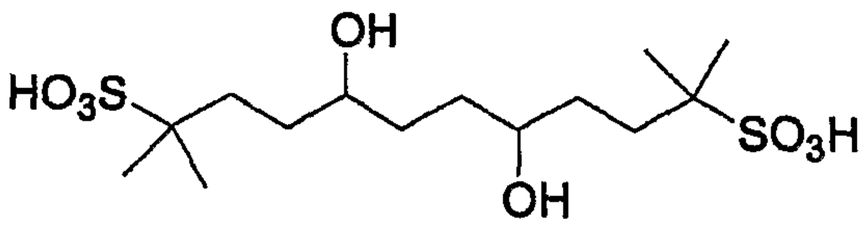
2,2,11,11-Tetramethyl-dodecane-1,5,8,12-tetraol

Compound 259



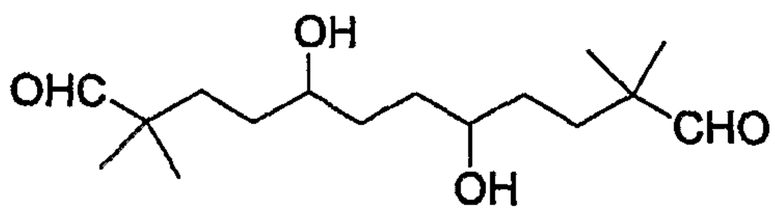
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedioic acid

Compound 260



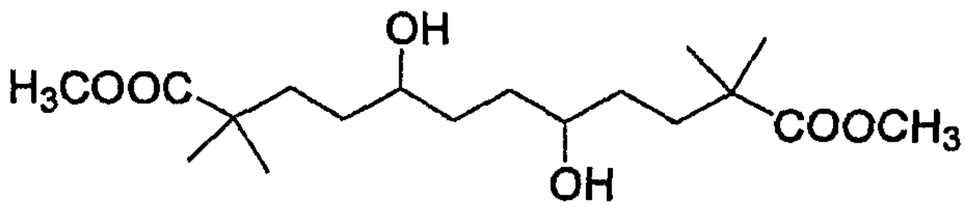
5,8-Dihydroxy-2,11-dimethyl-dodecane-2,11-disulfonic acid

Compound 261



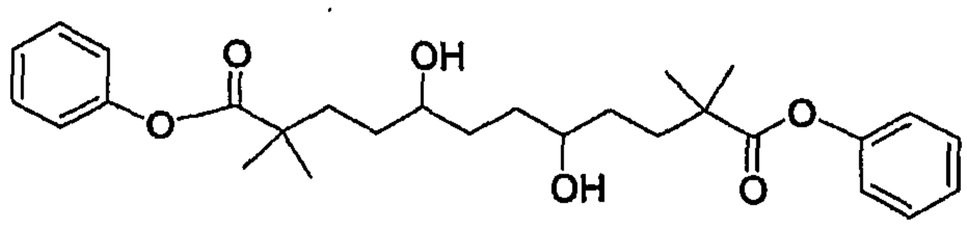
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedial

Compound 262



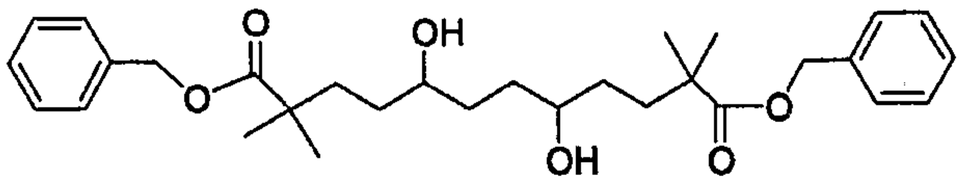
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedioic acid dimethyl ester

Compound 263



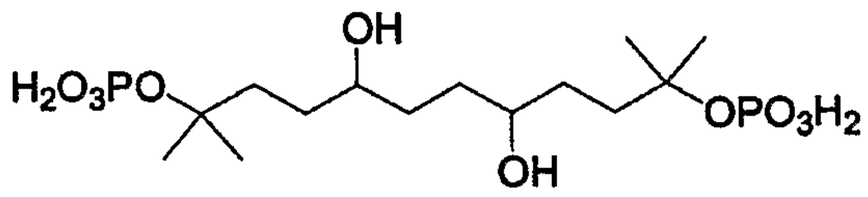
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedioic acid diphenyl ester

Compound 264



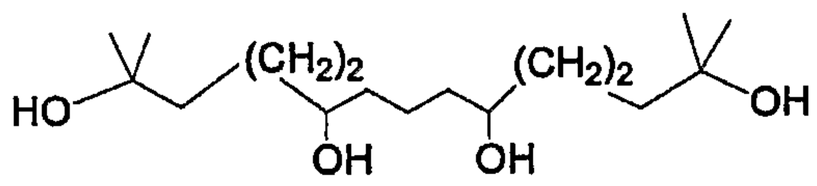
5,8-Dihydroxy-2,2,11,11-tetramethyl-dodecanedioic acid dibenzyl ester

Compound 265



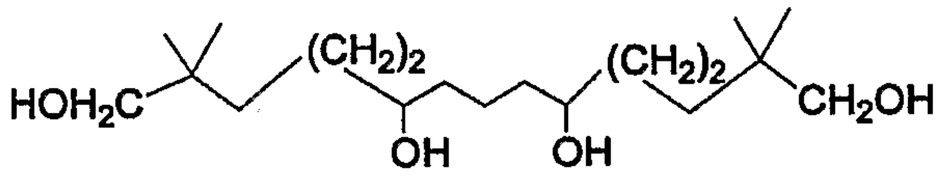
Phosphoric acid mono-(4,7-dihydroxy-1,1,10-trimethyl-10-phosphonooxy-undecyl) ester

Compound 266



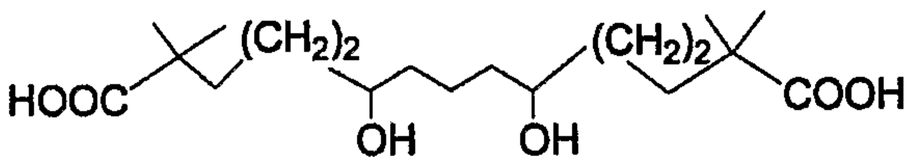
2,14-Dimethyl-pentadecane-2,6,10,14-tetraol

Compound 267



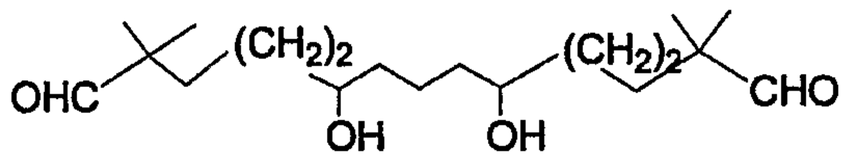
2,2,14,14-Tetramethyl-pentadecane-1,6,10,15-tetraol

Compound 268



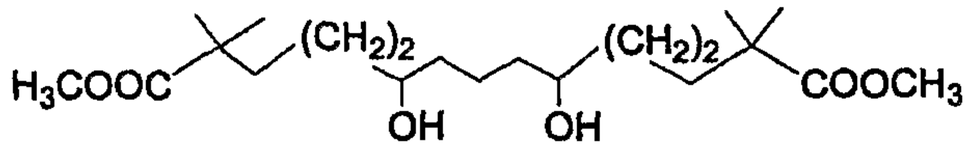
6,10-Dihydroxy-2,2,14,14-tetramethyl-pentadecanedioic acid

Compound 269



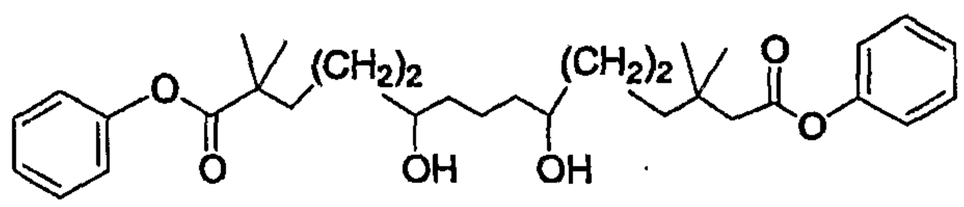
6,10-Dihydroxy-2,2,14,14-tetramethyl-pentadecanedial

Compound 270



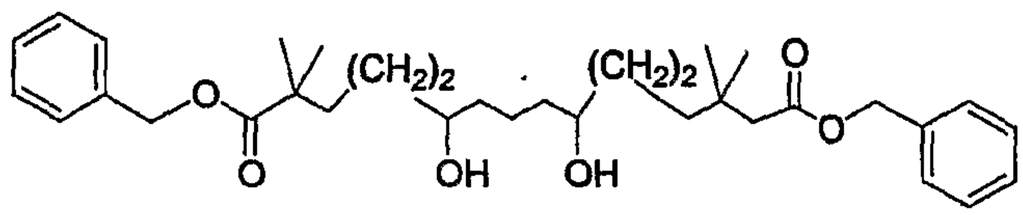
6,10-Dihydroxy-2,2,14,14-tetramethyl-pentadecanedioic acid dimethyl ester

Compound 271



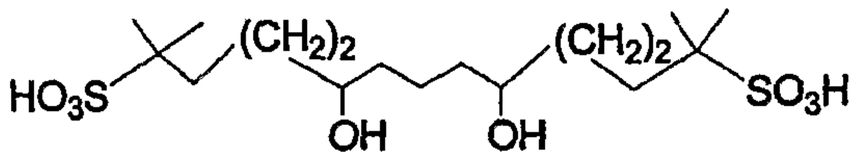
6,10-Dihydroxy-2,2,14,14-tetramethyl-hexadecanedioic acid diphenyl ester

Compound 272



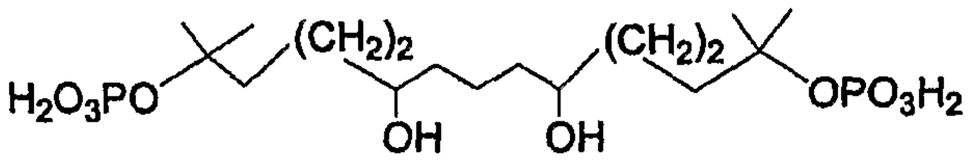
6,10-Dihydroxy-2,2,14,14-tetramethyl-hexadecanedioic acid dibenzyl ester

Compound 273



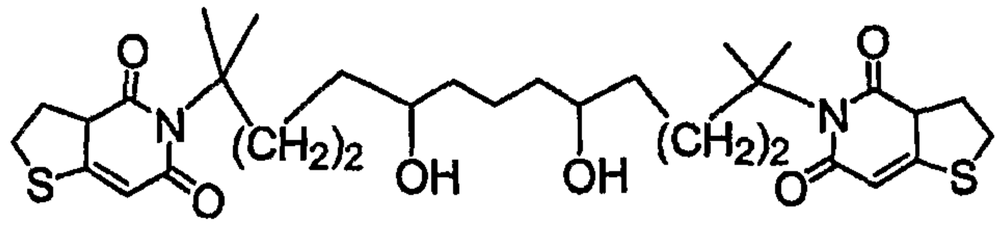
6,10-Dihydroxy-2,14-dimethyl-pentadecane-2,14-disulfonic acid

Compound 274



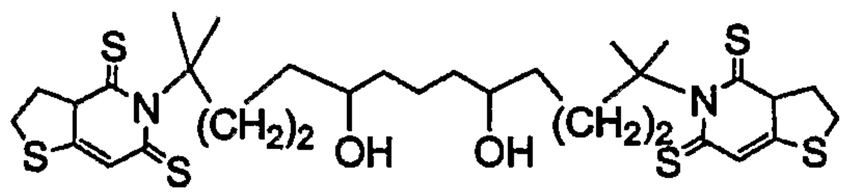
Phosphoric acid mono-(5,9-dihydroxy-1,1,13-trimethyl-13-phosphonooxy-tetradecyl) ester

Compound 275



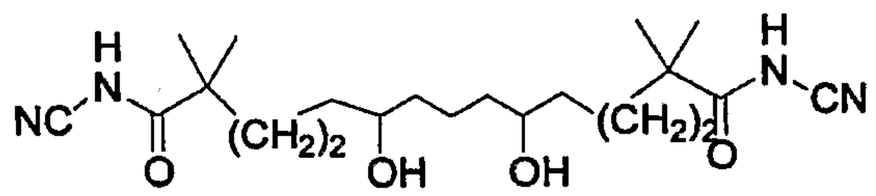
2,14-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dione))-6,10-dihydroxy-2,14-dimethyl-pentadecane

Compound 276



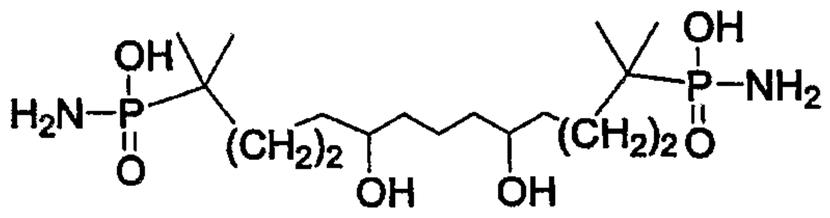
2,14-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dithioxo))-6,10-dihydroxy-2,14-dimethyl-pentadecane

Compound 277



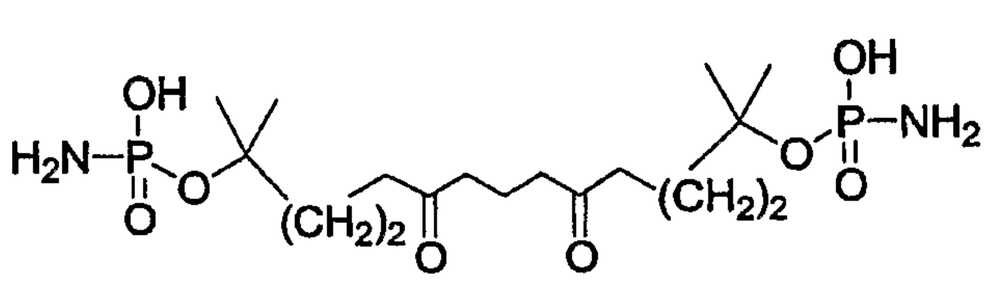
1,15-bis-(N-Cyanoamido)-6,10-dihydroxy-2,14-dimethyl-pentadecane

Compound 278



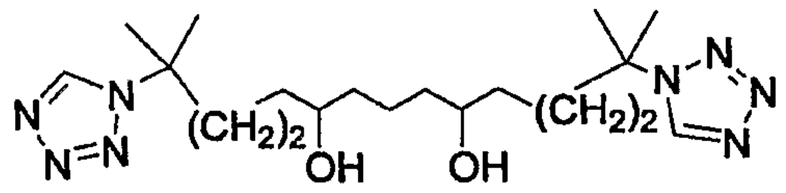
Phosphoramic acid mono-[13-(amino-hydroxy-phosphoryloxy)-1,1,13-trimethyl-5,9-dioxo-tetradecyl] ester

Compound 279



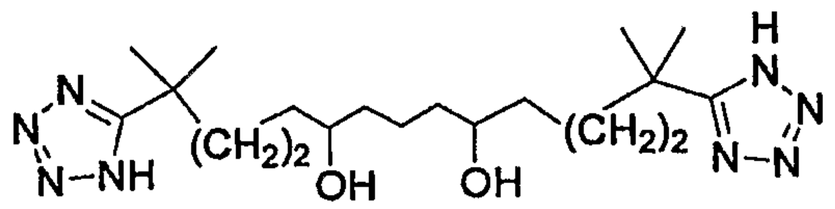
Phosphoramidic acid mono-[13-(amino-hydroxy-phosphoryloxy)-1,1,13-trimethyl-5,9-dioxo-tetradecyl] ester

Compound 280



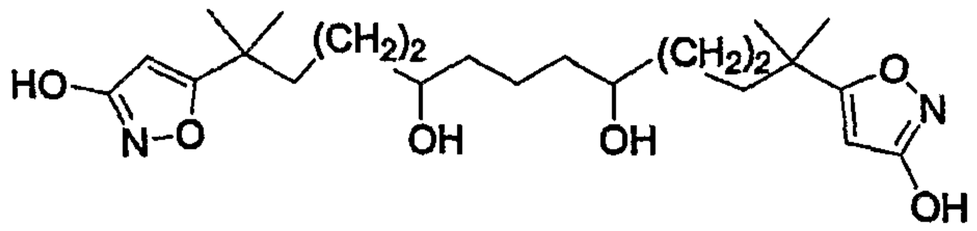
2,14-Dimethyl-2,14-bis-tetrazol-1-yl-pentadecane-6,10-diol

Compound 281



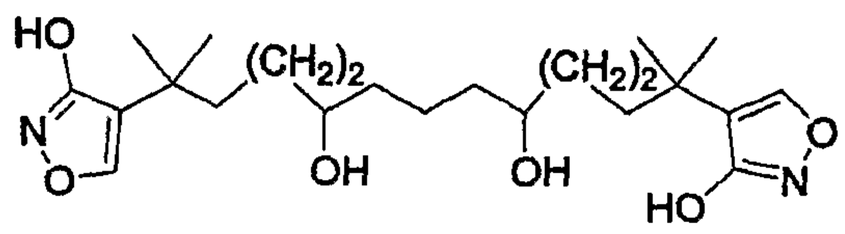
2,14-Dimethyl-2,14-bis-(1H-tetrazol-5-yl)-pentadecane-6,10-diol

Compound 282



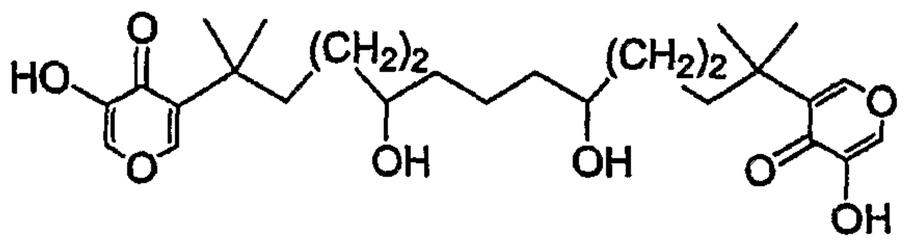
2,14-Bis-(3-hydroxy-isoxazol-5-yl)-2,14-dimethyl-pentadecane-6,10-diol

Compound 283



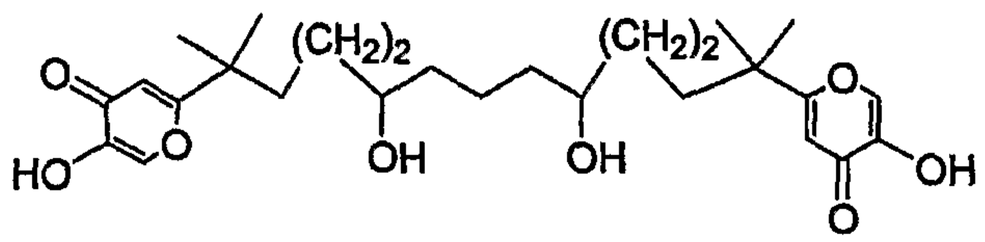
2,14-Bis-(3-hydroxy-isoxazol-4-yl)-2,14-dimethyl-pentadecane-6,10-diol

Compound 284



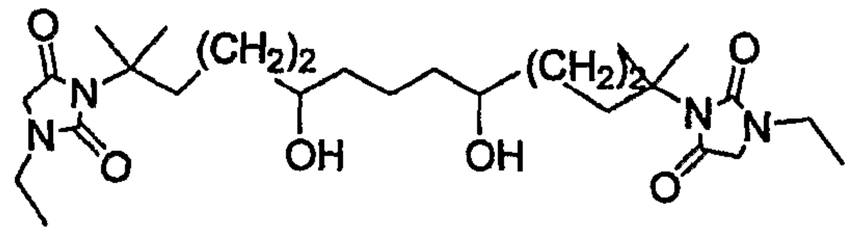
2,14-bis-(5-(3-Hydroxy-pyran-4-one)-2,14-dimethyl-pentadecane-6,10-diol

Compound 285



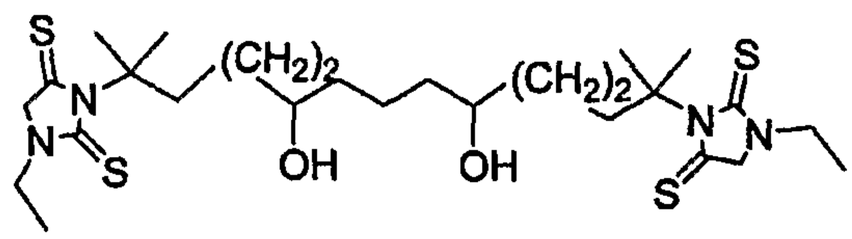
2,14-bis-(6-(3-Hydroxy-pyran-4-one)-2,14-dimethyl-pentadecane-6,10-diol

Compound 286



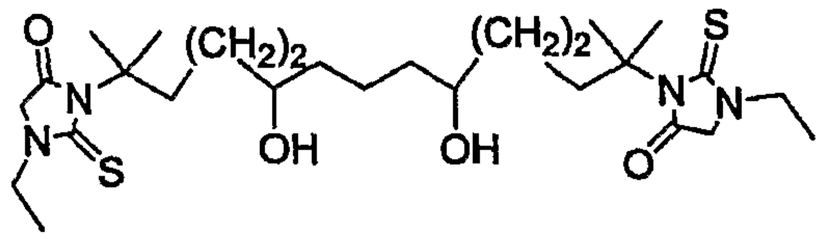
1,15-bis-(1-Ethyl-imidazolin-3-yl-2,4-dione)-2,14-dimethyl-pentadecane-6,10-diol

Compound 287



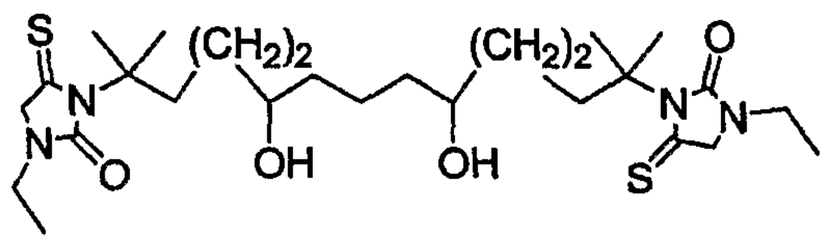
2,14-bis-(1-Ethyl-imidazolin-3-yl-2,4-dithioxo)-2,14-dimethyl-pentadecane-6,10-diol

Compound 288



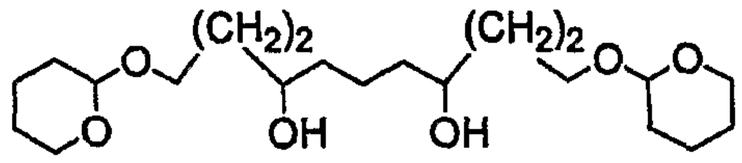
2,14-bis-(1-Ethyl-imidazolin-3-yl-2-thioxo-4-one)-2,14-dimethyl-pentadecane-6,10-diol

Compound 289



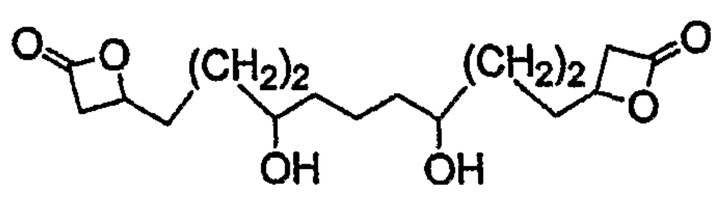
2,14-bis-(1-Ethyl-imidazolin-3-yl-4-thioxo-2-one)-2,14-dimethyl-pentadecane-6,10-diol

Compound 290



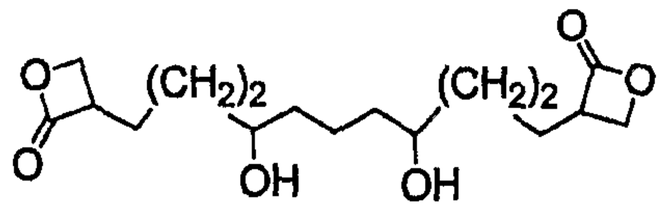
1,11-Bis-(tetrahydro-pyran-2-yloxy)-undecane-4,8-diol

Compound 291



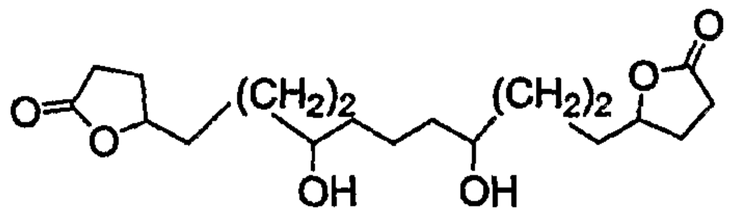
1,11-bis-(4-(Oxetan-2-one))-undecane-4,8-diol

Compound 292



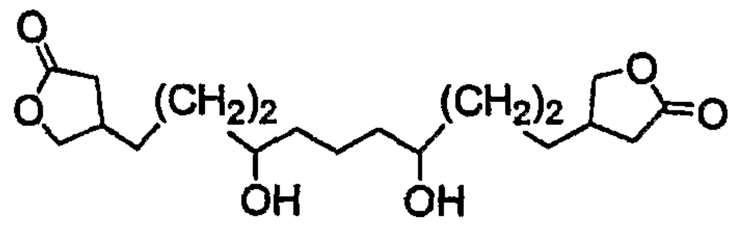
1,11-bis-(3-(Oxetan-2-one))-undecane-4,8-diol

Compound 293



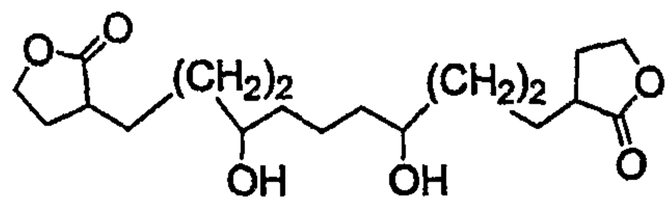
1,11-bis-(5-(Dihydro-furan-2-one))-undecane-4,8-diol

Compound 294



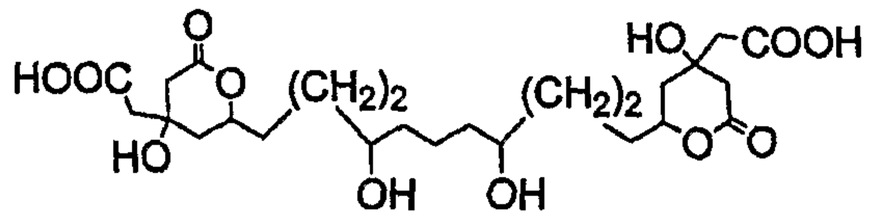
1,11-bis-(4-(Dihydro-furan-2-one))-undecane-4,8-diol

Compound 295



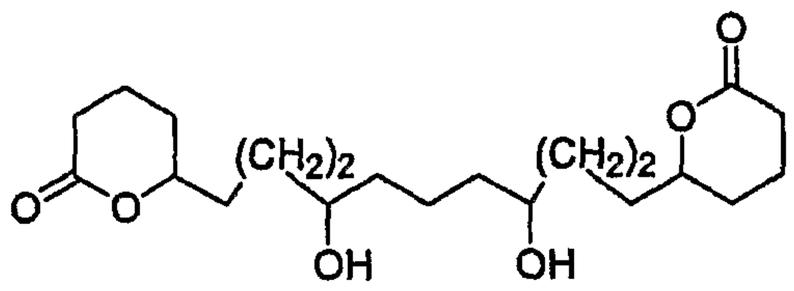
1,11-bis-(5-(Dihydro-furan-2-one))-undecane-4,8-diol

Compound 296



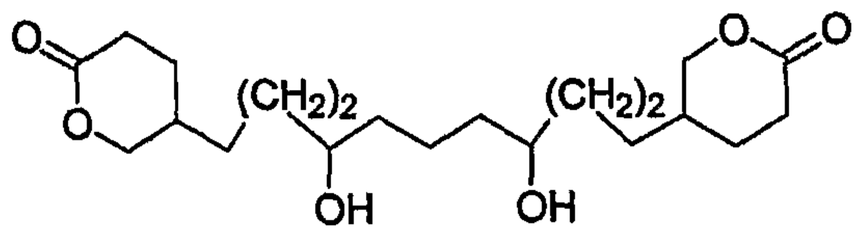
{2-[11-(4-Carboxymethyl-4-hydroxy-6-oxo-tetrahydro-pyran-2-yl)-4,8-dihydroxy-undecyl]-4-hydroxy-6-oxo-tetrahydro-pyran-4-yl}-acetic acid

Compound 297



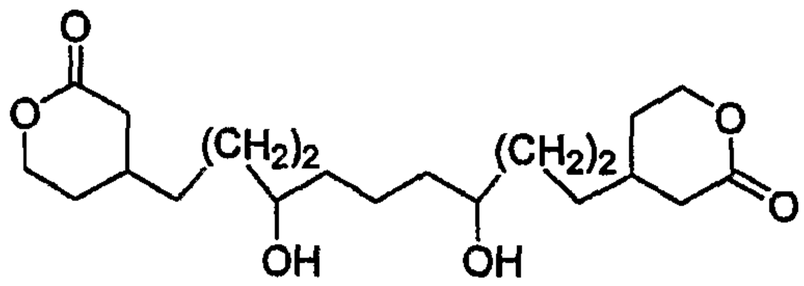
1,11-bis-(6-(Tetrahydro-pyran-2-one))-undecane-4,8-diol

Compound 298



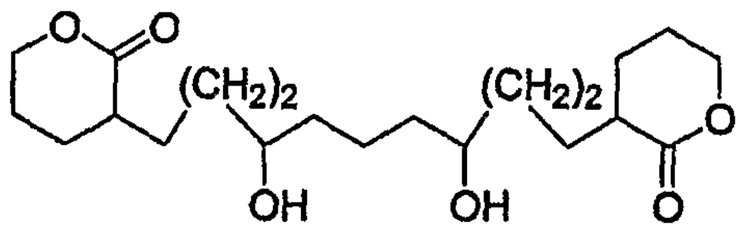
1,11-bis-(5-(Tetrahydro-pyran-2-one))-undecane-4,8-diol

Compound 299



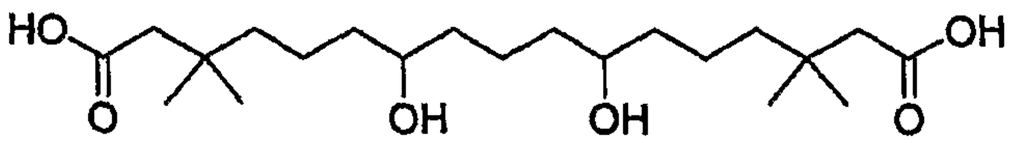
1,11-bis-(4-(Tetrahydro-pyran-2-one))-undecane-4,8-diol

Compound 300



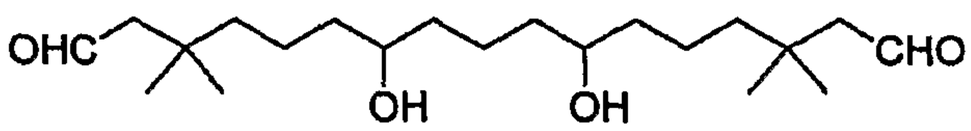
1,11-bis-(3-(Tetrahydro-pyran-2-one))-undecane-4,8-diol

Compound 301



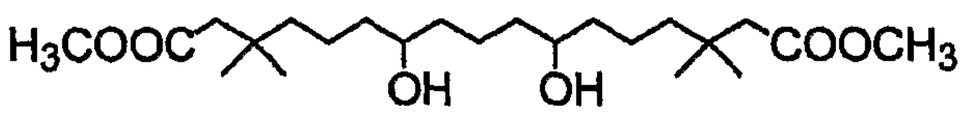
7,11-Dihydroxy-3,3,15,15-tetramethyl-heptadecanedioic acid

Compound 302



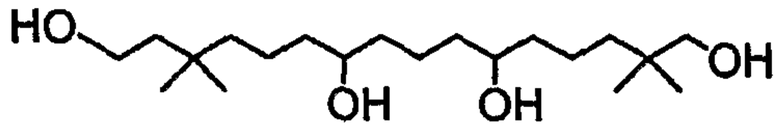
7,11-Dihydroxy-3,315,15-tetramethyl-heptad

Compound 303



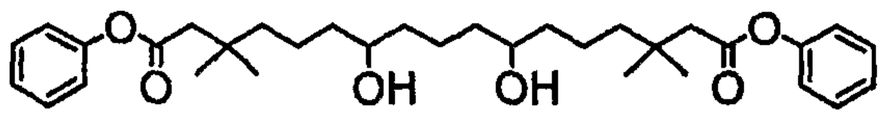
7,11-Dihydroxy-3,3,15,15-tetramethyl-heptadecanedioic acid dimethyl ester

Compound 304



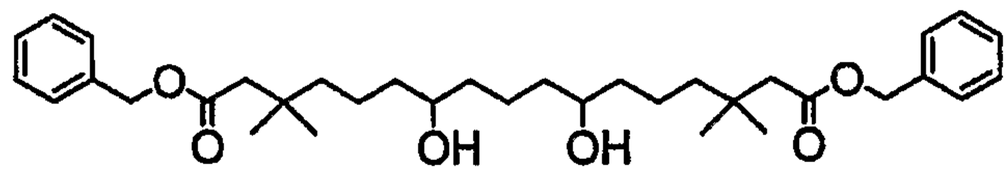
3,3,15,15-Tetramethyl-heptadecane-1,7,11,17-tetraol

Compound 305



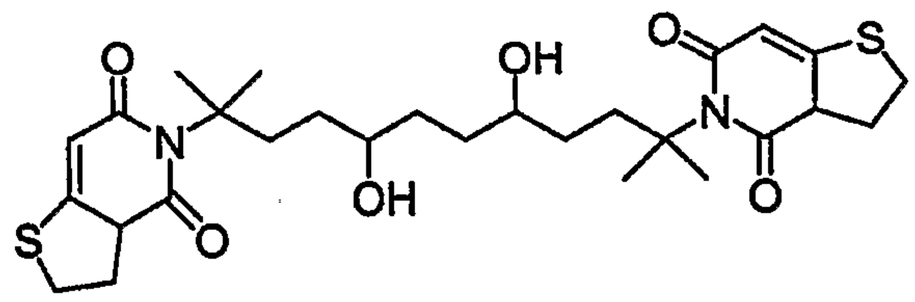
7,11-Dihydroxy-3,3,15,15-tetramethyl-heptadecanedioic acid diphenyl ester

Compound 306



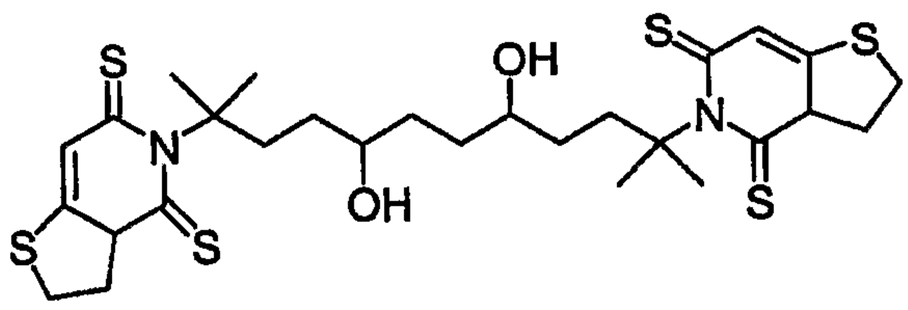
7,11-Dihydroxy-3,3,15,15-tetramethyl-heptadecanedioic acid dibenzyl ester

Compound 307



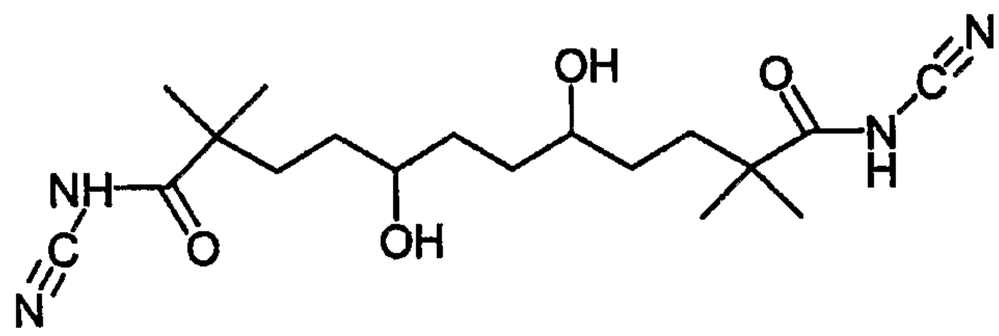
1,11-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dione))-5,8-dihydroxy-2-11-dimethyl-dodecane

Compound 308



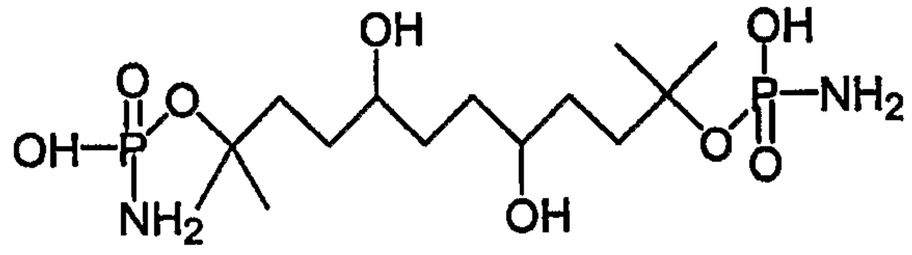
1,11-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dithioxo))-5,8-dihydroxy-2-11-dimethyl-dodecane

Compound 309



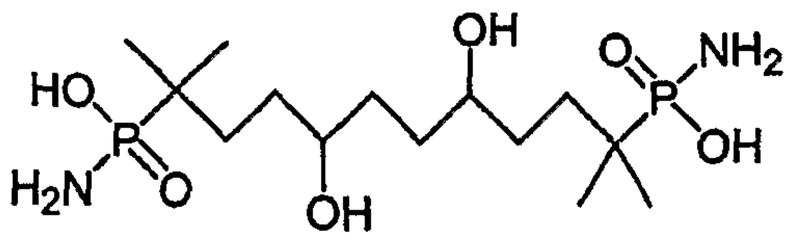
2,11-bis-(N-Cyanoamido)-5,8-dihydroxy-2,11-dimethyl-dodecane

Compound 310



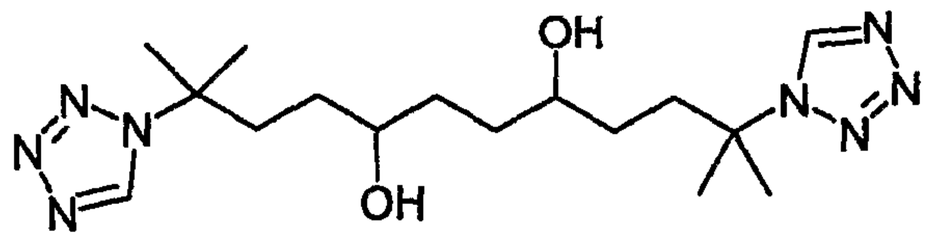
2-Phosphoramidic acid mono-[11-(amino-hydroxy-phosphoryloxy)-2,11,11-trimethyl-5,8-dioxo-dodecyl] ester

Compound 311



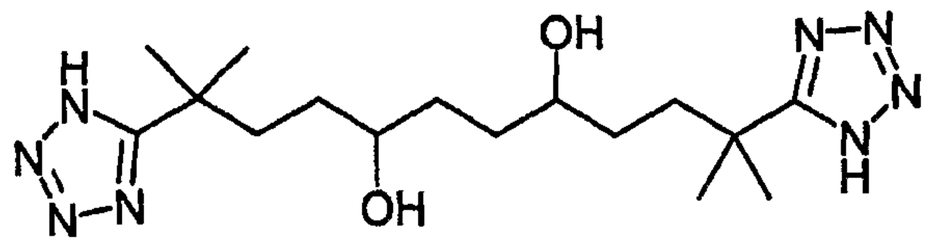
Phosphoramic acid mono-[11-(amino-hydroxy-phosphoryloxy)-1,1,11-trimethyl-5,8-dioxo-dodecyl] ester

Compound 312



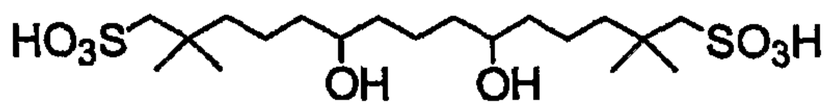
Phosphoramic acid mono-[11-(amino-hydroxy-phosphoryloxy)-1,1,11-trimethyl-5,8-dioxo-dodecyl] ester

Compound 313



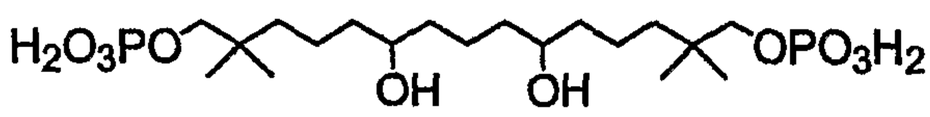
2,11-Dimethyl-2,11-bis-(1H-tetrazol-5-yl)-dodecane-5,8-diol

Compound 314



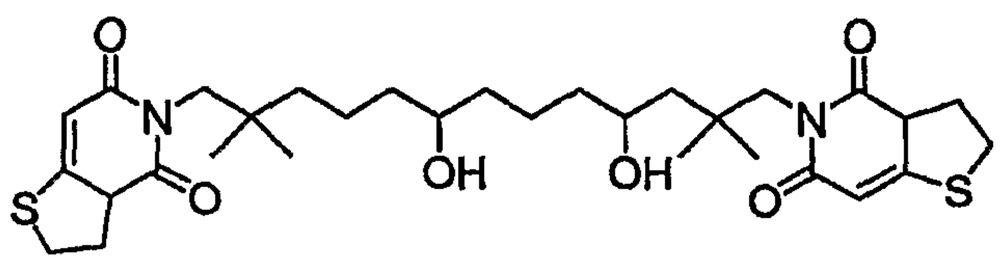
6,10-Dihydroxy-2,2,14,14-tetramethyl-pentadecane-1,15-disulfonic acid

Compound 315



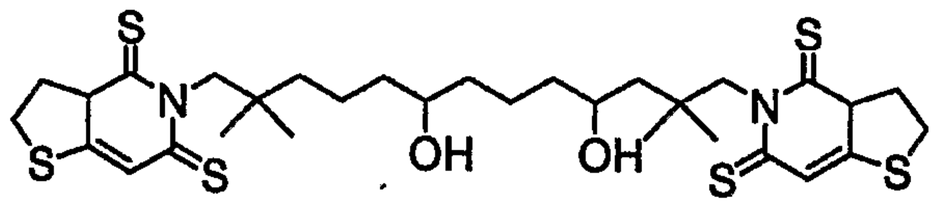
Phosphoric acid mono-(6,10-dihydroxy-2,2,14,14-tetramethyl-15-phosphonooxy-pentadecyl) ester

Compound 316



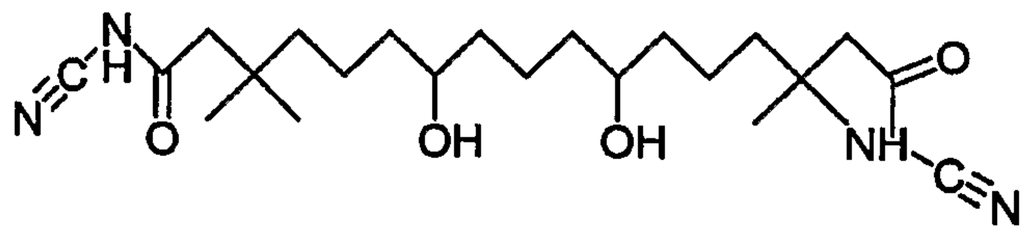
1,15-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dione))-6,10-dihydroxy-2,2,14,14-tetramethyl-pentadecane

Compound 317



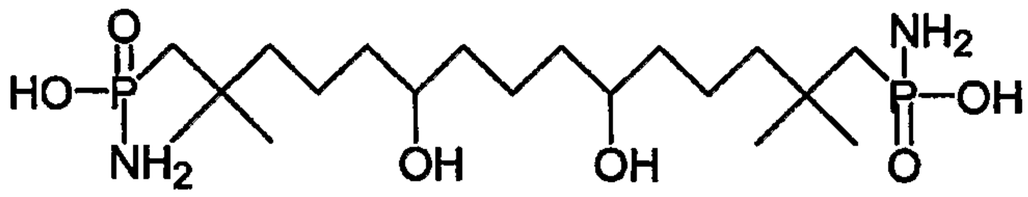
1,15-bis-(N-(3,3a-dihydro-2H-thieno[3,2,c]pyridine-4,6-dithioxo))-6,10-dihydroxy-2,2,14,14-tetramethyl-pentadecane

Compound 318



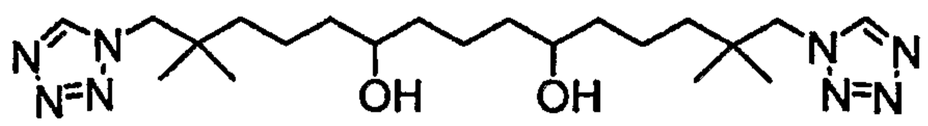
1,15-bis-(N-Cyanoamido)-6,10-dihydroxy-2,14-tetramethyl-pentadecane

Compound 319



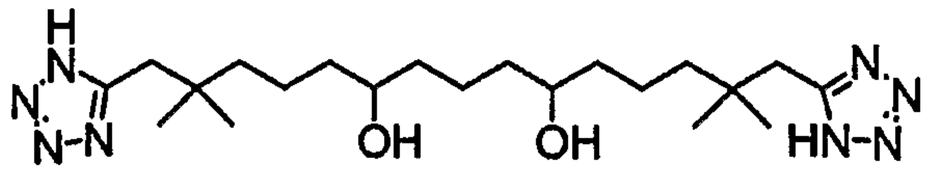
Phosphoramidic acid mono-15-(amino-hydroxy-phosphoryloxy)-(2,2,14,14-tetramethyl-6,10-dioxo)-pentadecane

Compound 320



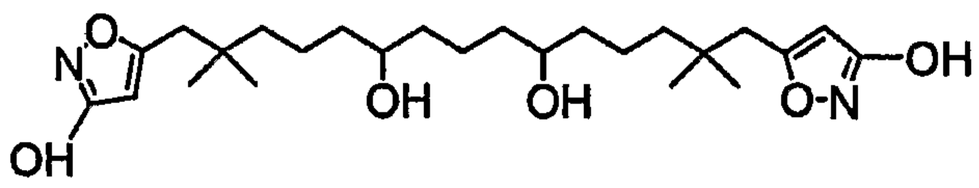
2,2,14,14-Tetramethyl-1,15-bis-tetrazol-1-yl-pentadecane-6,10-diol

Compound 321



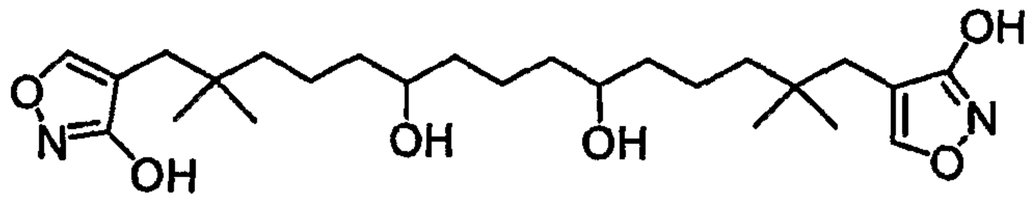
2,2,14,14-Tetramethyl-1,15-bis-(1H-tetrazol-5-yl)-pentadecane-6,10-diol

Compound 322



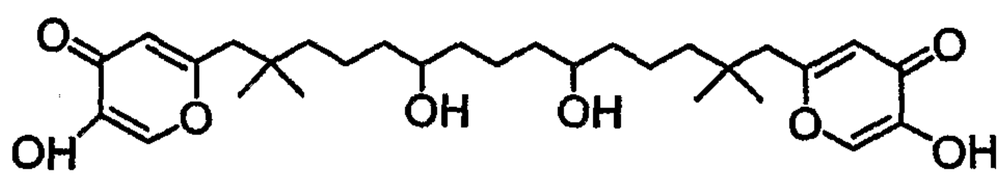
1,15-Bis-(3-hydroxy-isoxazol-5-yl)-2,2,14,14-tetramethyl-pentadecane-6,10-diol

Compound 323



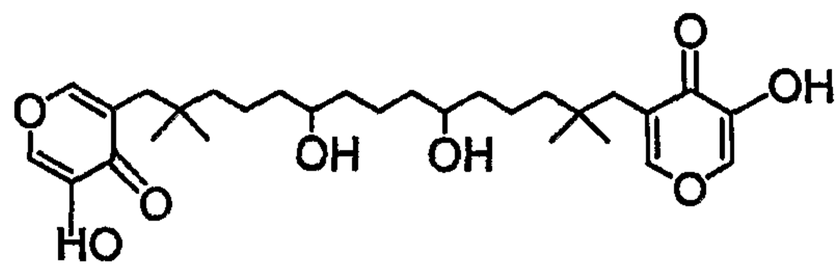
1,15-Bis-(3-hydroxy-isoxazol-4-yl)-2,2,14,14-tetramethyl-pentadecane-6,10-diol

Compound 324



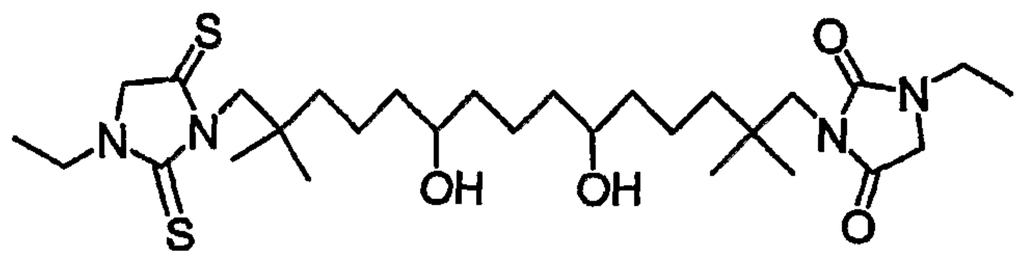
1,15-Bis-(6-(3-hydroxy-pyran-4-one)-2,2,14,14-tetramethyl-pentadecane-6,10-diol

Compound 325



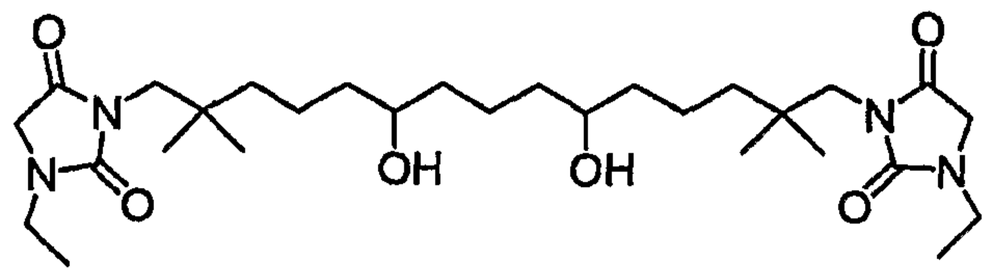
1,15-Bis-(5-(3-hydroxy-pyran-4-one)-2,2,14,14-tetramethyl-pentadecane-6,10-diol

Compound 326



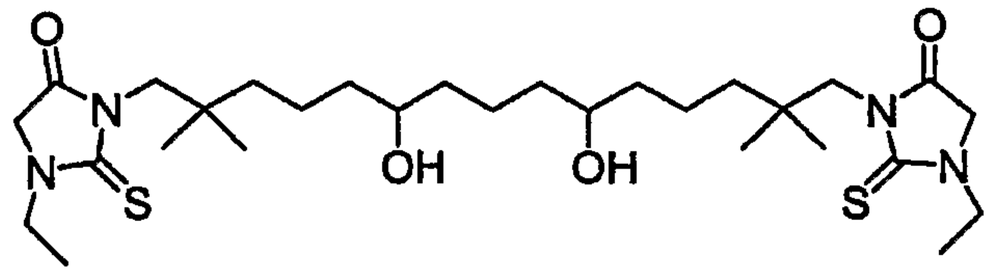
1-Ethyl-3-[15-(3-ethyl-2,5-dithioxo-imidazolidin-1-yl)-6,10-dihydroxy-2,2,14,14-tetramethyl-pentadecyl]-imidazolidine-2,4-dione

Compound 327



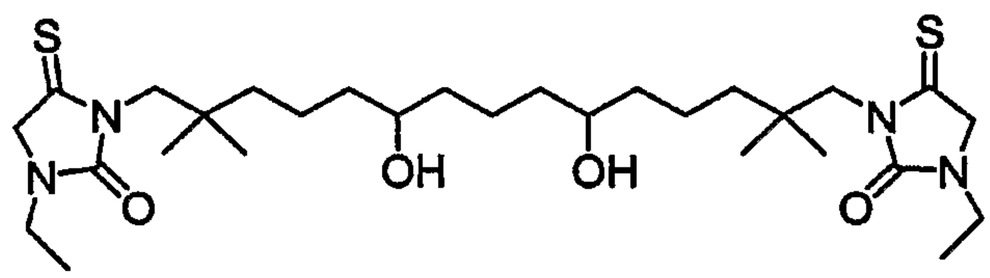
1,15-bis-(1-Ethyl-imidazolin-3-yl-2,4-dithioxo)-2,2,14,14-dimethyl-pentadecane-6,10-diol

Compound 328



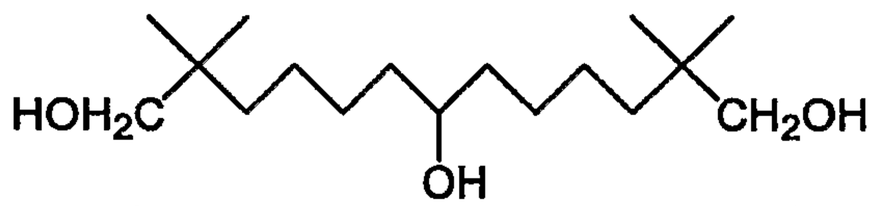
1,15-bis-(1-Ethyl-imidazolin-3-yl-2-thioxo-4-one)-2,2,14,14-tetramethyl-pentadecane-6,10-diol

Compound 329



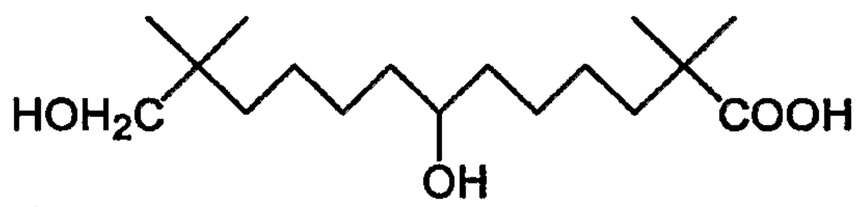
1,15-bis-(1-Ethyl-imidazolin-3-yl-4-thioxo-2-one)-2,2,14,14-tetramethyl-pentadecane-6,10-diol

Compound 330



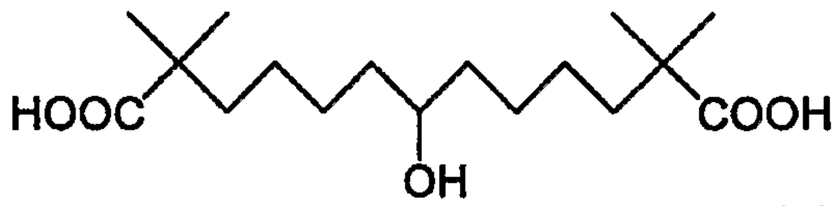
1,7,13-Trihydroxy-2,2,12,12-tetramethyl-tridecane

Compound 331



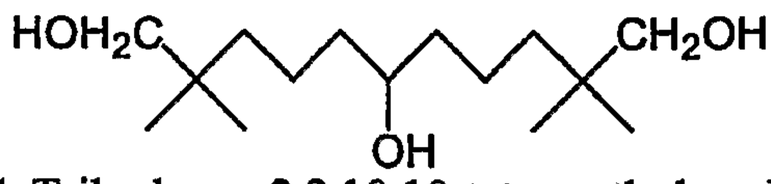
13,7-Dihydroxy-2,2,12,12-tetramethyl-tridecanoic acid

Compound 332



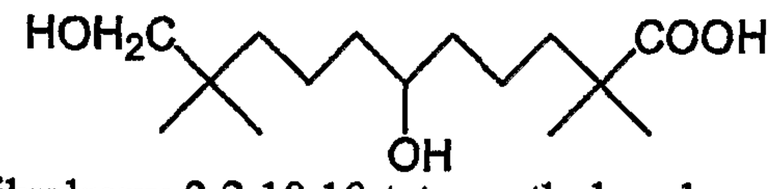
2,2,12,12-Tetramethyl-7-hydroxy-tridecanedioic acid

Compound 333



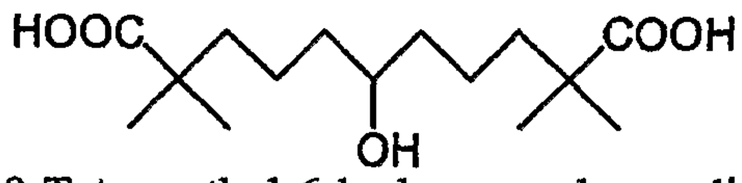
1,7,11-Trihydroxy-2,2,10,10-tetramethyl-undecane

Compound 334



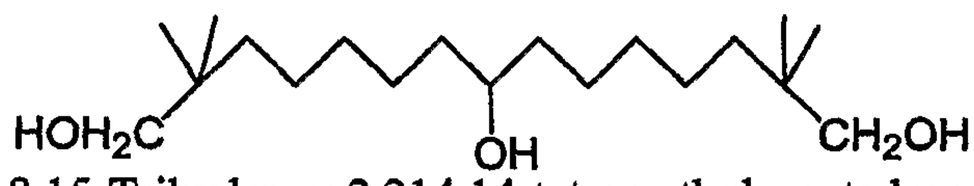
6,11-Dihydroxy-2,2,10,10-tetramethyl-undecanoic acid

Compound 335



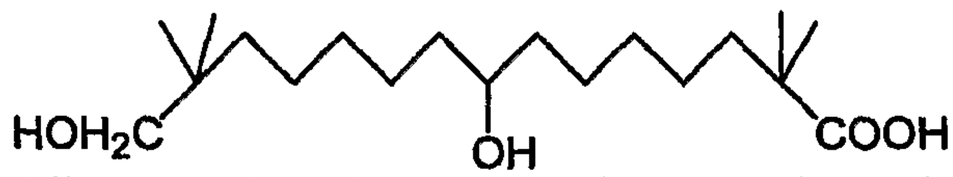
2,210,10-Tetramethyl-6-hydroxy-undecanedioic acid

Compound 336



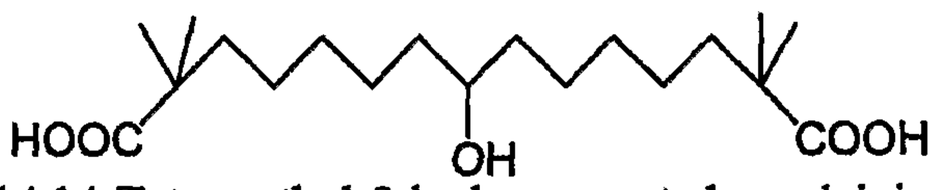
1,8,15-Trihydroxy-2,214,14-tetramethyl-pentadecane

Compound 337



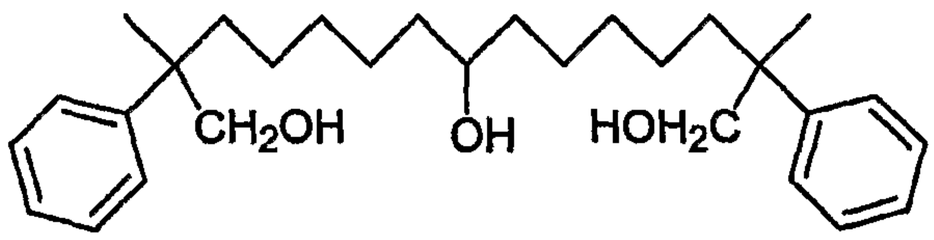
8,15-Dihydroxy-2,2,14,14-tetramethyl-pentadecanoic acid

Compound 338



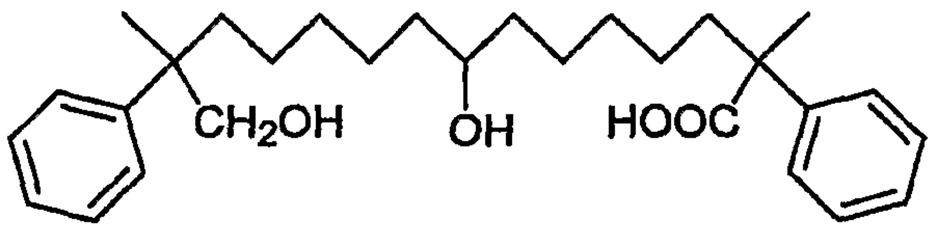
2,2,14,14-Tetramethyl-8-hydroxy-pentadecandeioic acid

Compound 339



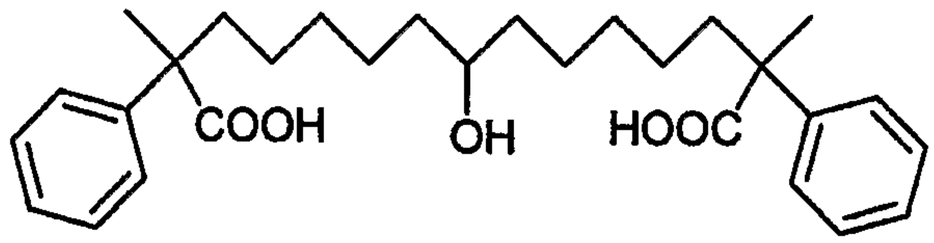
1,8,15-Trihydroxy-2,14-dimethyl-2,14-diphenyl-pentadecane

Compound 340



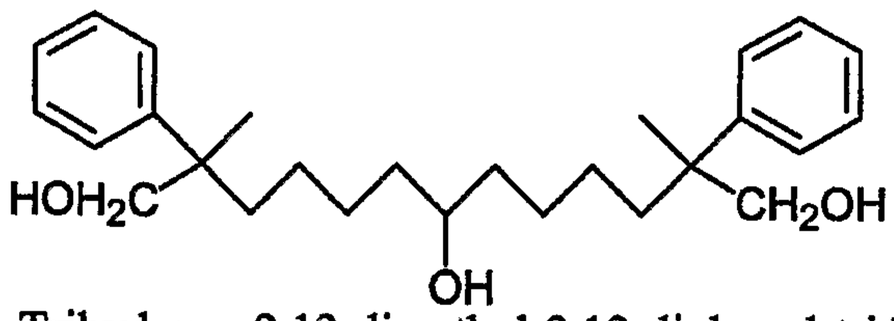
8,15-Dihydroxy-2,14-dimethyl-2,14-diphenyl-pentadecanoic acid

Compound 341



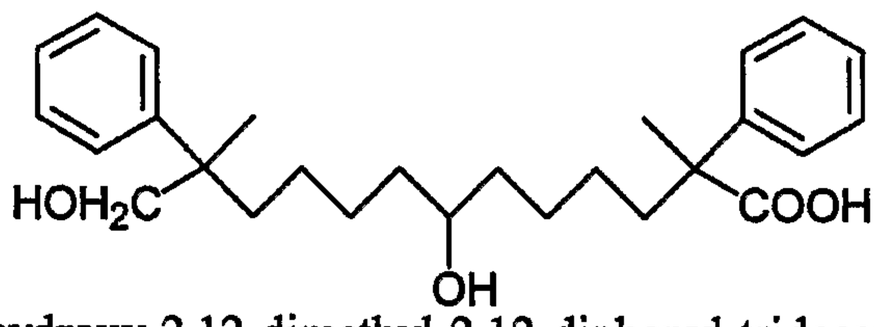
2,14-Dimethyl-8-hydoxy-2,14-diphenyl-pentadecanedioic acid

Compound 342



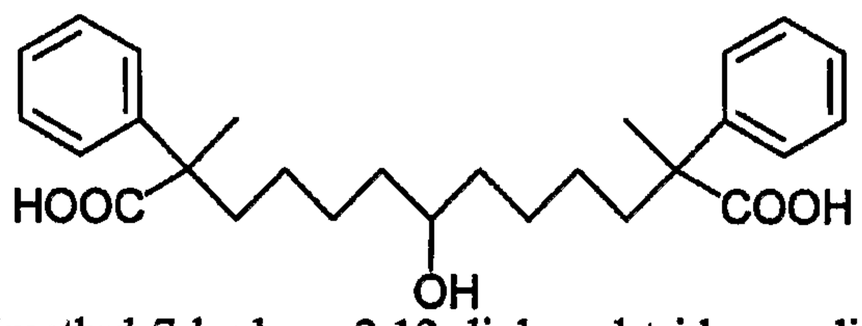
1,7,13-Trihydroxy-2,12-dimethyl-2,12-diphenyl-tridecane

Compound 343



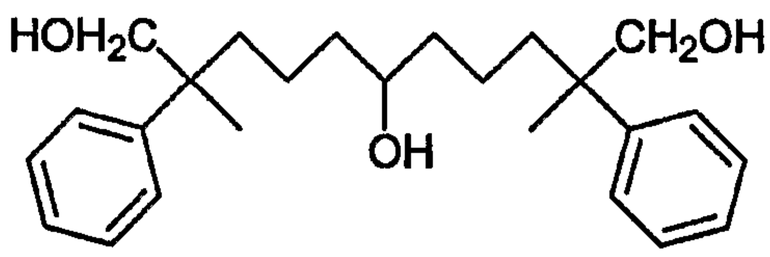
7,13-Dihydroxy-2,12-dimethyl-2,12-diphenyl-tridecanoic acid

Compound 344



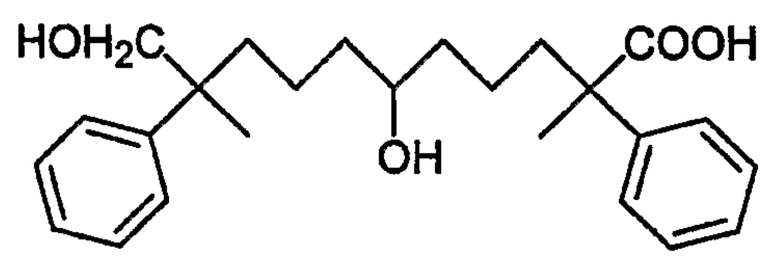
2,12-Dimethyl-7-hydoxy-2,12-diphenyl-tridecanedioic acid

Compound 345



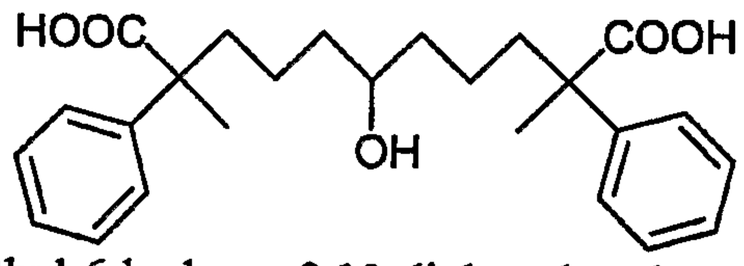
1,6,11-Trihydroxy-2,10-dimethyl-2,10-diphenyl-undecane

Compound 346



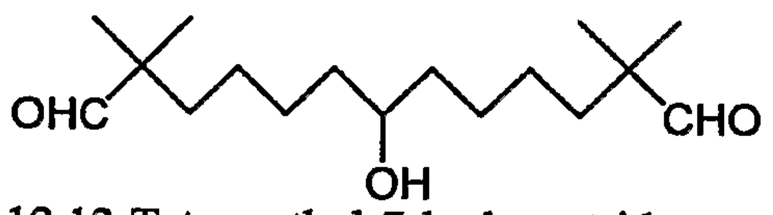
6,11-Dihydroxy-2,10-dimethyl-2,10-diphenyl-undecanoic acid

Compound 347



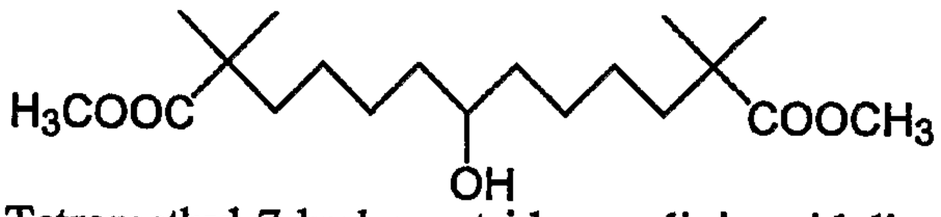
2,10-Dimethyl-6-hydroxy-2,10-diphenyl-undecanedioic acid

Compound 348



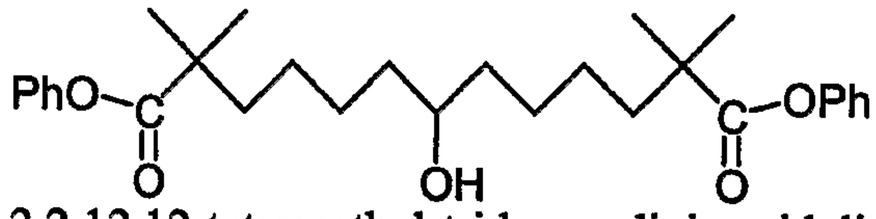
2,2,12,12-Tetramethyl-7-hydoxy-tridecanedial

Compound 349



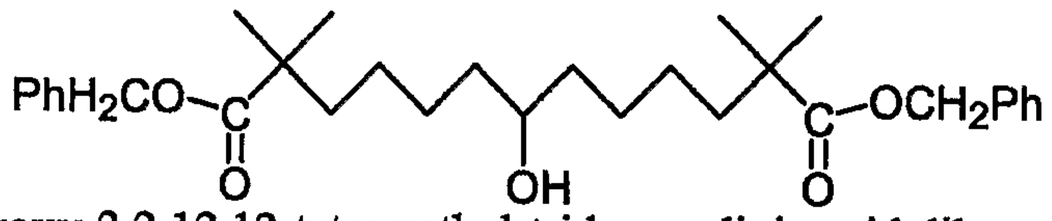
2,2,12,12-Tetramethyl-7-hydroxy-tridecanedioic acid dimethyl ester

Compound 350



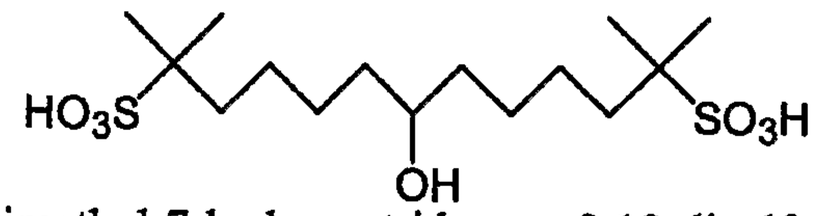
7-Hydroxy-2,2,12,12-tetramethyl-tridecanedioic acid diphenyl ester

Compound 351



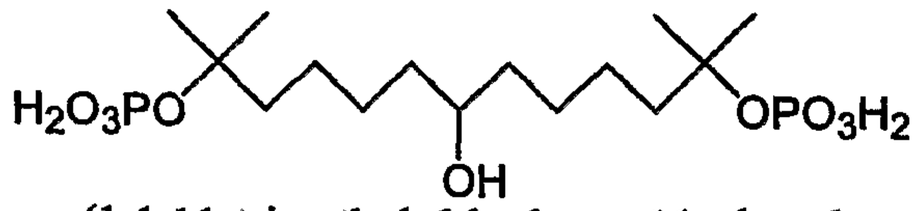
7-Hydroxy-2,2,12,12-tetramethyl-tridecanedioic acid dibenzyl ester

Compound 352



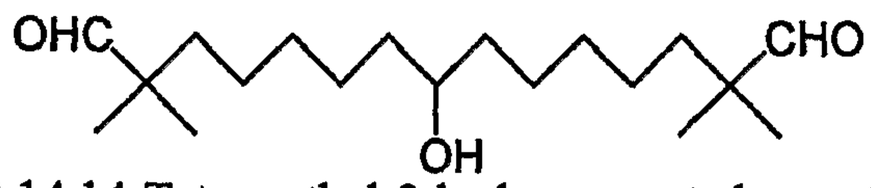
2,12-Dimethyl-7-hydroxy-tridecane-2,12-disulfonic acid

Compound 353



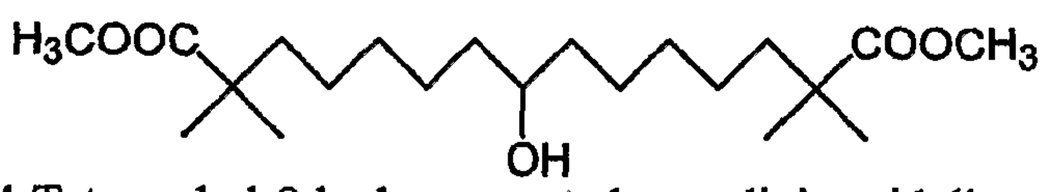
Phosphoric acid mono-(1,1,11-trimethyl-6-hydroxy-11-phosphonooxy-dodecyl) ester

Compound 354



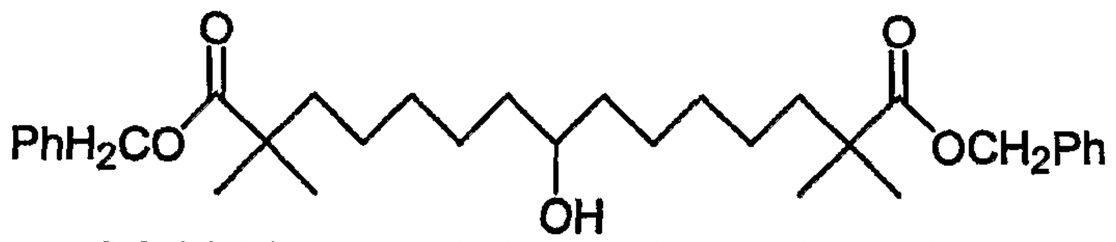
2,2,14,14-Tetramethyl-8-hydroxy-pentadecanedial

Compound 355



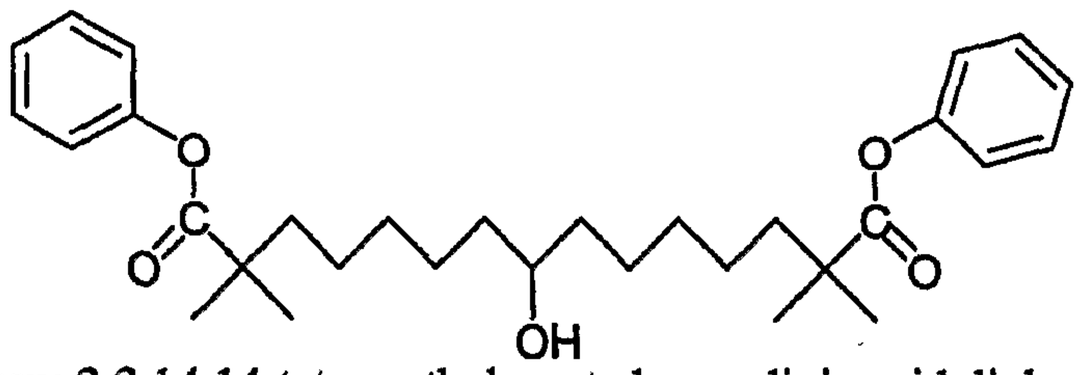
2,2,14,14-Tetramehyl-8-hydroxy-pentadecanedioic acid dimethyl ester

Compound 356



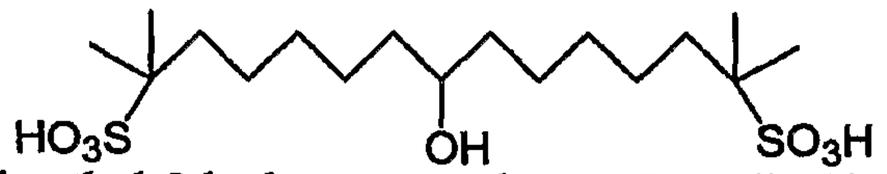
8-Hydroxy-2,2,14,14-tetramethyl-pentadecanedioic acid dibenzyl ester

Compound 357



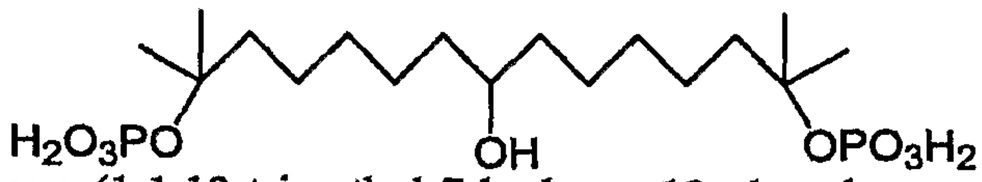
8-Hydroxy-2,2,14,14-tetramethyl-pentadecanedioic acid diphenyl ester

Compound 358



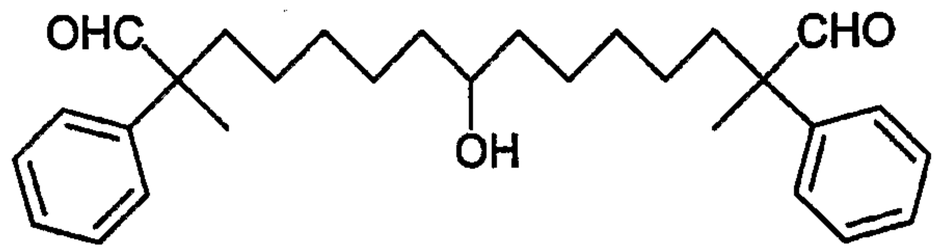
2,14-Dimethyl-8-hydroxy-pentadecane-2,14-disulfonic acid

Compound 359



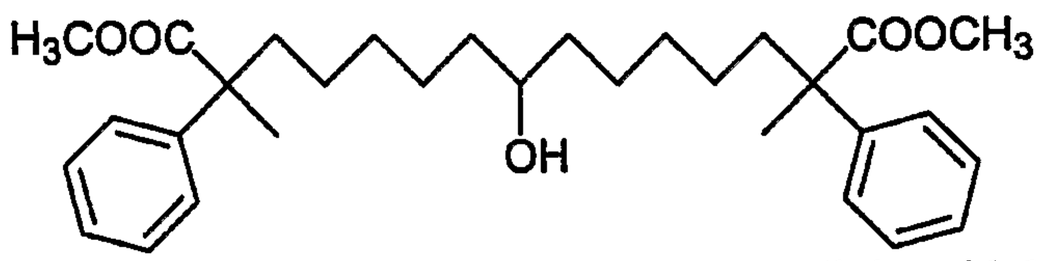
Phosphoric acid mono-(1,1,13-trimethyl-7-hydroxy-13-phosphonooxy-tetradecyl) ester

Compound 360



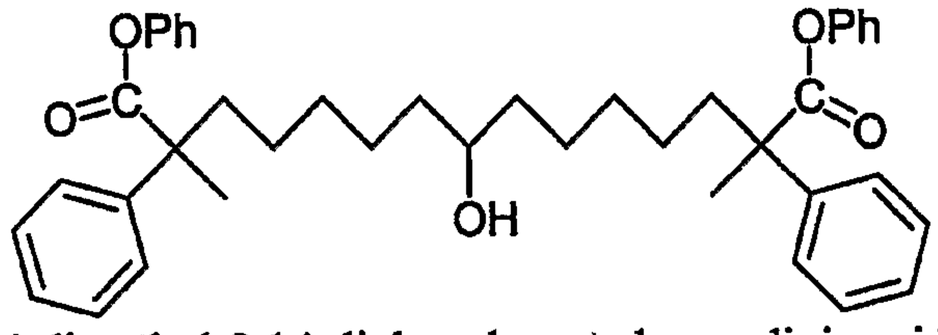
8-Hydroxy-2,14-dimethyl-2,14-diphenyl-pentadecanedial

Compound 361



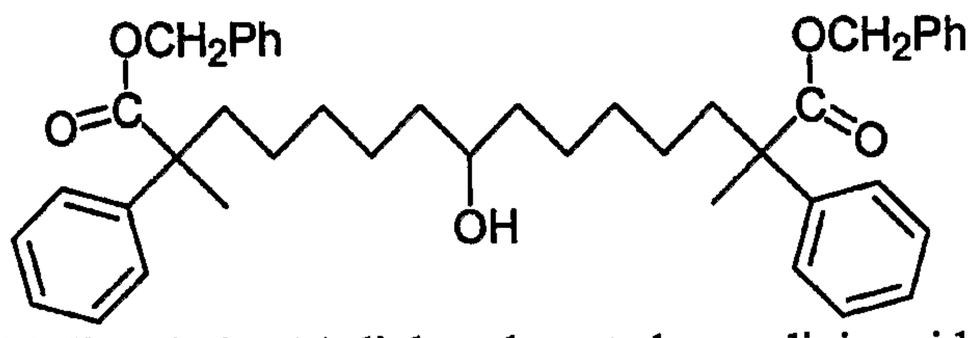
2,14-Dimethyl-8-hydroxy-2,14-diphenyl-pentadecanedioic acid dimethyl ester

Compound 362



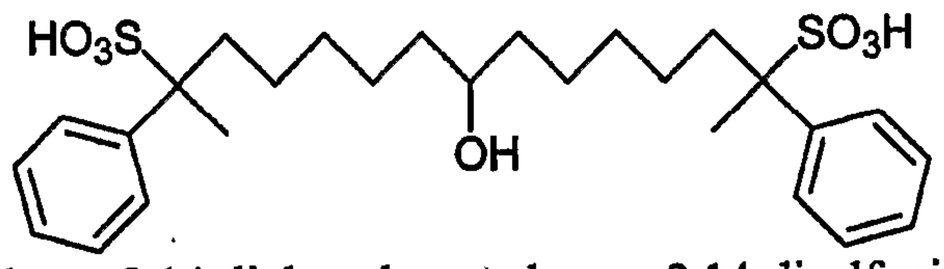
8-Hydroxy-2,14-dimethyl-2,14-diphenyl-pentadecanedioic acid diphenyl ester

Compound 363



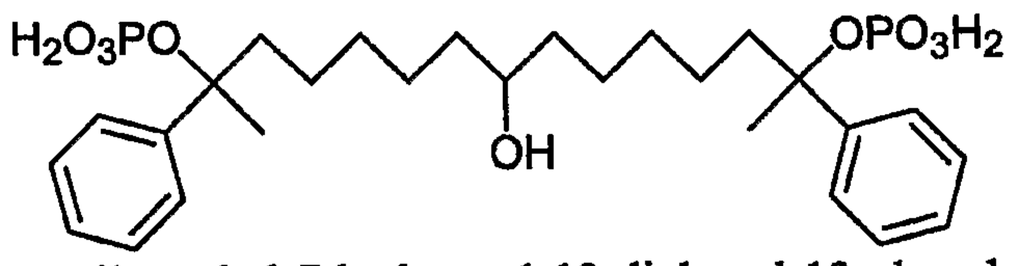
8-Hydroxy-2,14-dimethyl-2,14-diphenyl-pentadecanedioic acid dibenzyl ester

Compound 364



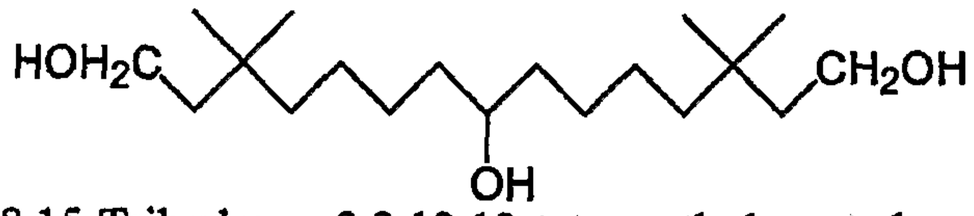
8-Hydroxy-2,14-diphenyl-pentadecane-2,14-disulfonic acid

Compound 365



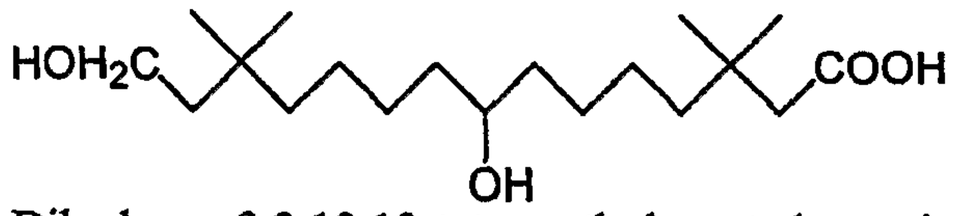
Phosphoric acid mono-(1-methyl-7-hydroxy-1,13-diphenyl-13-phosphonooxy-tetradecyl) ester

Compound 366



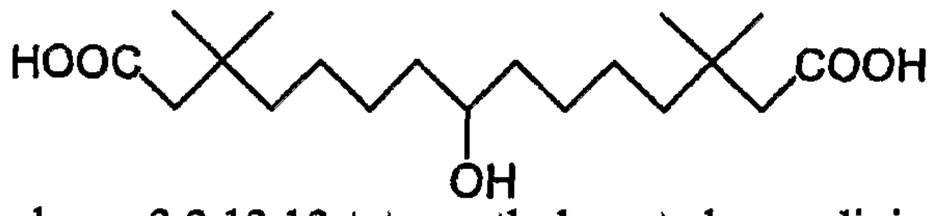
1,8,15-Trihydroxy-3,3,13,13-tetramethyl-pentadecane

Compound 367



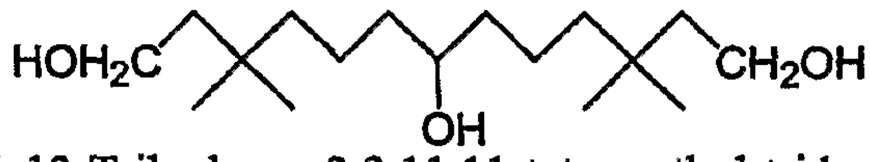
8,15-Dihydroxy-3,3,13,13-tetramethyl-pentadecanoic acid

Compound 368



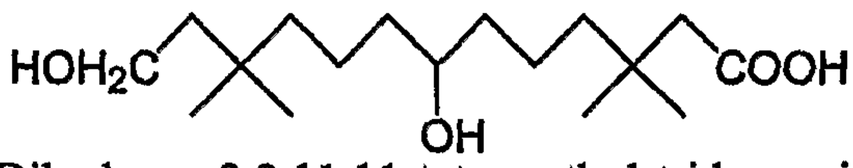
8-Hydroxy-3,3,13,13-tetramethyl-pentadecanedioic acid

Compound 369



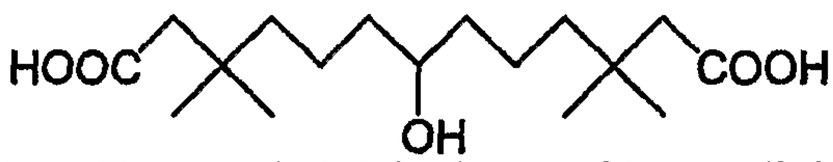
1,7,.13-Trihydroxy-3,3,11,11-tetramethyl-tridecane

Compound 370



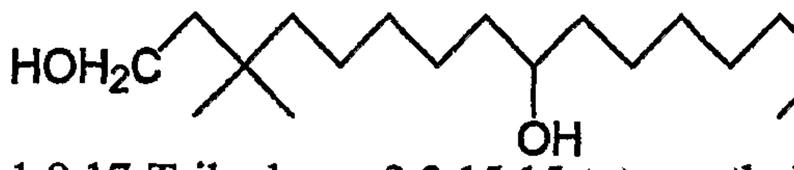
7,13-Dihydroxy-3,3,11,11-tetramethyl-tridecanoic acid

Compound 371



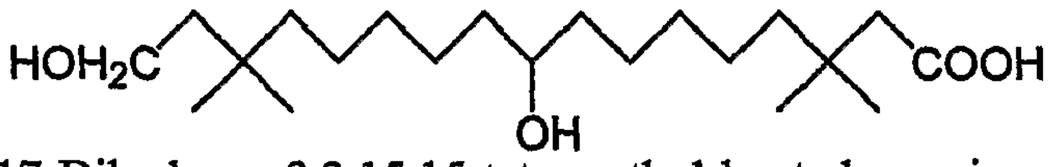
3,3,11,11-Tetramethyl-7-hydroxy-tridecanedioic acid

Compound 372



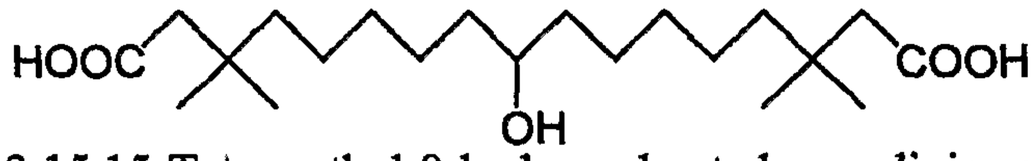
1,9,17-Trihydroxy-3,3,15,15-tetramethyl-heptadecane

Compound 373



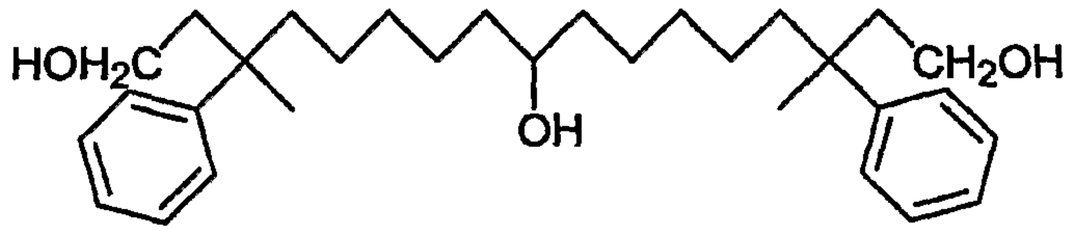
9,17-Dihydroxy-3,3,15,15-tetramethyl-heptadecanoic acid

Compound 374



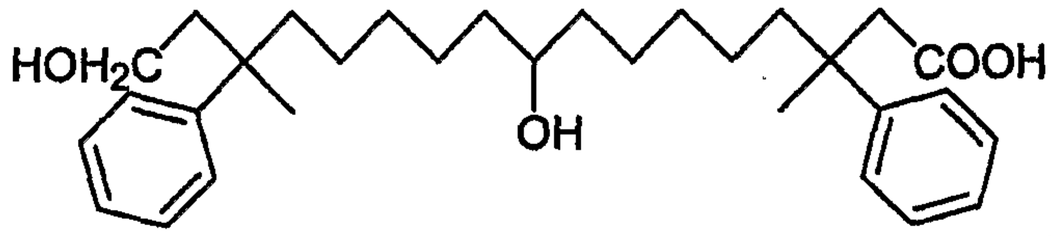
3,3,15,15-Tetramethyl-9-hydroxy-heptadecanedioic acid

Compound 375



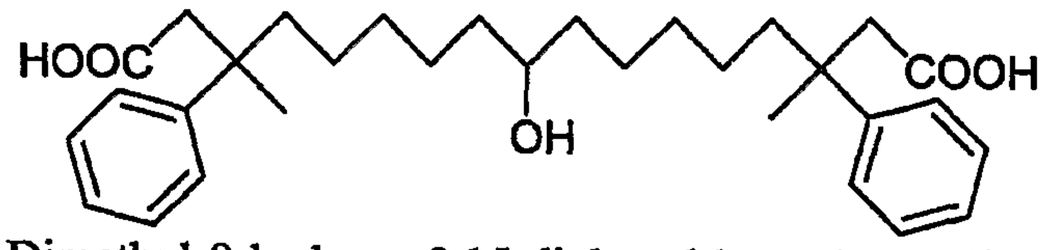
1,9,17-Trihydroxy-3,15-dimethyl-3,15-diphenyl-heptadecane

Compound 376



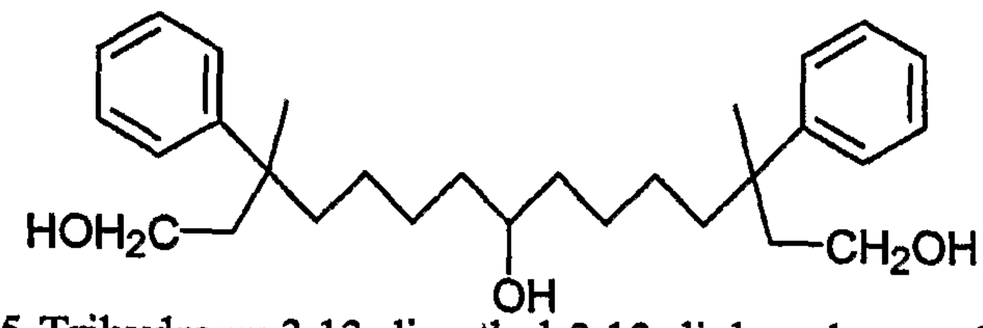
9,17-Dihydroxy-3,15-dimethyl-3,15-diphenyl-heptadecanoic acid

Compound 377



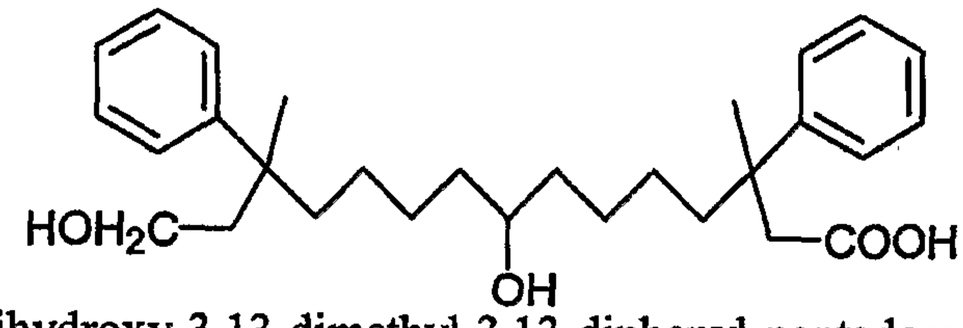
3,15-Dimethyl-9-hydroxy-3,15-diphenyl-heptadecanedioic acid

Compound 378



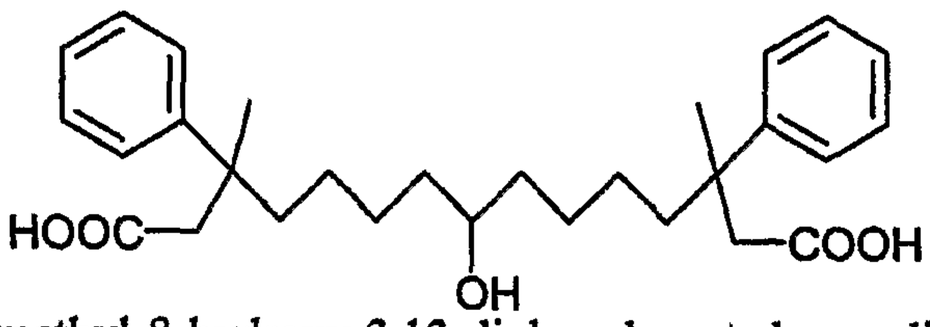
1,8,15-Trihydroxy-3,13-dimethyl-3,13-diphenyl-pentadecane

Compound 379



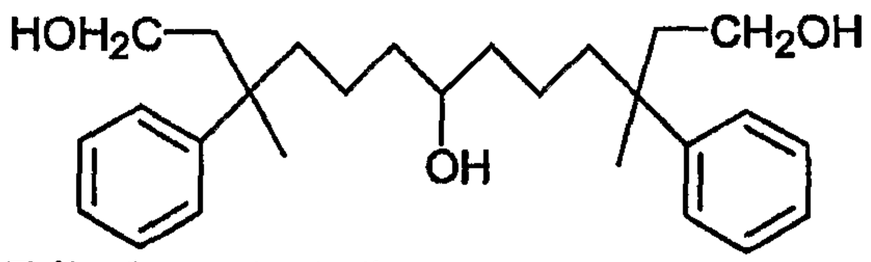
8,15-Trihydroxy-3,13-dimethyl-3,13-diphenyl-pentadecanoic acid

Compound 380



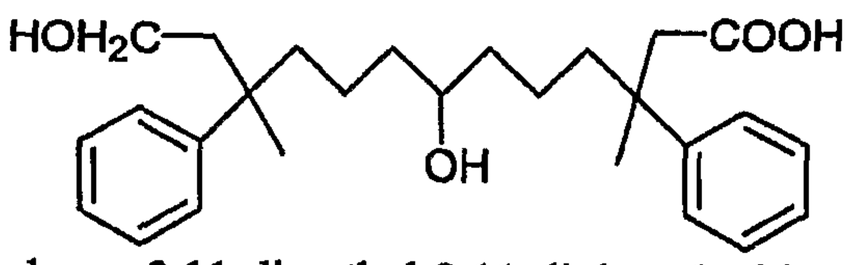
3,13-Dimethyl-8-hydroxy-3,13-diphenyl-pentadecanedioic acid

Compound 381



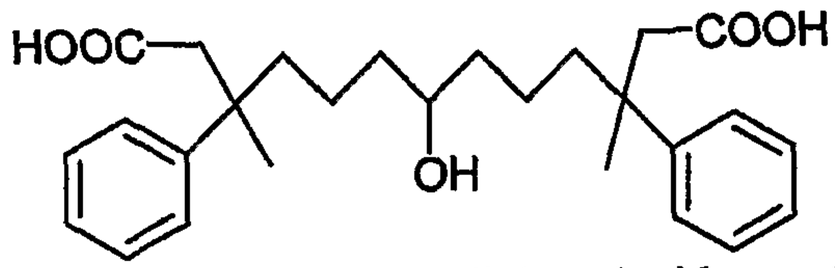
1,7,13-Trihydroxy-3,11-dimethyl-3,11-diphenyl-tridecane

Compound 382



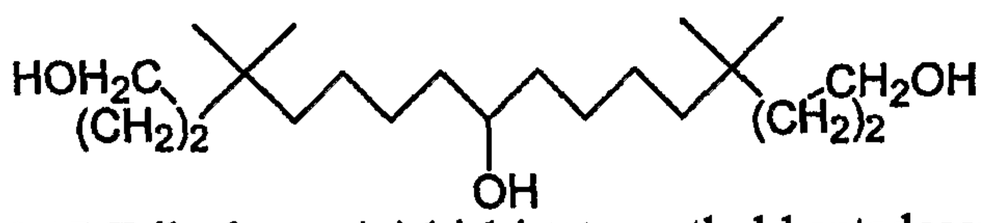
7,13-Dihydroxy-3,11-dimethyl-3,11-diphenyl-tridecanoic acid

Compound 383



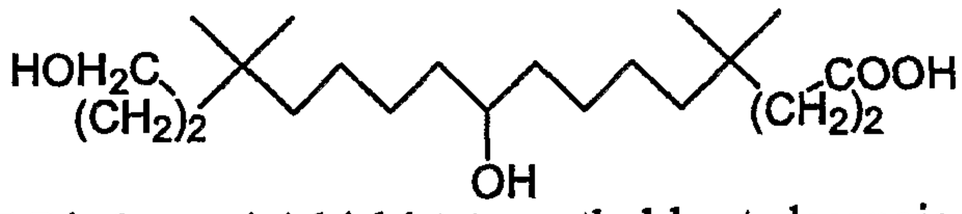
3,11-Dimethyl-7-hydroxy-3,11-diphenyl-tridecanedioic acid

Compound 384



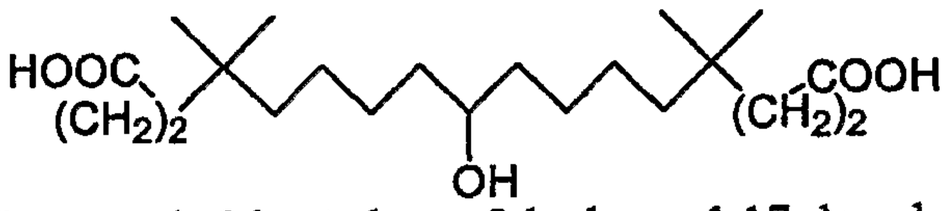
1,9,17-Trihydroxy-4,4,14,14-tetramethyl-heptadecane

Compound 385



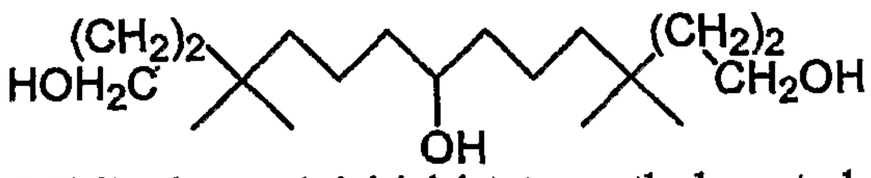
9,17-Diydroxy-4,4,14,14-tetramethyl-heptadecanoic acid

Compound 386



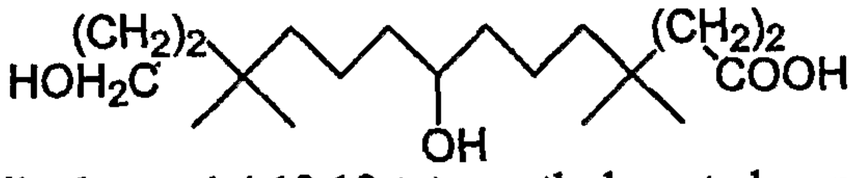
4,4,14,14-Tetramethyl-heptadecan-9-hydroxy-1,17-decarboxylic acid

Compound 387



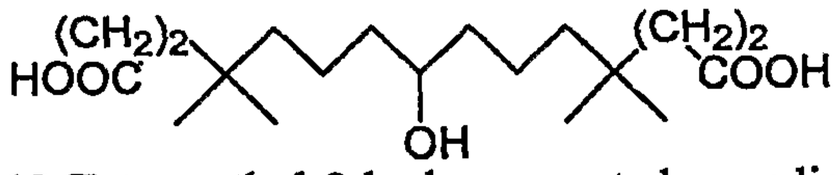
1,8,15-Trihydroxy-4,4,14,14-tetramethyl-pentadecane

Compound 388



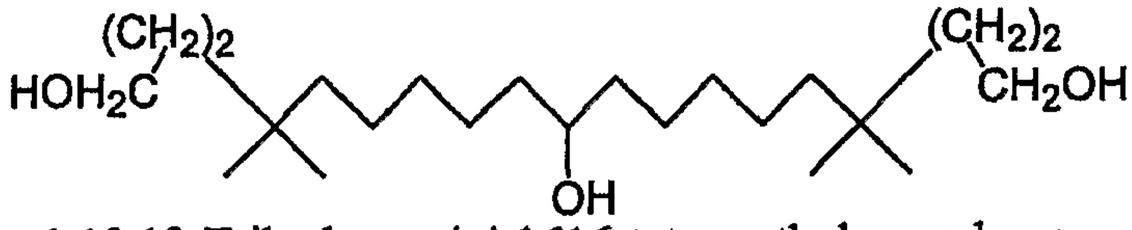
8,15-Trihydroxy-4,4,12,12-tetramethyl-pentadecanoic acid

Compound 389



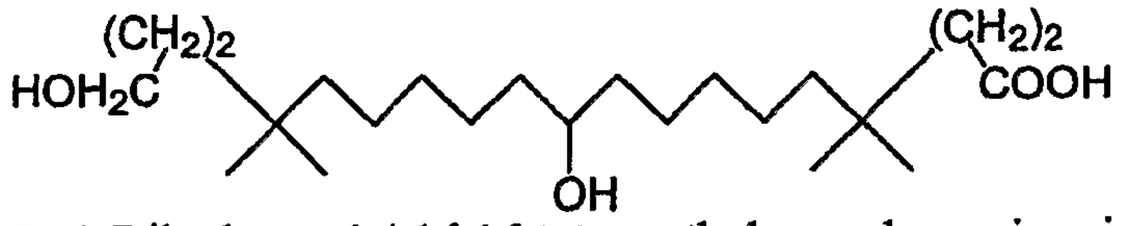
4,4,12,12-Tetramethyl-8-hydroxy-pentadecanedioic acid

Compound 390



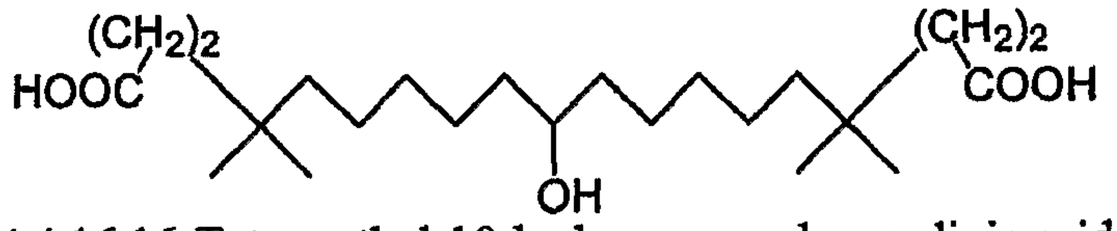
1,10,19-Trihydroxy-4,4,1616-tetramethyl-nonadecane

Compound 391



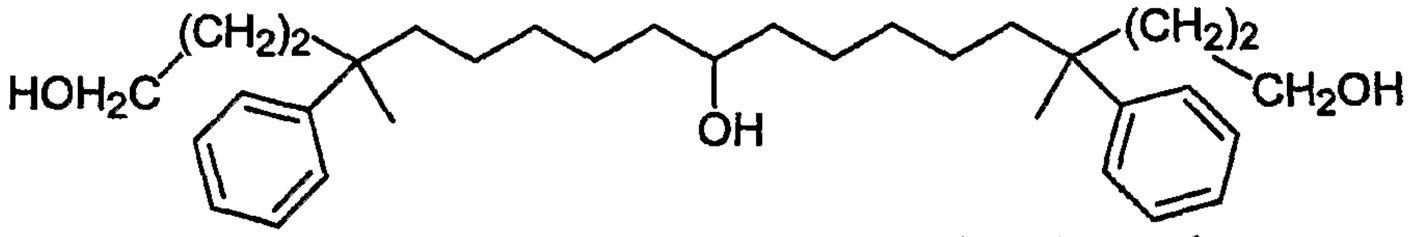
10,19-Dihydroxy-4,4,16,16-tetramethyl-nonadecanoic acid

Compound 392



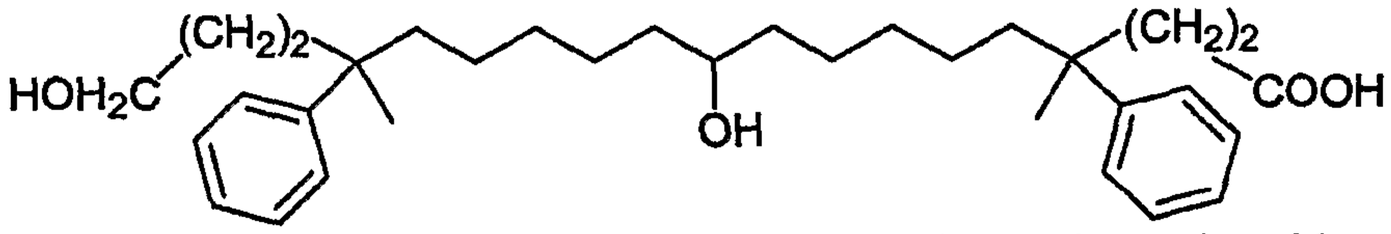
4,4,16,16-Tetramethyl-10-hydroxy-nonadecanedioic acid

Compound 393



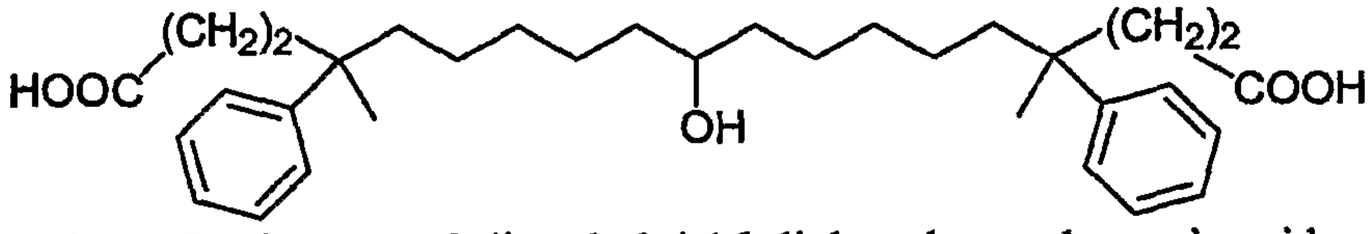
1,10,19-Trihydroxy-4,16-dimethyl-4,16-diphenyl-nonadecane

Compound 394



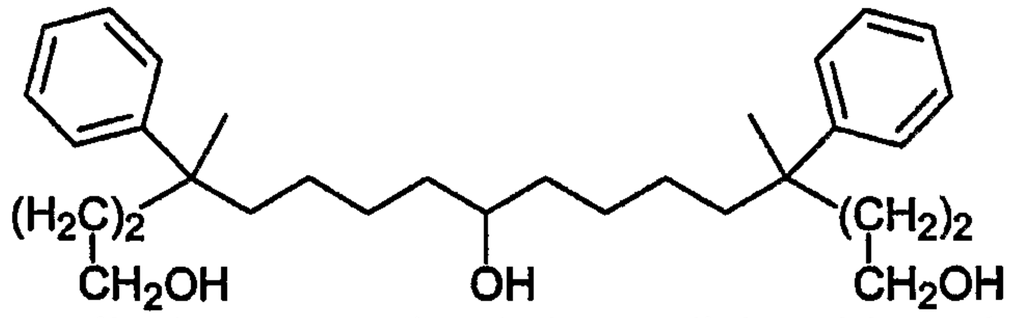
10,19-Hydroxy-4,16-dimethyl-4,16-diphenyl-nonadecanoic acid

Compound 395



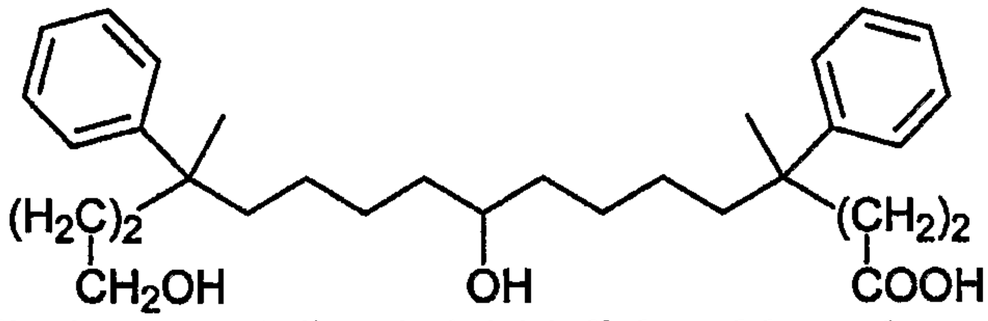
10,19-Hydroxy-4,16-dimethyl-4,16-diphenyl-nonadecanoic acid

Compound 396



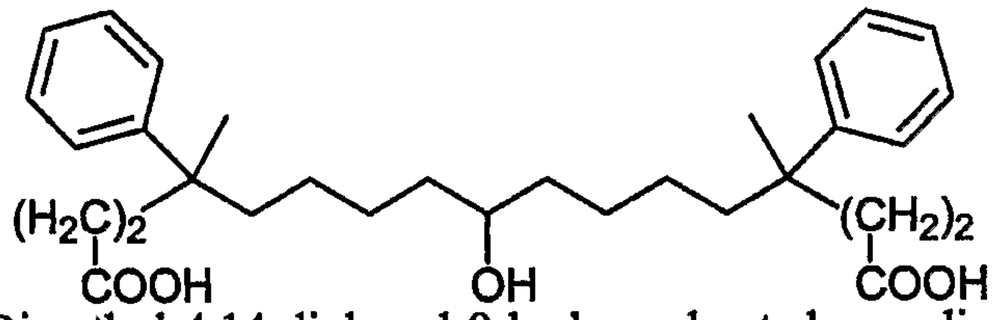
1,9,17-Trihydroxy-4,14-dimethyl-4,14-diphenyl-heptadecane

Compound 397



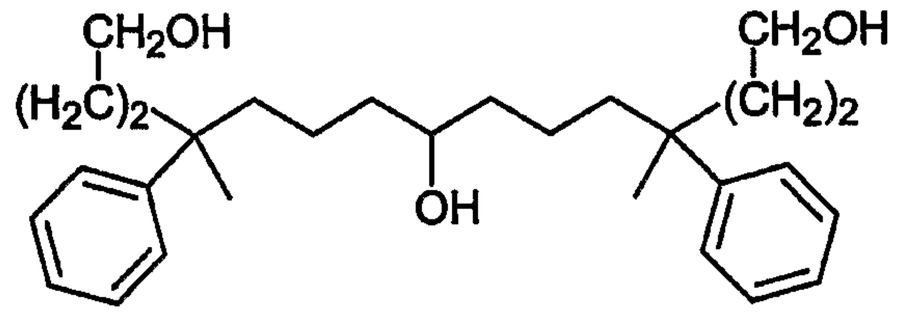
9,17-Dihydroxy-4,14-dimethyl-4,14-diphenyl-heptadecanoic acid

Compound 398



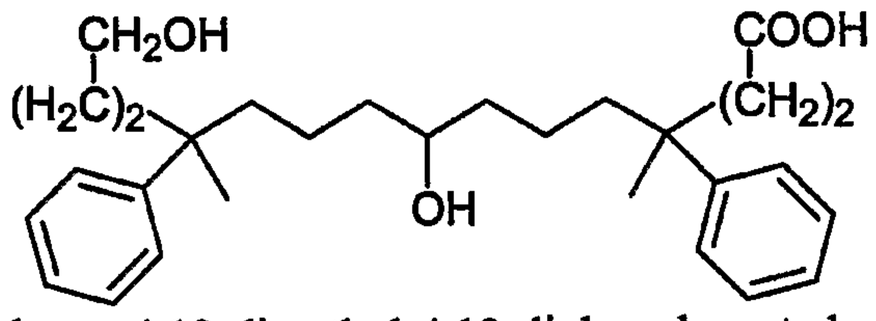
4,14-Dimethyl-4,14-diphenyl-9-hydroxy-heptadecanedioic acid

Compound 399



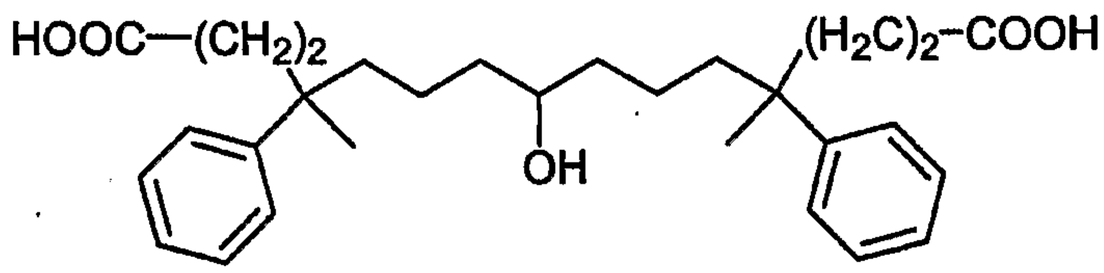
1,8,15-Trihydroxy-4,12-dimethyl-4,12-diphenyl-pentadecane

Compound 400



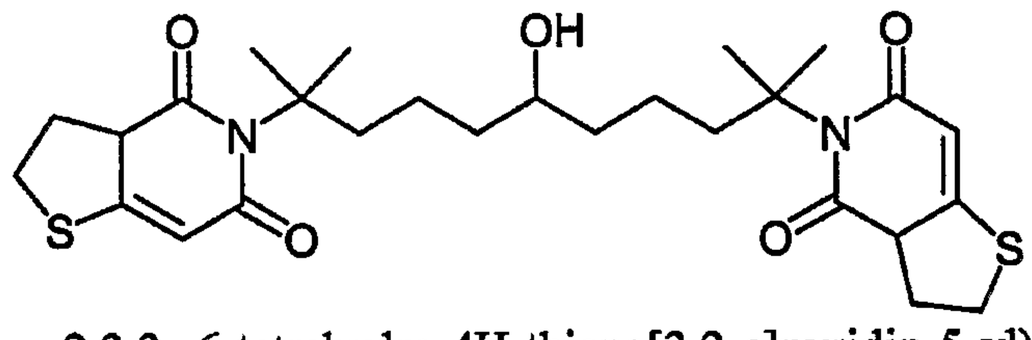
8,15-Dihydroxy-4,12-dimethyl-4,12-diphenyl-pentadecanoic acid

Compound 401



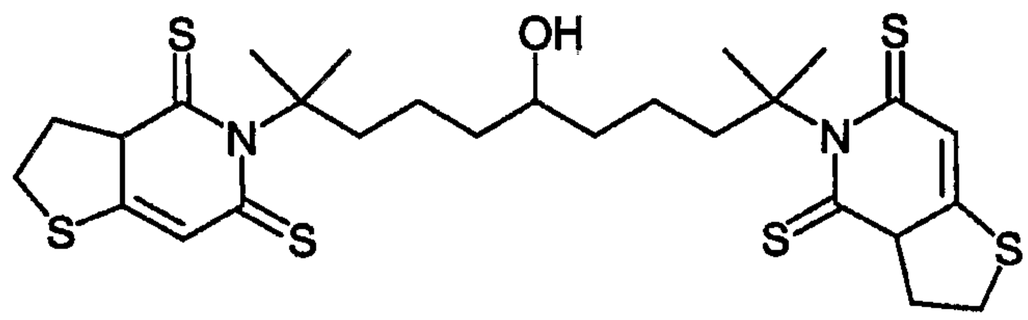
4,12-Dimethyl-8-hydroxy-4,12-diphenyl-pentadecanedioic acid

Compound 402



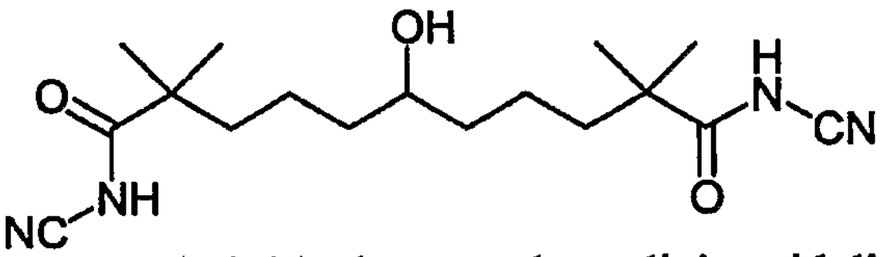
2-10-Bis-(4,6-dioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-2,10-dimethyl-6-hydoxy-undecane

Compound 403



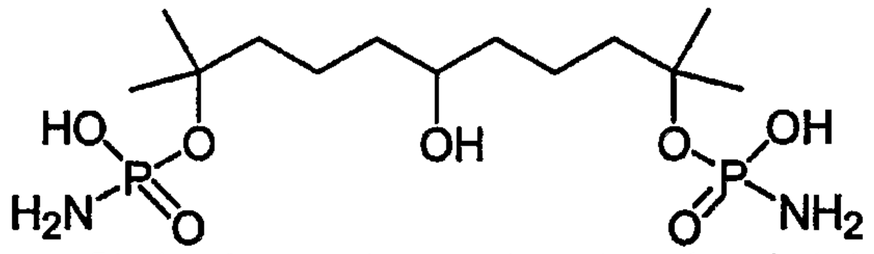
2-10-Bis-(4,6-dithioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-2,10-dimethyl-6-hydoxy-undecane

Compound 404



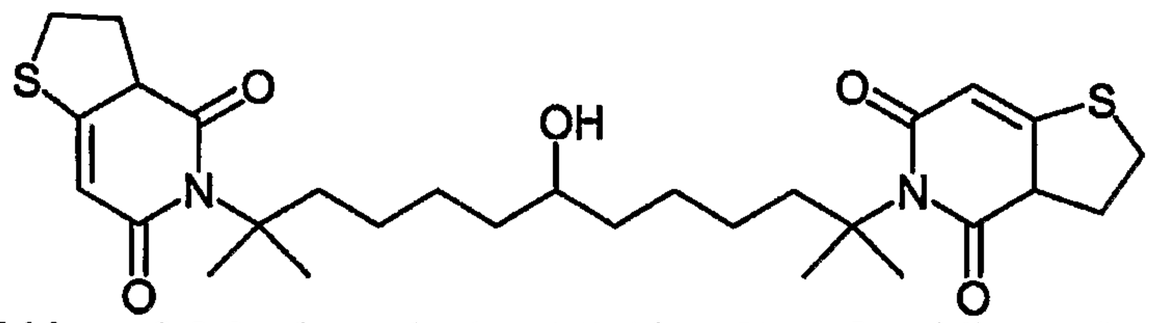
2,2,10,10-Tetramethyl-6-hydroxy-undecandioic acid dicyanimide

Compound 405



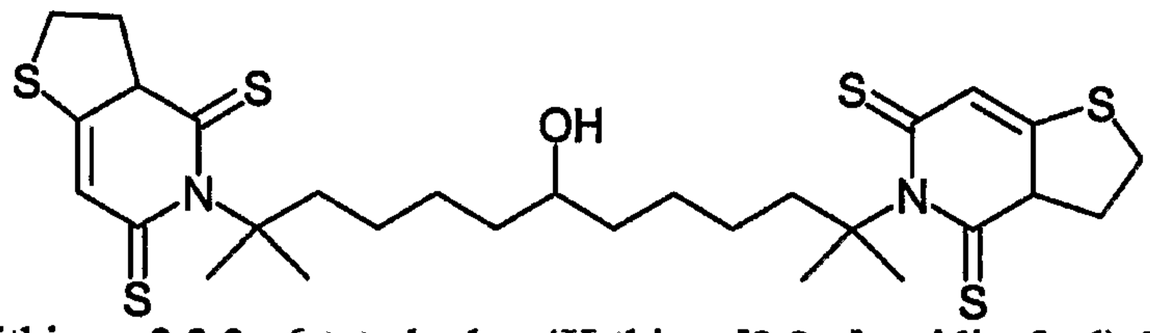
Phosphoramidic acid mono-[9-(amino-hydroxy-phosphoryloxy)-1,1,9-trimethyl-5-hydroxy-decyl]ester

Compound 406



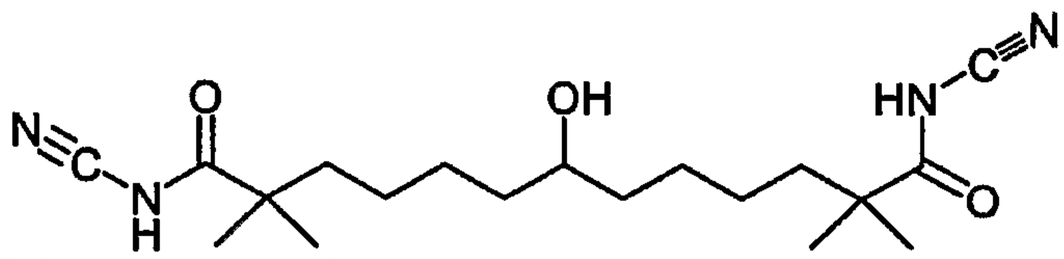
2-12-Bis-(4,6-dithioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-2,10-dimethyl-6-hydoxy-undecane

Compound 407



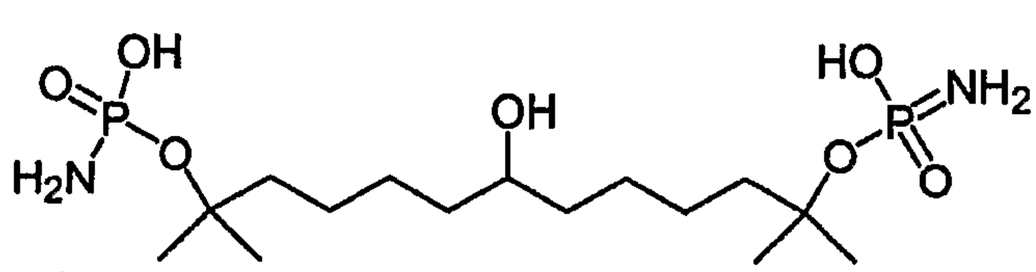
2-12-Bis-(4,6-dithioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-2,10-dimethyl-6-hydoxy-undecane

Compound 408



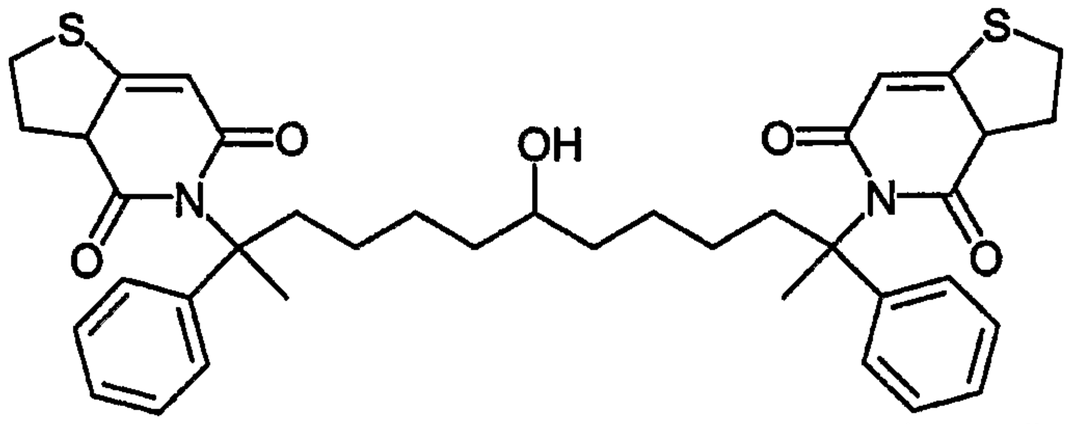
2,2,10,10-Tetramethyl-6-hydroxy-tridecandioic acid dicyanimide

Compound 409



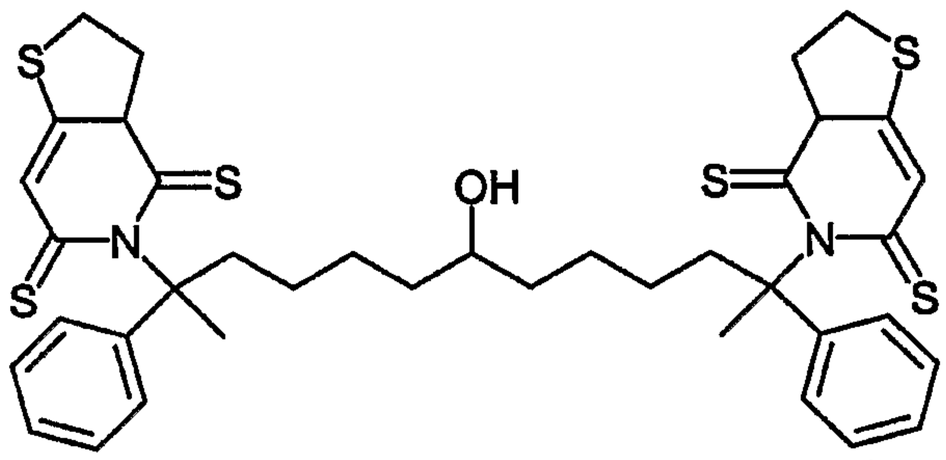
Phosphoramidic acid mono-[11=(amino-hydroxy-phosphoryloxy)-1,1,11-trimethyl-7-hydroxy-dodecyl] ester

Compound 410



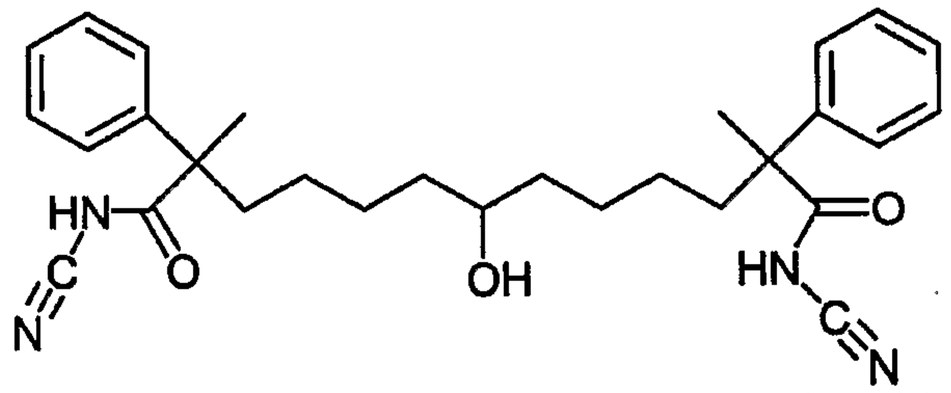
2,12-Bis-(4,6-dioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 411



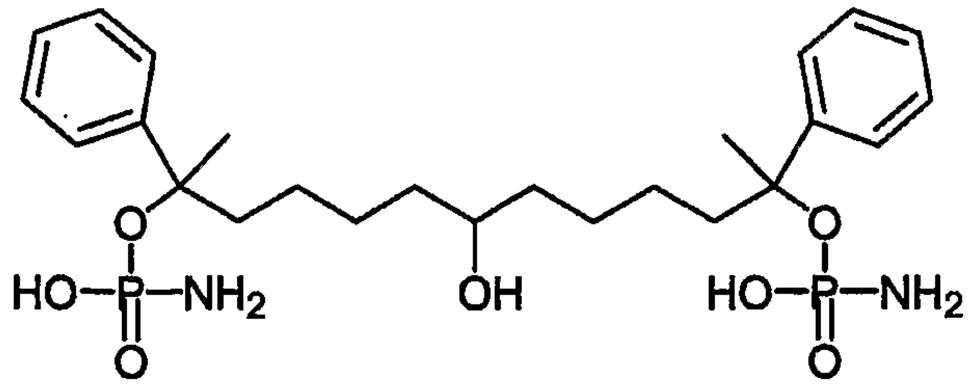
2,12-Bis-(4,6-dithioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 412



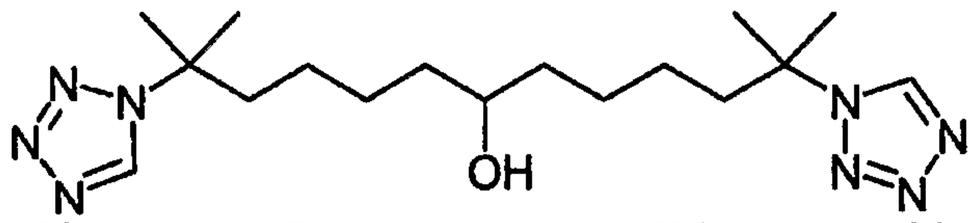
2,12-Dimethyl-2,12-diphenyl-7-hydroxy-tridecandioic acid dicyanimide

Compound 413



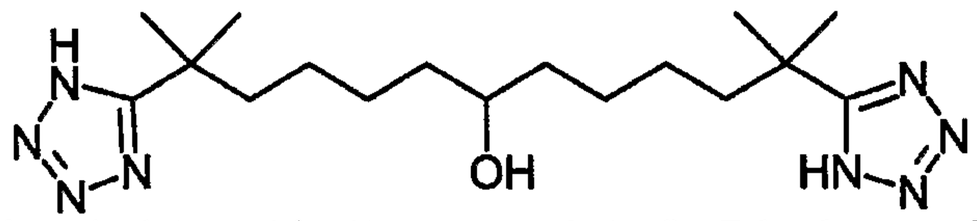
Phosphoramidic acid mono-[11-(amino-hydroxy-phosphoryloxy)-1-methyl-6-hydroxy-1,11-diphenyl-dodecyl] ester

Compound 414



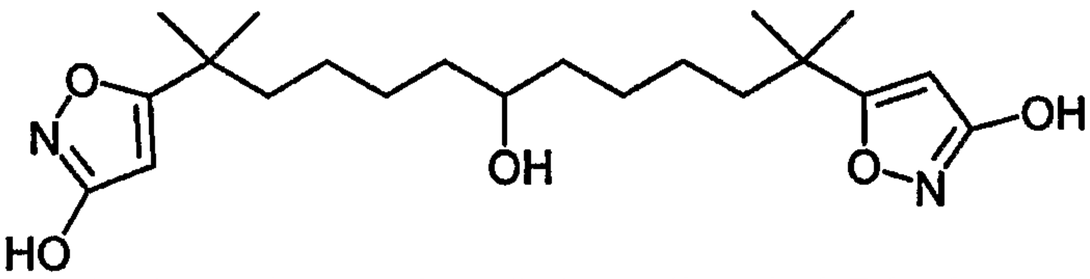
2,12-Dimethyl-2,12-bis-tetrazol-1-yl-7-hydroxy-tridecane

Compound 415



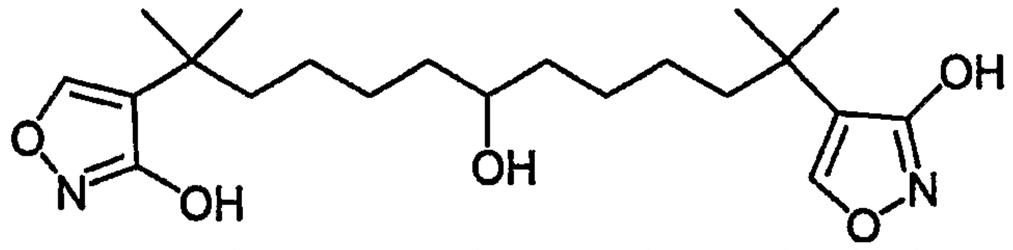
2,12-Dimethyl-2,12-bis-(1H-tetrazol-5-yl)- 7-hydroxy-tridecane

Compound 416



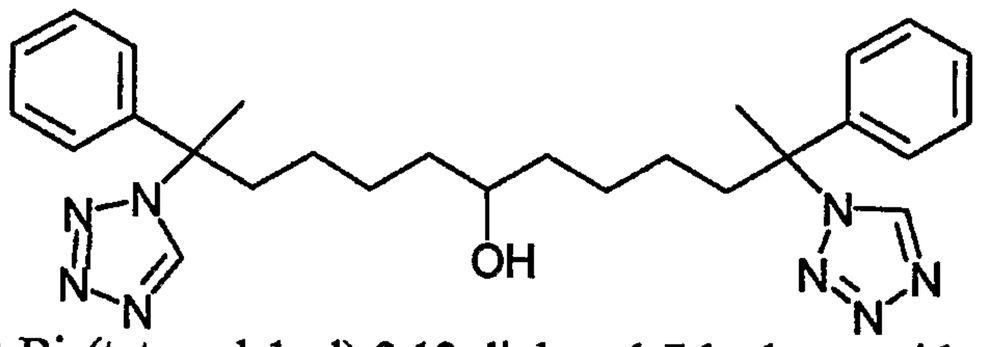
2,12-Bis-(3-hydroxy-isoxazol-5-yl)-2,12-dimethyl-7-hydroxy-tridecane

Compound 417



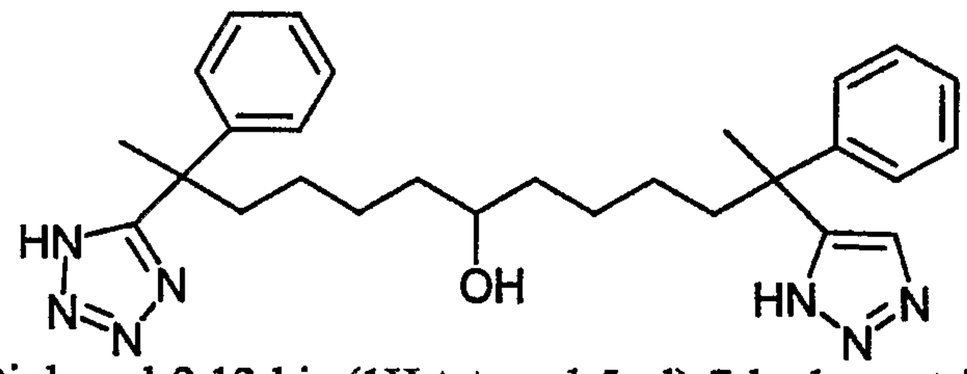
2,12-Bis-(3-hydroxy-isoxazol-4-yl)-2,12-dimethyl-7-hydroxy-tridecane

Compound 418



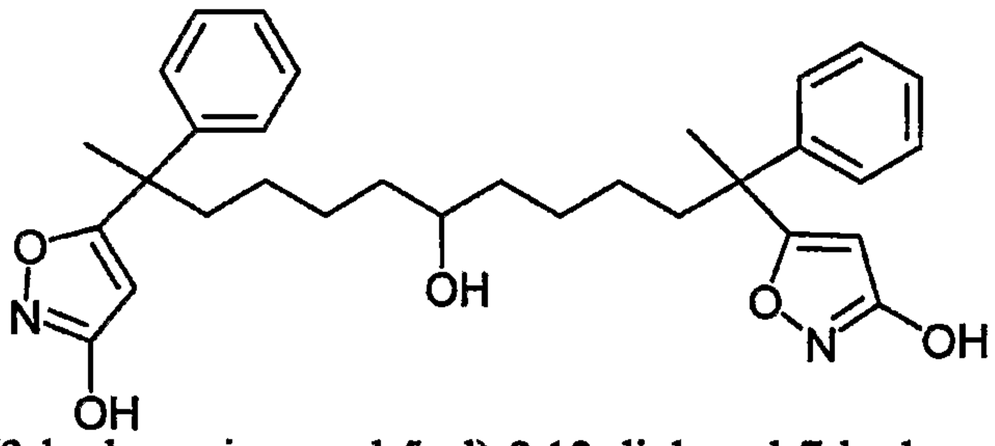
2,12-Bis(tetrazol-1-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 419



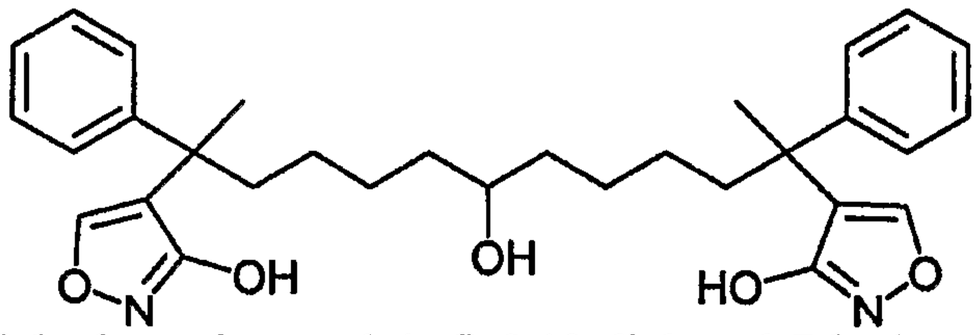
2,12-Diphenyl-2,12-bis-(1H-tetrazol-5-yl)-7-hydroxy-tridecane

Compound 420



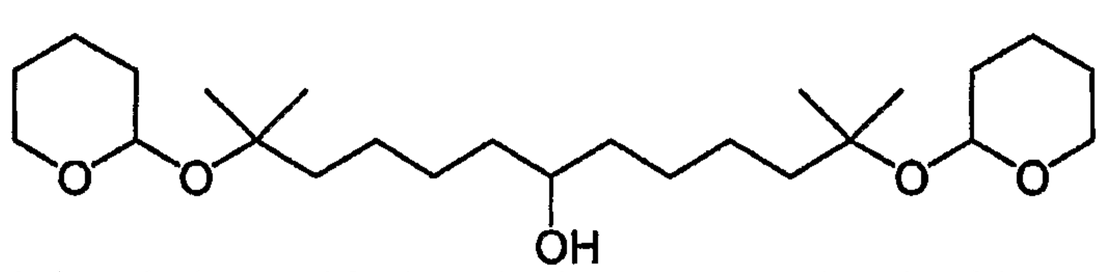
2,12-Bis-(3-hydroxy-isoxazol-5-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 421



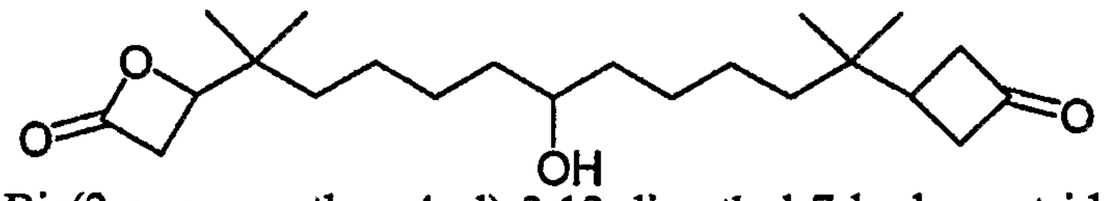
2,12-Bis-(3-hydroxy-isoxazol-4-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 422



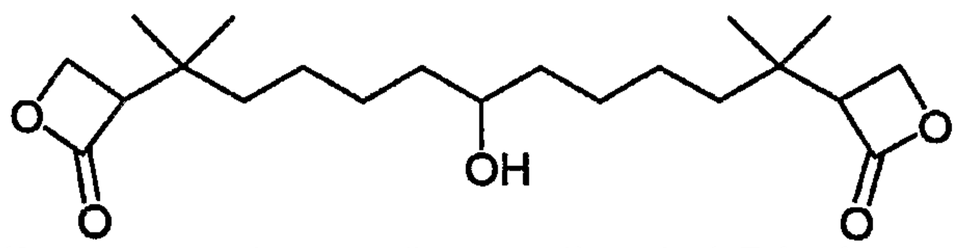
2,12-Dimethyl-2,12-bis-(tetrahydro-pyran-2-yloxy)-tridecan-7-ol

Compound 423



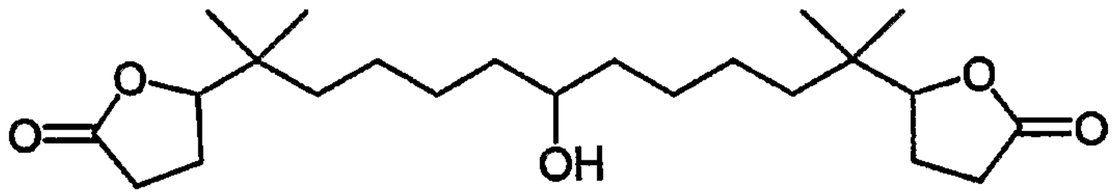
2,12-Bis(2-oxo-oxoethan-4-yl)-2,12-dimethyl-7-hydroxy-tridecane

Compound 424



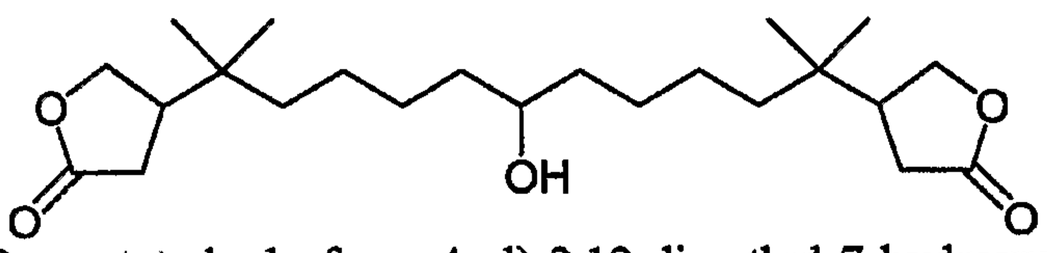
2,12-Bis(2-oxo-oxoethan-3-yl)-2,12-dimethyl-7-hydroxy-tridecane

Compound 425



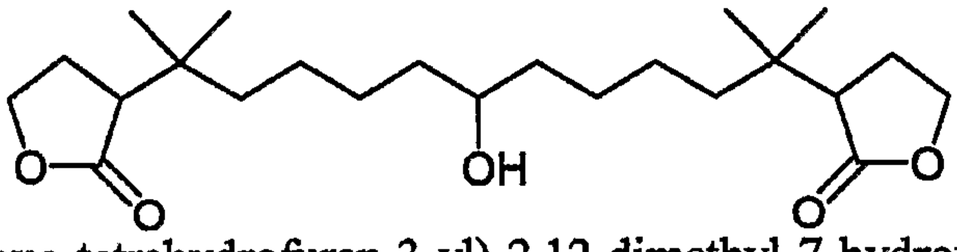
2,12-Bis(2-oxo-tetrahydrofuran-5-yl)-2,12-dimethyl-7-hydroxy-tridecane

Compound 426



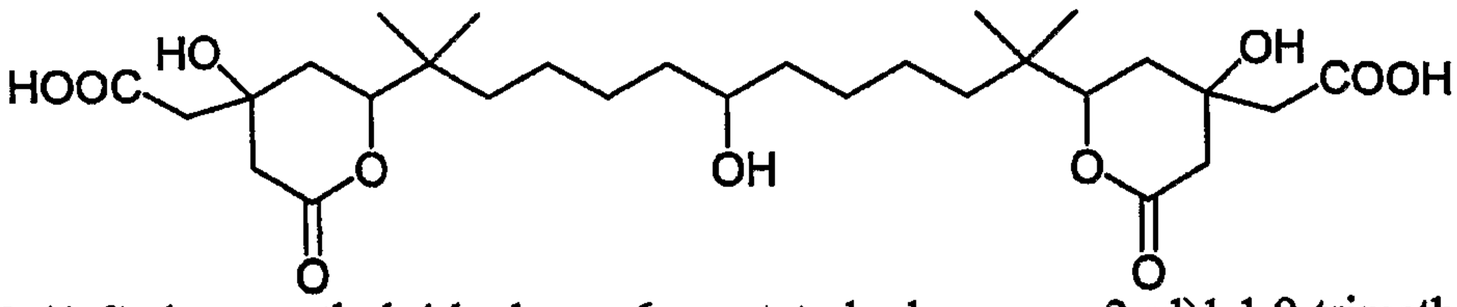
2,12-Bis(2-oxo-tetrahydrofuran-4-yl)-2,12-dimethyl-7-hydroxy-tridecane

Compound 427



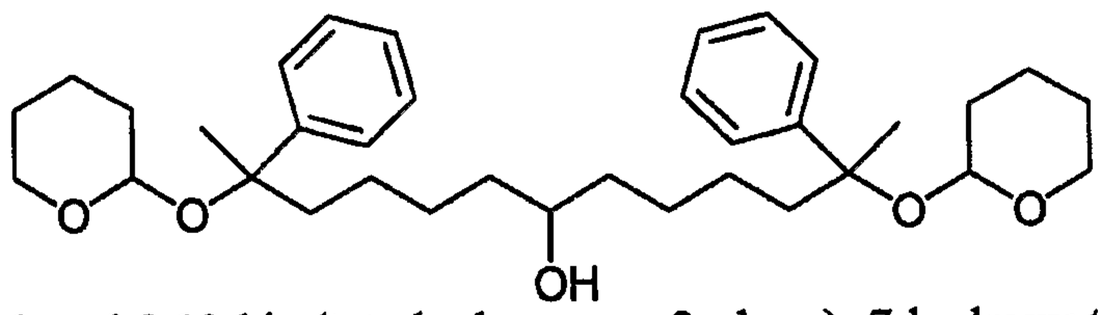
2,12-Bis(2-oxo-tetrahydrofuran-3-yl)-2,12-dimethyl-7-hydroxy-tridecane

Compound 428



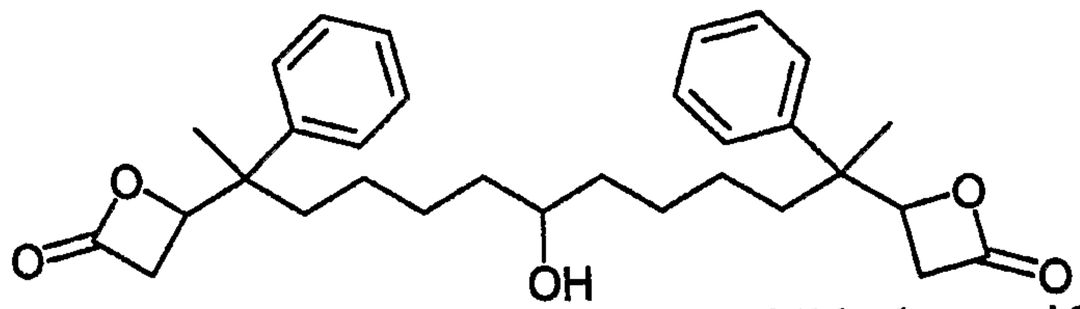
{2-[9-(4-Carboxymethyl-4-hydroxy-6-oxo-tetrahydro-pyran-2-yl)1,1,9-trimethyl-5-hydroxy-decyl]-4-hydroxy-6-oxo-tetrahyrdro-pyran-4-yl}-cetic acid

Compound 429



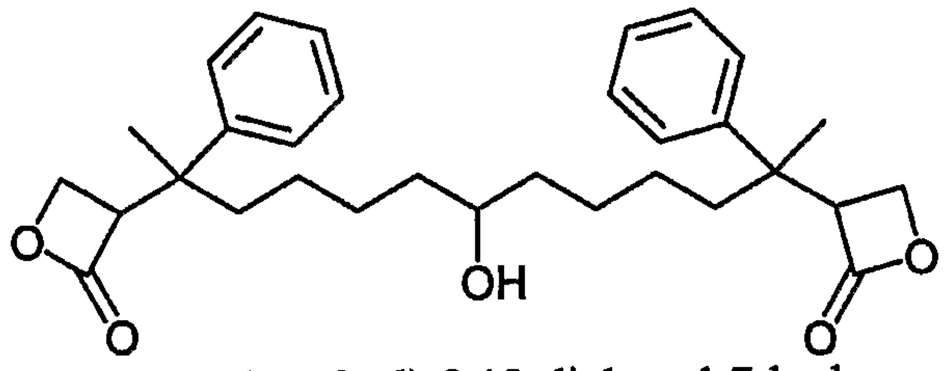
2,12-Diphenyl-2,12-bis-(tetrahydro-pyran-2-yloxy)- 7-hydroxy-tridecane

Compound 430



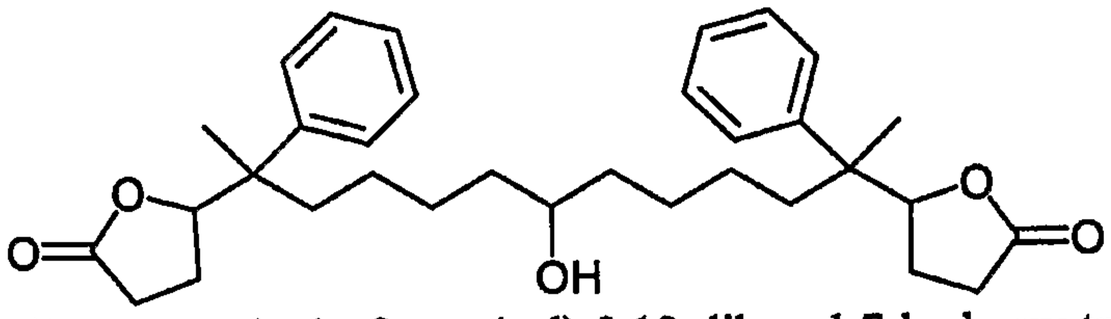
2,12-Bis(2-oxo-oxoethan-4-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 431



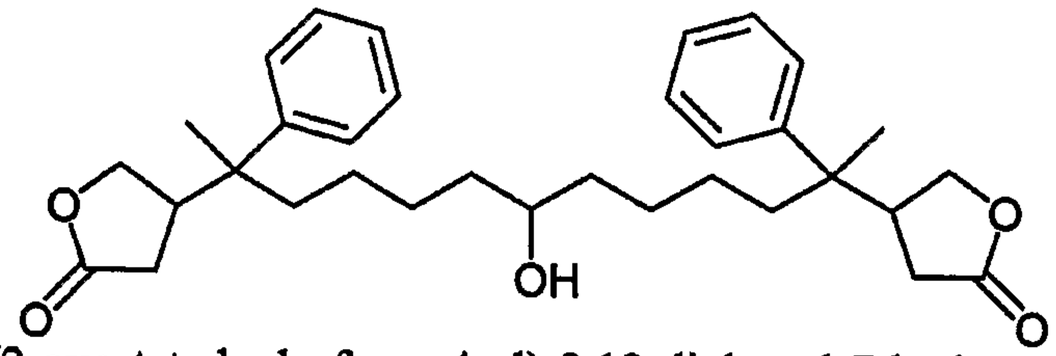
2,12-Bis(2-oxo-oxoethan-3-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 432



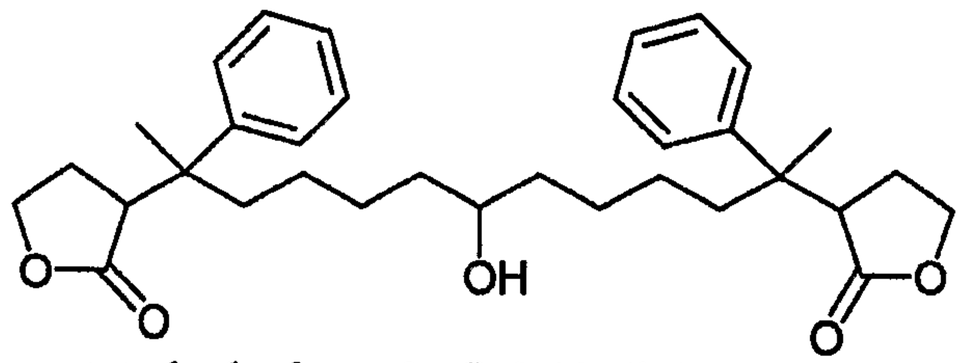
2,12-Bis(2-oxo-tetrahydrofuran-4-yl)-2,12-dihenyl-7-hydroxy-tridecane

Compound 433



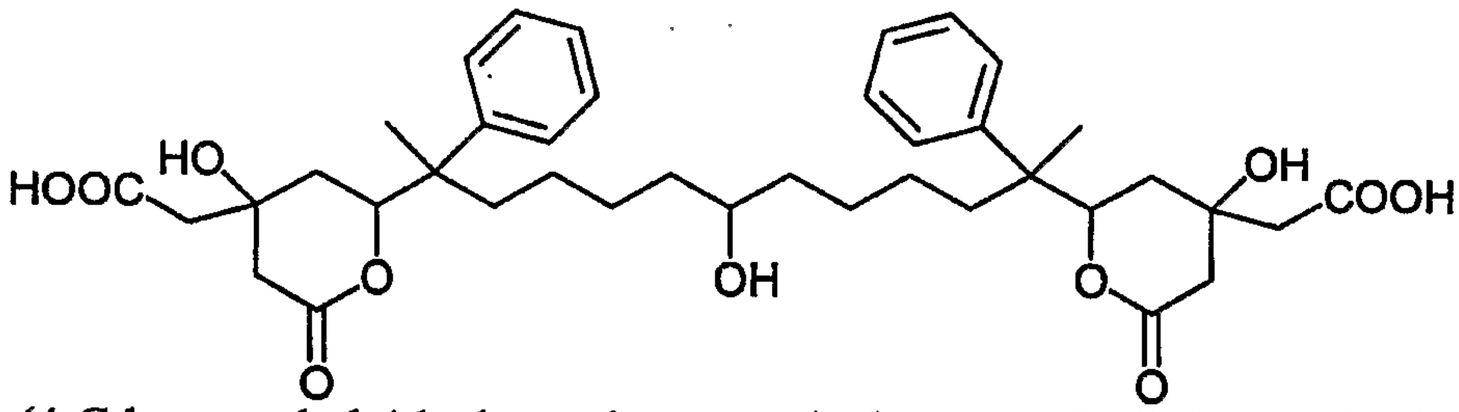
2,12-Bis(2-oxo-tetrahydrofuran-4-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 434



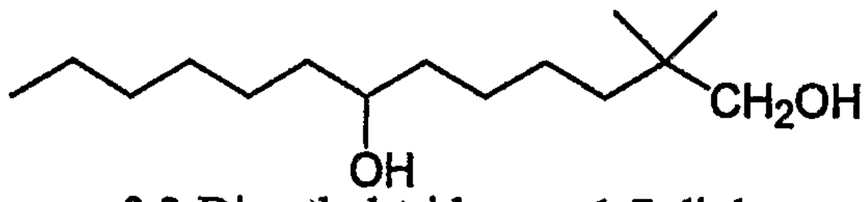
2,12-Bis(2-oxo-tetrahydrofuran-3-yl)-2,12-diphenyl-7-hydroxy-tridecane

Compound 435



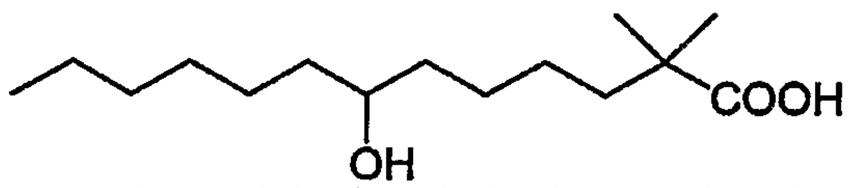
{2-[11-(4-Crboxymethyl-4-hydroxy-6-oxo-tetrahydro-pyran-2-yl)-1-methyl-6-hydroxy-1,11-diphenyl-dodecyl]-4-hydroxy-6-oxo-tetrahydro-pyran-4-yl}-acetic acid

Compound 436



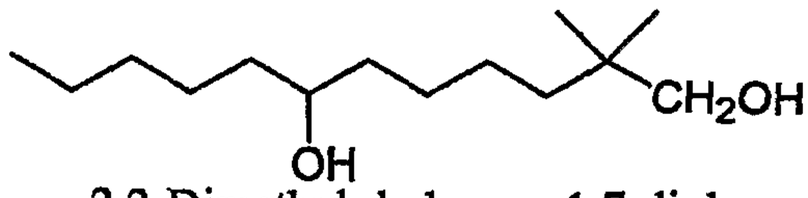
2,2-Dimethyl-tridecane-1,7-diol

Compound 437

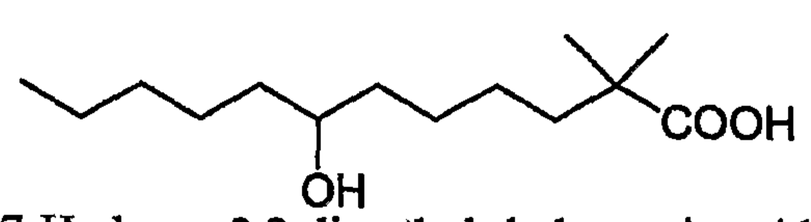


7-Hydroxy-2,2-dimethyl-tridecanoic acid

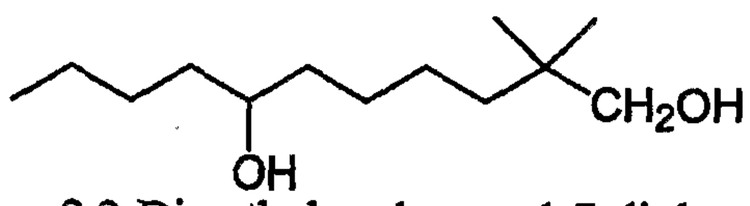
Compound 438



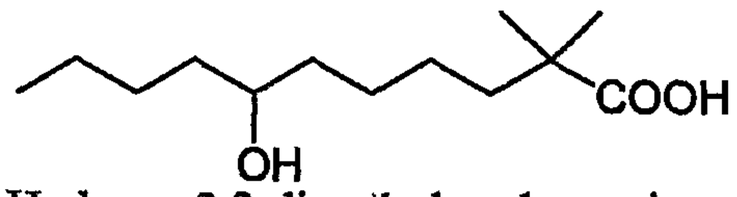
2,2-Dimethyl-dodecane-1,7-diol
Compound 439



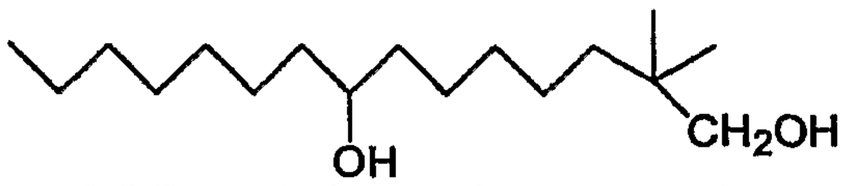
7-Hydroxy-2,2-dimethyl-dodecanoic acid
Compound 440



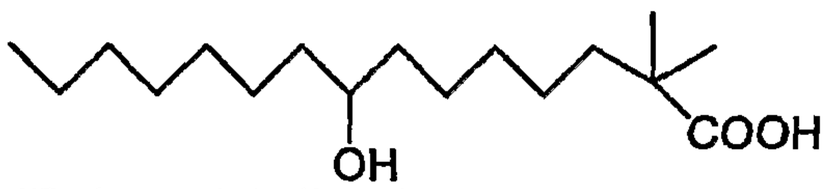
2,2-Dimethyl-undecane-1,7-diol
Compound 441



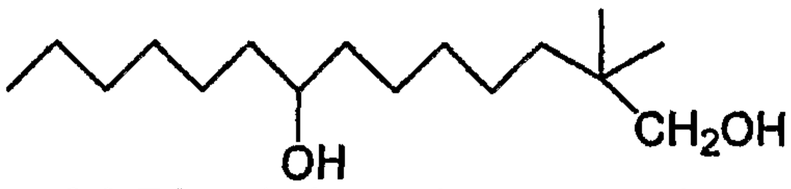
7-Hydroxy-2,2-dimethyl-undecanoic acid
Compound 442



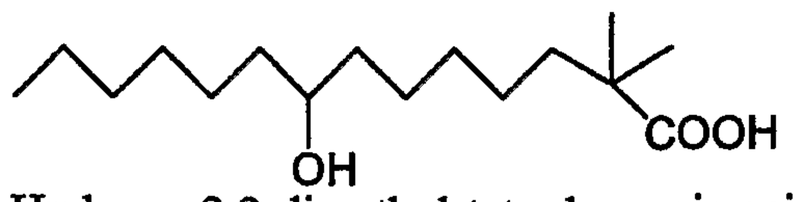
2,2-Dimethyl-pentadecane-1,8-diol
Compound 443



8-Hydroxy-2,2-dimethyl-pentadecanoic acid
Compound 444

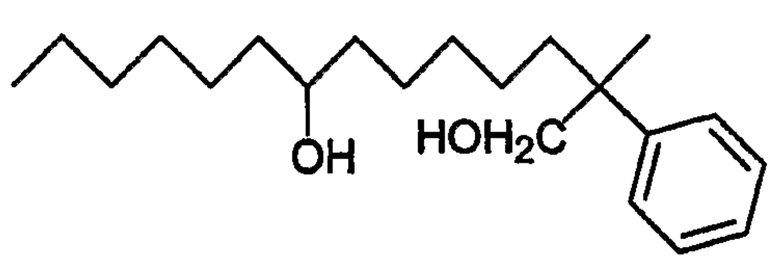


2,2-Dimethyl-tetradecane-1,8-diol
Compound 445



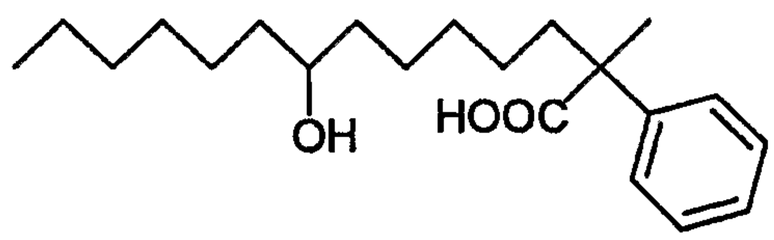
8-Hydroxy-2,2-dimethyl-tetradecanoic acid

Compound 446



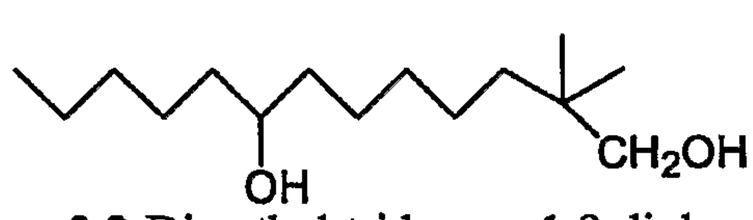
2-Methyl-2-phenyl-tetradecane-1,8-diol

Compound 447



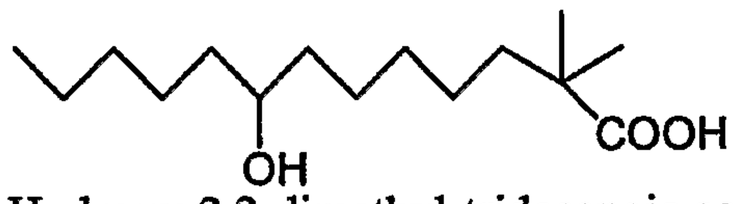
8-Hydroxy-2-methyl-2-phenyl-tetradecanoic acid

Compound 448



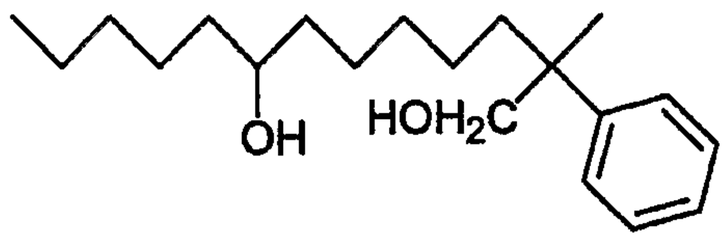
2,2-Dimethyl-tridecane-1,8-diol

Compound 449

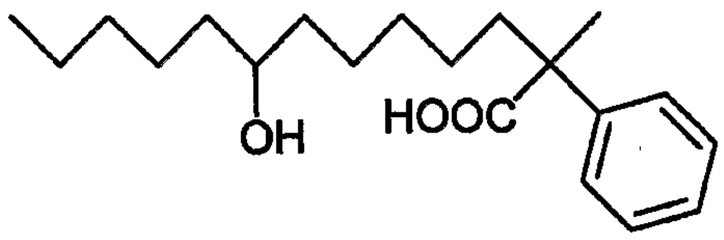


8-Hydroxy-2,2-dimethyl-tridecanoic acid

Compound 450

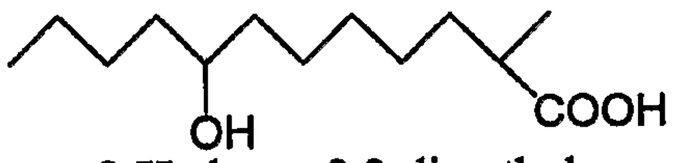


2-Methyl-2-phenyl-tridecane-1,8-diol
Compound 451

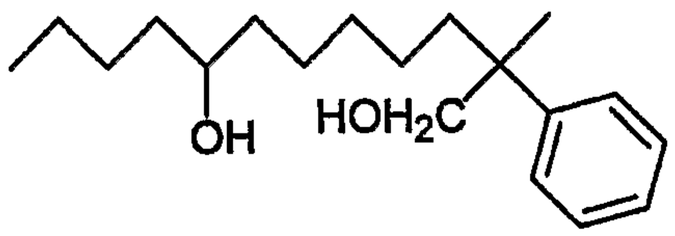


8-Hydroxy-2-methyl-2-phenyl-tridecanoic acid
Compound 452

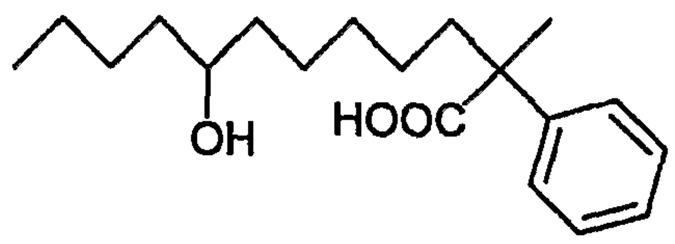
2,2-Dimethyl-dodecane-1,8-diol
Compound 453



8-Hydroxy-2,2-dimethyl
Compound 454

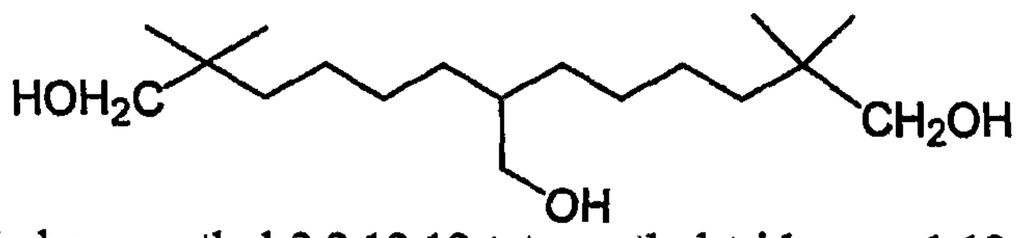


2-Methyl-2-phenyl-dodecane-1,8-diol
Compound 455



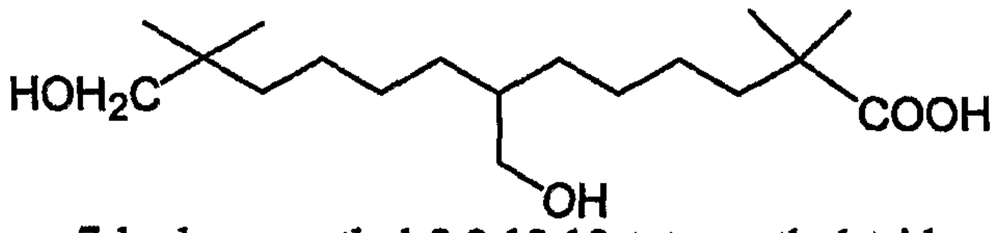
8-Hydroxy-2-methyl-2-phenyl-dodecanoic acid

Compound 456



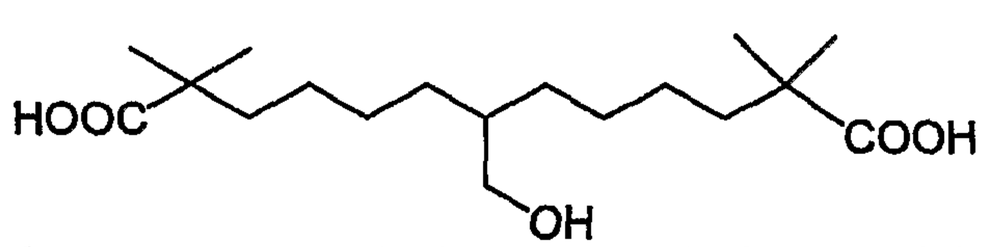
7-Hydroxymethyl-2,2,12,12-tetramethyl-tridecane-1,13-diol

Compound 457



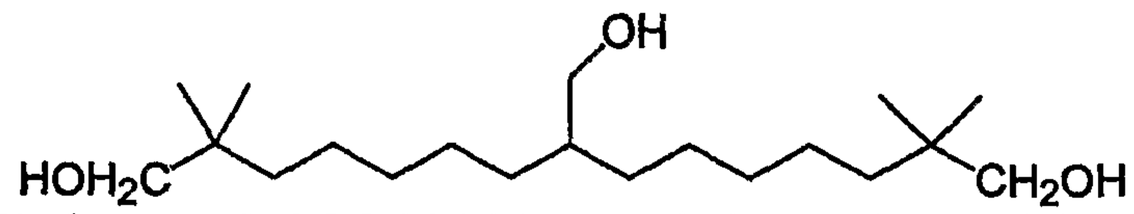
13-Hydroxy-7-hydroxymethyl-2,2,12,12-tetramethyl-tridecanoic acid

Compound 458



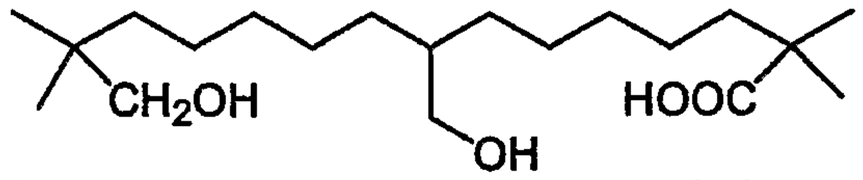
7-Hydroxymethyl-2,2,12,12-tetramethyl-tridecanedioic acid

Compound 459



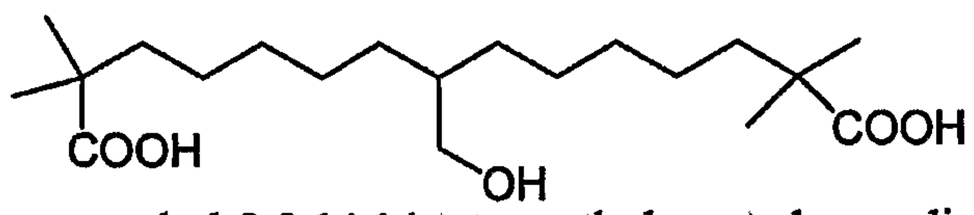
8-Hydroxymethyl-2,2,14,14-tetramethyl-pentadecane-1,15-diol

Compound 460



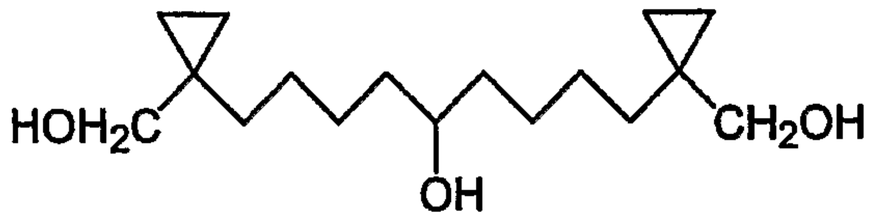
15-Hydroxy-8-hydroxymethyl-2,2,14,14-tetramethyl-pentadecanoic acid

Compound 461



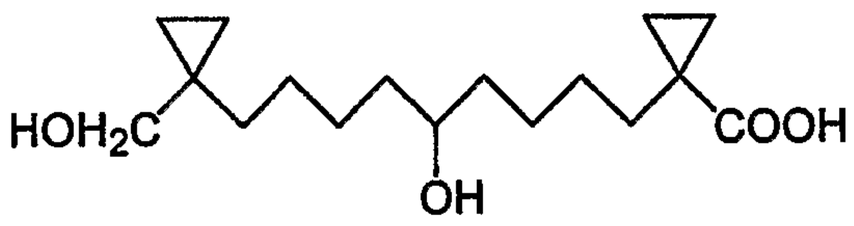
8-Hydroxymethyl-2,2,14,14-tetramethyl-pentadecanedioic acid

Compound 462



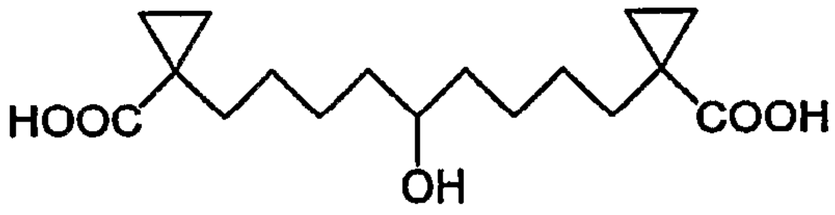
1,9-Bis-(1-hydroxymethyl-cyclopropyl)-nonan-5-ol

Compound 463



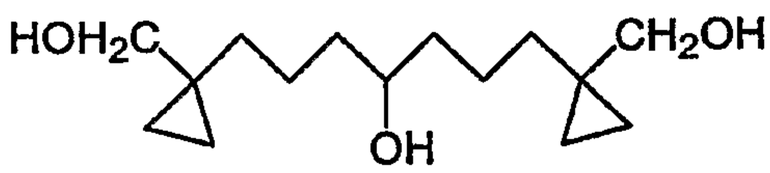
1-[5-Hydroxy-9-(1-hydroxymethyl-cyclopropyl)-nonyl]-cyclopropanecarboxylic acid

Compound 464



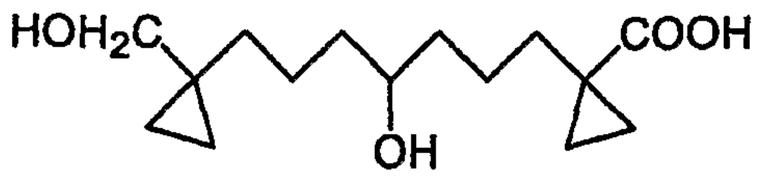
1,9-Bis-(1-carboxy-cyclopropyl)-nonan-5-ol

Compound 465



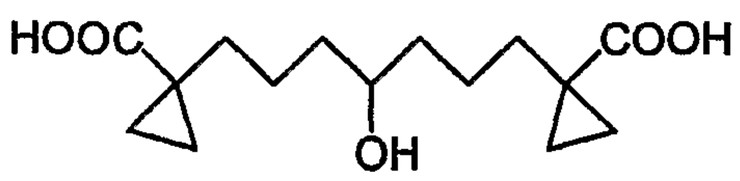
1,7-Bis-(1-hydroxymethyl-cyclopropyl)-heptan-4-ol

Compound 466



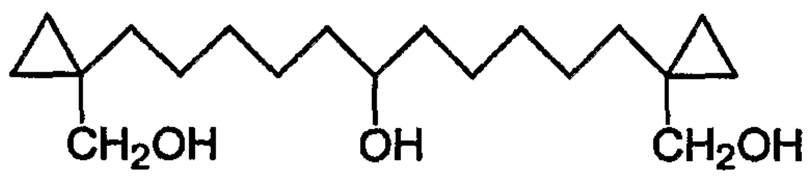
1-[4-Hydroxy-7-(1-hydroxymethyl-cyclopropyl)-heptyl]-cyclopropaneocarboxylic acid

Compound 467



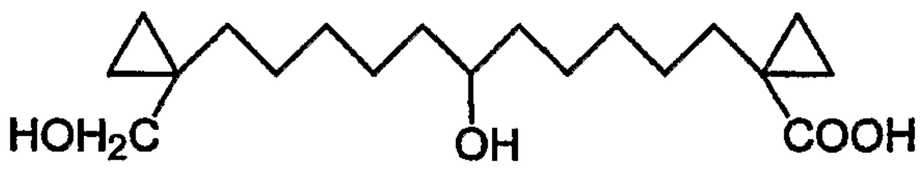
1,7-Bis-(1-carboxy-cyclopropyl)-heptan-4-ol

Compound 468



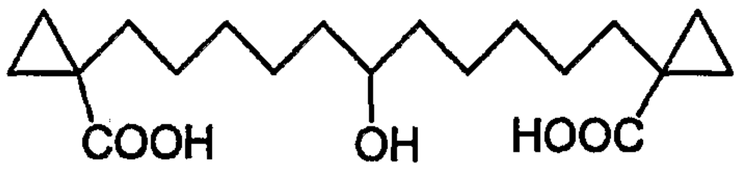
1,11-Bis-(1-hydroxymethyl-cyclopropyl)-undecan-6-ol

Compound 469



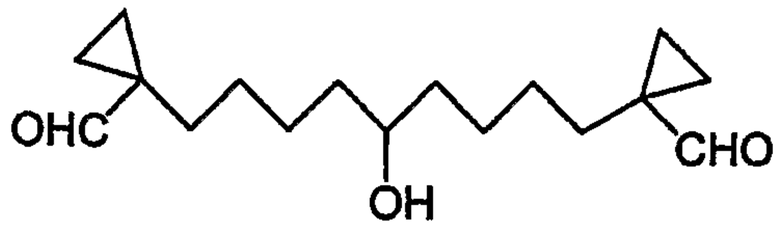
1-[6-Hydroxy-11-(1-hydroxymethyl-cyclopropyl)-undecyl]-cyclopropanecarboxylic acid

Compound 470



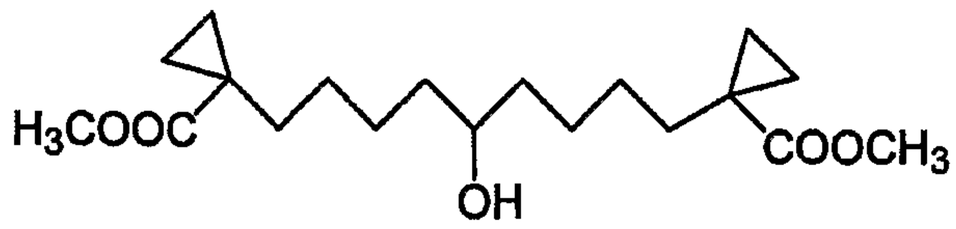
1,11-Bis-(1-carboxy-cyclopropyl)-undecan-6-ol

Compound 471



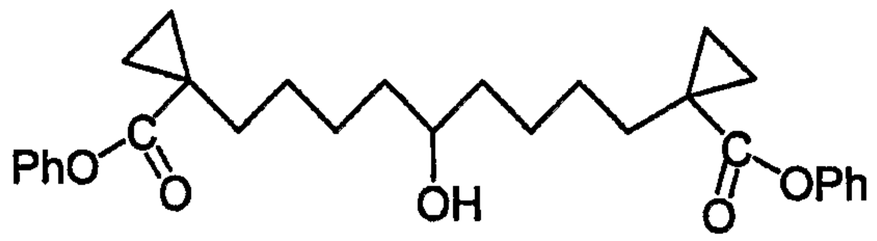
1,9-Bis-(1-oxa-cyclopropyl)-nonan-5-ol

Compound 472



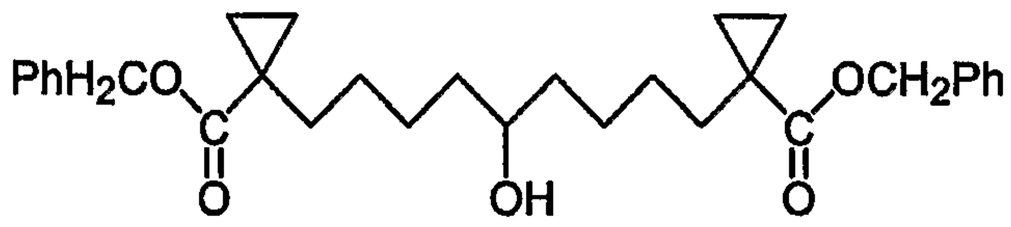
1,9-Bis-(1-carbomethoxy-cyclopropyl)-nonan-5-ol

Compound 473



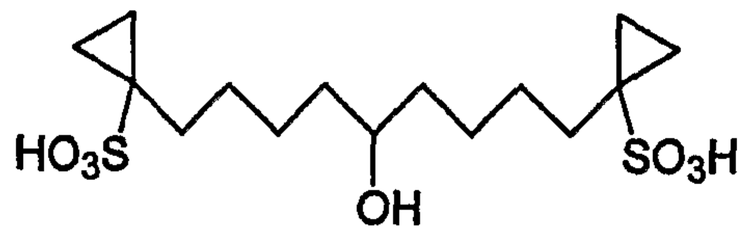
1,9-Bis-(1-phenoxycarbonyl-cyclopropyl)-nonan-5-ol

Compound 474



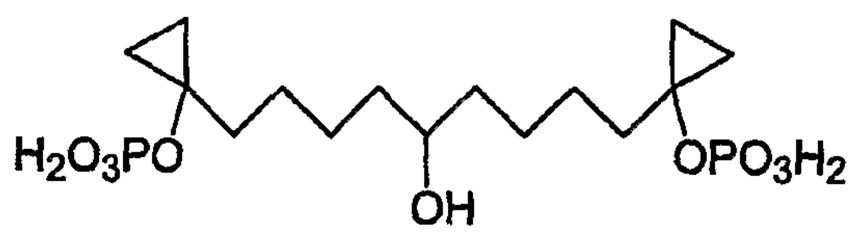
1,9-Bis-(1-benzyloxycarbonyl-cyclopropyl)-nonan-5-ol

Compound 475



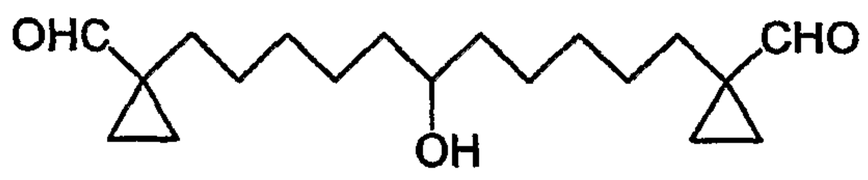
1,9-Bis-(1-sufonyloxy-cyclopropyl)-nonan-5-ol

Compound 476



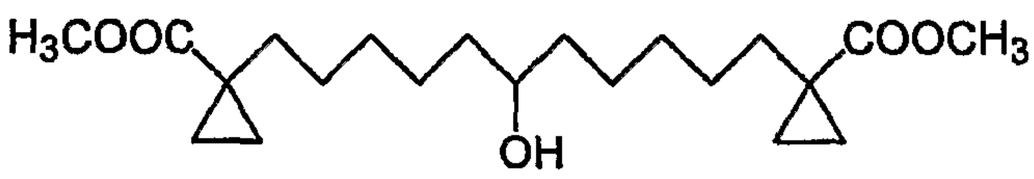
1,9-Bis-(1-phosphonooxy-cyclopropyl)-nonan-5-ol

Compound 477



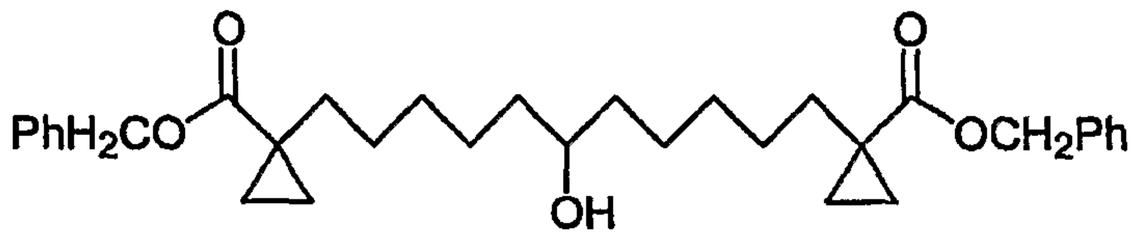
1,11-Bis-(1-oxa-cyclopropyl)-undecan-6-ol

Compound 478



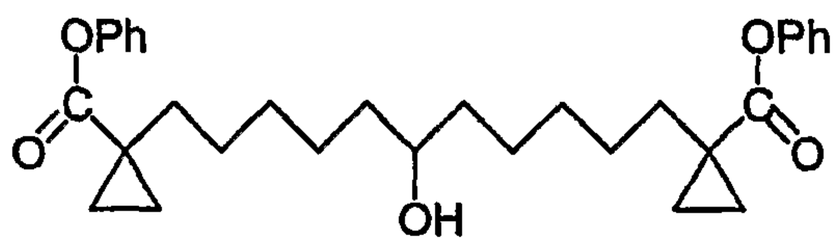
1,11-Bis-(1-carbomethyoxy-cyclopropyl)-undecan-6-ol

Compound 479



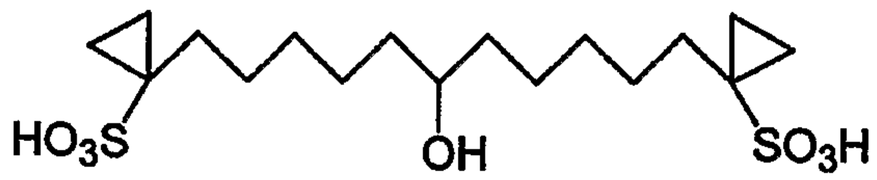
1,11-Bis-(1-benzyloxycarbonyl-cyclopropyl)-undecan-6-ol

Compound 480



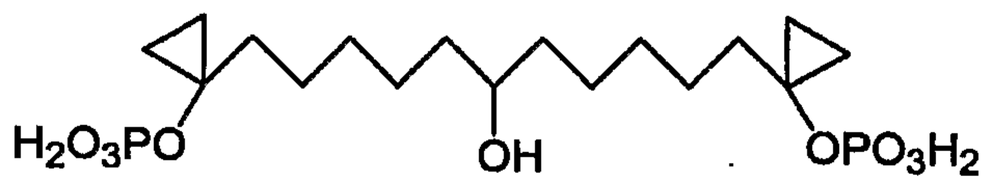
1,11-Bis-(1-phenoxycarbonyl-cylopropyl)-undecan-6-ol

Compound 481



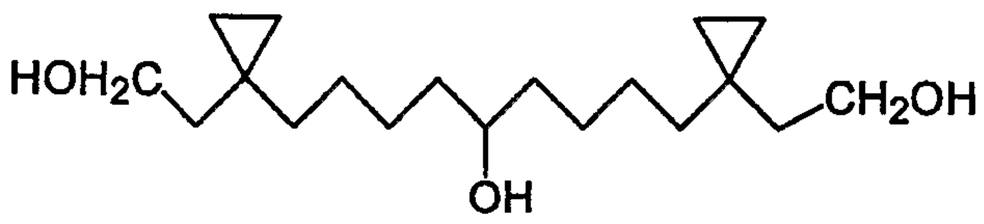
1,11-Bis-(1-sufonyloxy-cyclopropyl)-undecan-6-ol

Compound 482



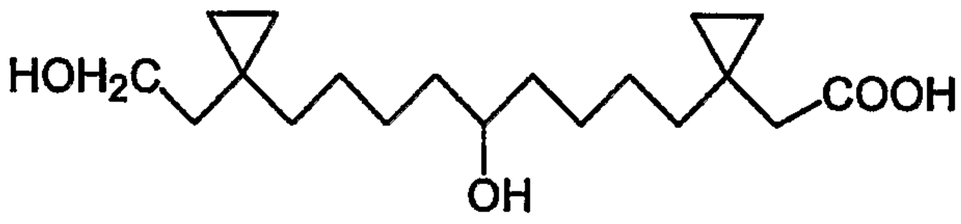
1,9-Bis-(1-phosphonooxy-cyclopropyl)-nonan-5-ol

Compound 483



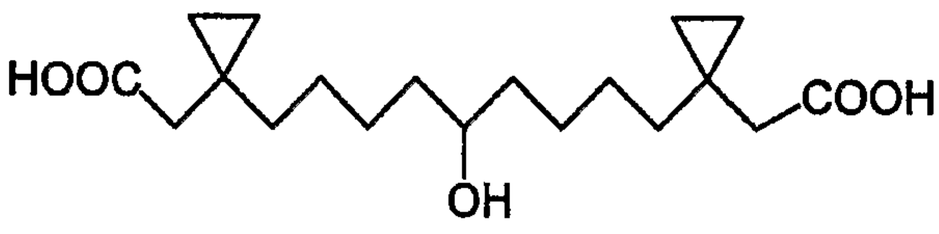
1,9-Bis-[1-(2-hydroxy-ethyl)-cyclopropyl]-nonan-5-ol

Compound 484



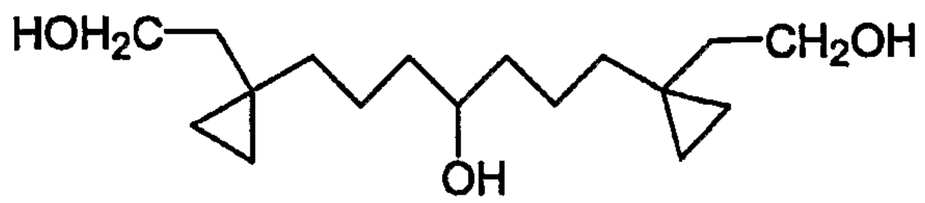
(1-{5-Hydroxy-9-[1-(2-hydroxy-ethyl)-cyclopropyl]-nonyl}-cyclopropyl)-acetic acid

Compound 485



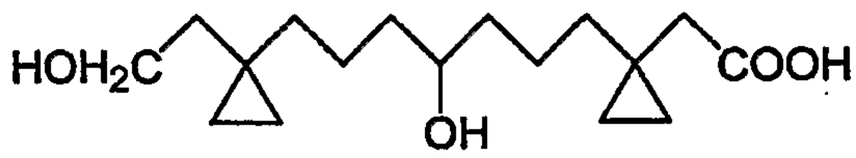
{1-[9-(1-Carboxymethyl-cyclopropyl)-5-hydroxy-nonyl]-cyclopropyl}-acetic acid

Compound 486



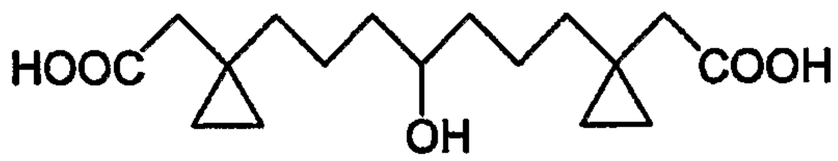
1,7-Bis-[1-(2-hydroxy-ethl)-cyclopropyl]-heptan-4-ol

Compound 487



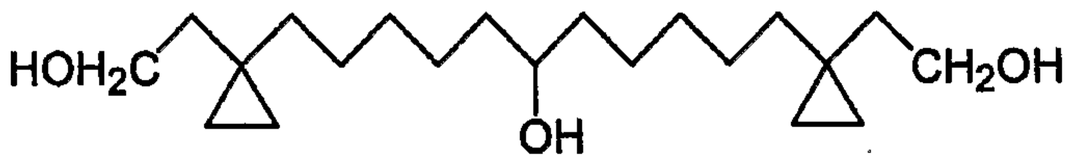
(1-{4-Hydroxy-7-[1-(2-hydroxy-ethyl)-cyclopropyl]-heptyl}-cyclopropyl)-acetic acid

Compound 488



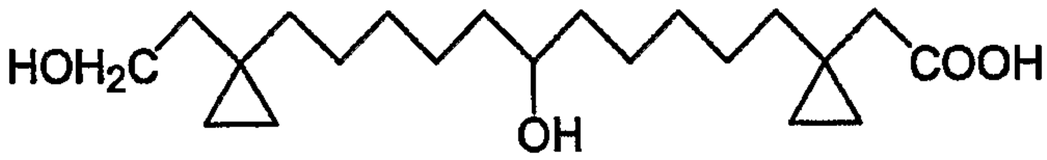
{1-[7-(1-Carboxymethyl-cyclopropyl)-4-hydroxy-heptyl]-cyclopropyl}-acetic acid

Compound 489



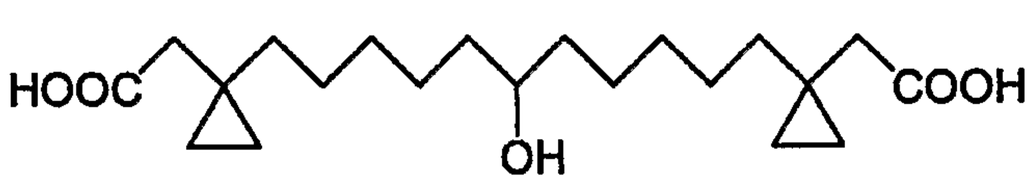
1,11-Bis-[1-2-hydroxy-ethyl)-cyclopropyl]-undecan-6-ol

Compound 490



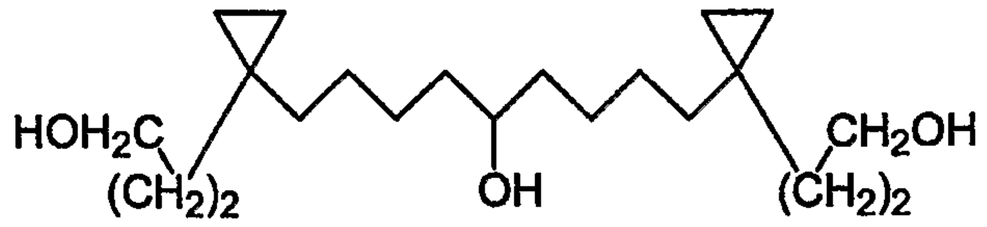
(1-{6-Hydroxy-11-[1-(2-hydroxy-ethyl)-cyclopropyl]-undecyl}-cyclopropyl)-acetic acid

Compound 491



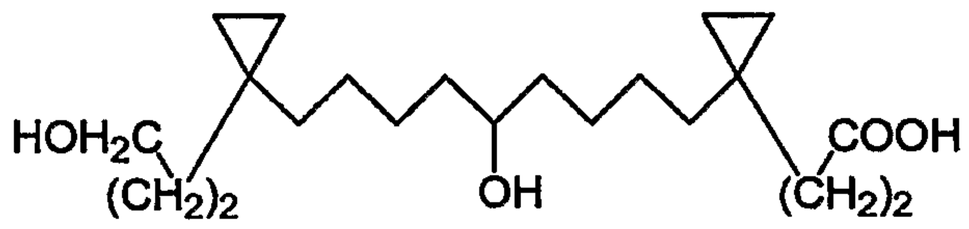
{1-11-(1-Carobxymethyl-cyclopropyl)-6-hydroxy-undecyl]-cyclopropyl}-acetic acid

Compound 492



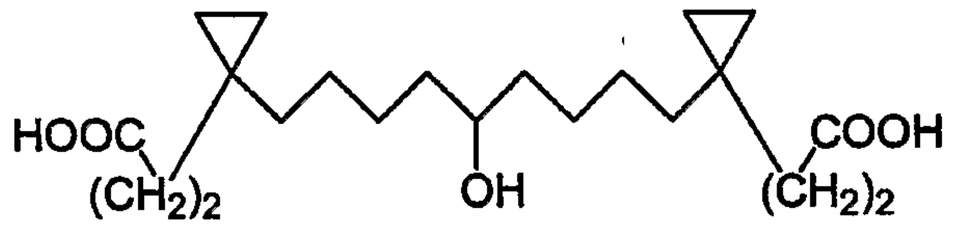
1,9-Bis-[1-(3-hydroxy-propyl)-cyclopropyl]-nonan-5-ol

Compound 493



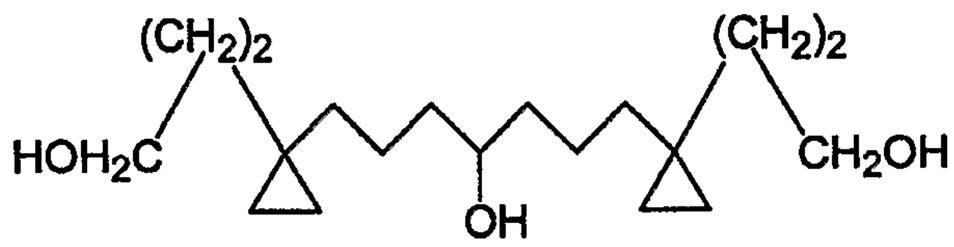
3-(1-{5-Hydroxy-9-[1-(3-hydroxy-propyl)-cyclopropyl]-nonyl}-cyclopropyl)-propionic acid

Compound 494



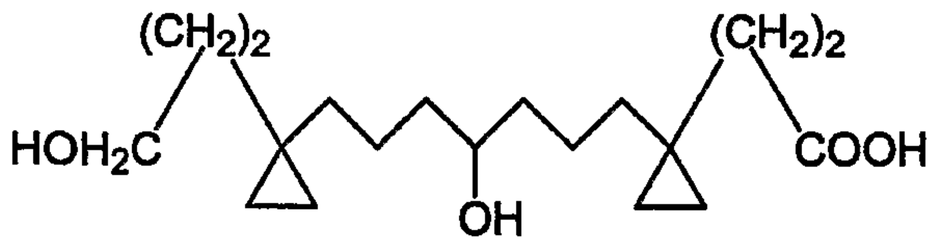
3-(1-{9-[1-(3-Carboxy-ethyl)-5-hydroxy-cyclopropyl]-nonyl}-cyclopropyl)-propionic acid

Compound 495



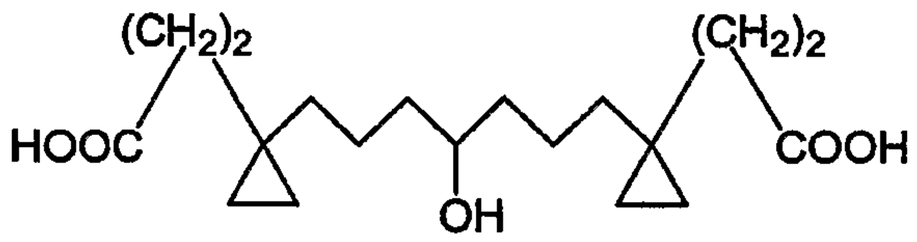
1,7-Bis-[1-(3-hydroxy-propyl)-cyclopropyl]-heptan-4-ol

Compound 496



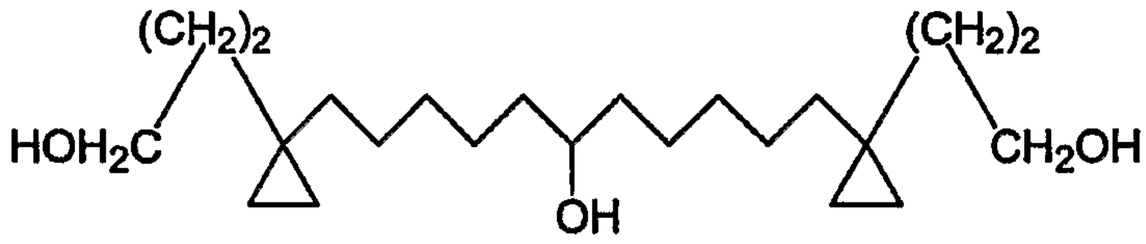
3-(1-{4-Hydroxy-7-[1-(3-hydroxy-propyl)-cyclopropyl]-heptyl}-cyclopropyl)-propionic acid

Compound 497



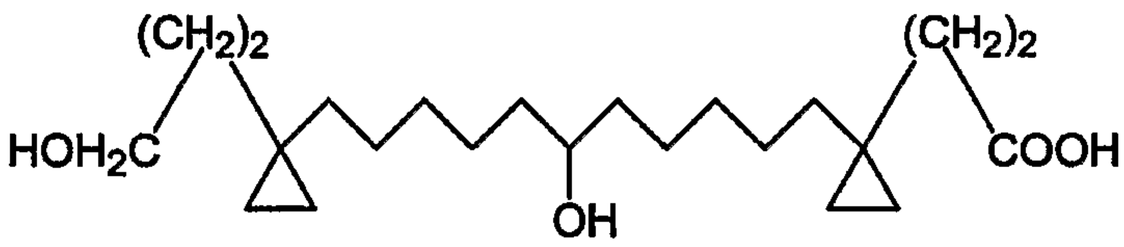
3-(1-{7-[1-(2-Carboxy-ethyl)-cyclopropyl]-4-hydroxy-heptyl}-cyclopropyl)-propionic acid

Compound 498



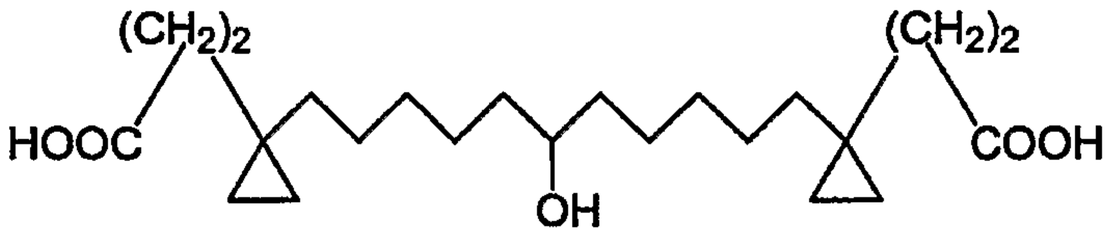
1,11-Bis-[1-(3-hydroxy-propyl)-cyclopropyl]-undecan-6-ol

Compound 499



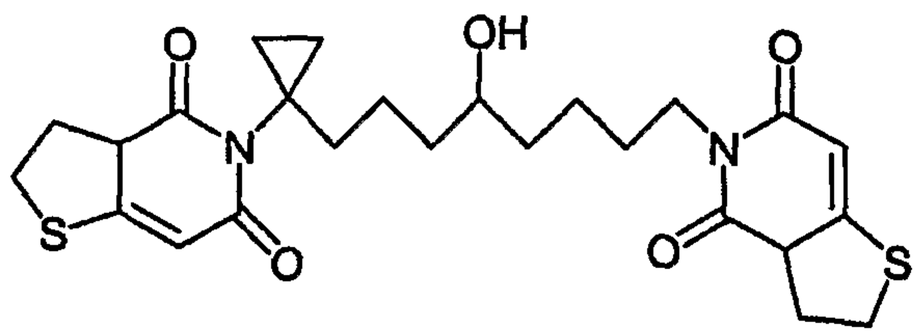
3-(1-{6-Hydroxy-11-[1-(3-hydroxy-propyl)-cyclopropyl]-undecyl}-cyclopropyl)-propionic acid

Compound 500



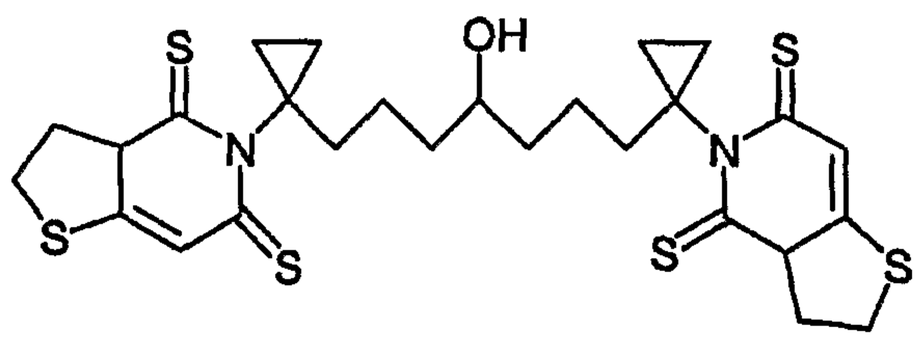
3-(1-{11-[1-(2-Carboxy-ethyl)-cyclopropyl]-6-hydroxy-undecyl}-cyclopropyl)-propionic acid

Compound 501



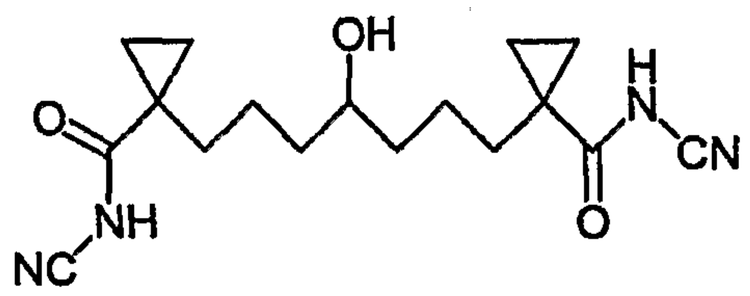
1,7-Bis-(4,6-dioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-1-(cyclopropyl)-6-hydroxy-heptane

Compound 502



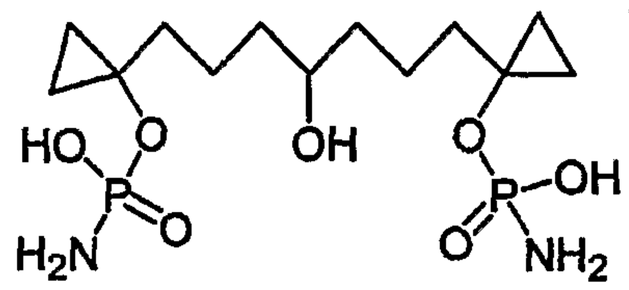
1,7-Bis-(4,6-dithioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-1,7-bis-(cyclopropyl)-6-hydroxy-undecane

Compound 503



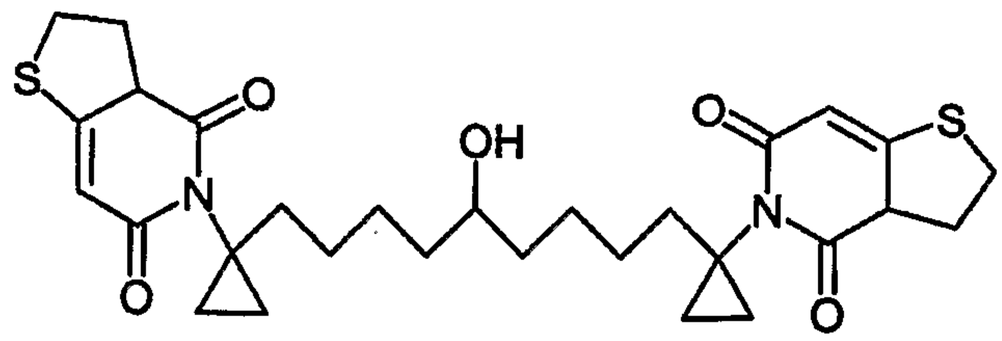
1,7-Bis-(1-dicyanimido-cyclopropyl)-4-hydroxy-heptane

Compound 504



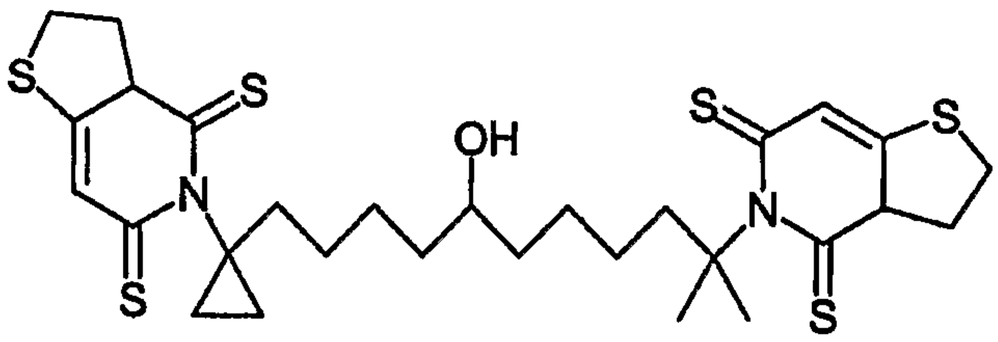
1,7-Bis-(1-phosponamid-cyclopropyl)-4-hydroxy-heptane

Compound 505



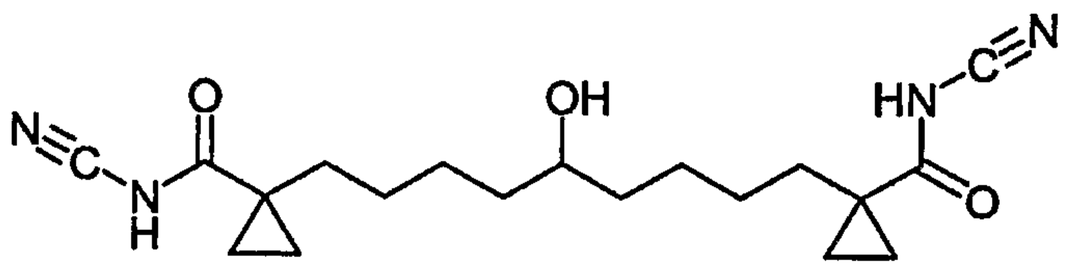
2,9-Bis-(4,6-dioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-2,9-bis-(cyclopropyl)-5-hydroxy-nonane

Compound 506



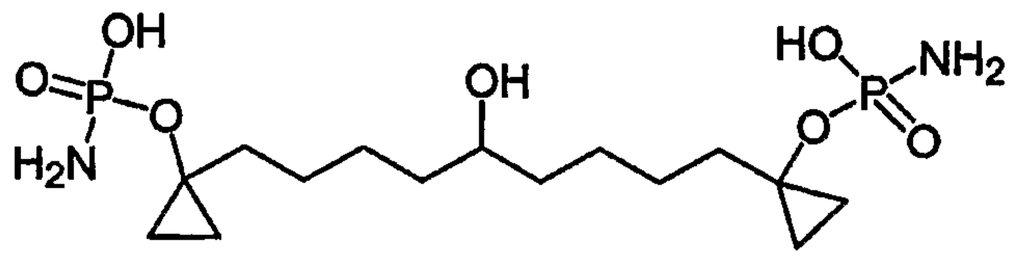
2,12-Bis-(4,6-dithioxo-2,3,3a,6-tetrahydro-4H-thieno[3,2-c]pyridin-5-yl)-2-methyl-12-(cyclopropyl)-7-hydroxy-dodecane

Compound 507



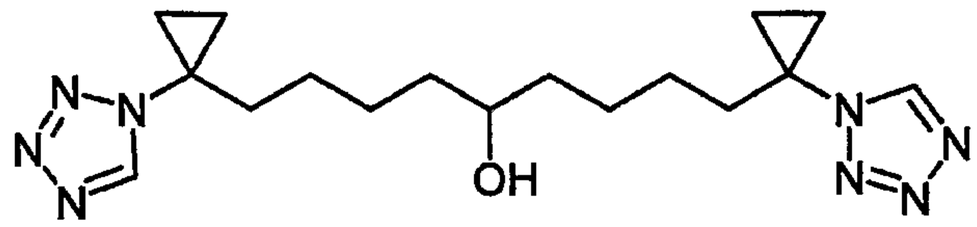
1,7-Bis-(1-dicyanimido-cyclopropyl)-5-hydroxy-nonane

Compound 508



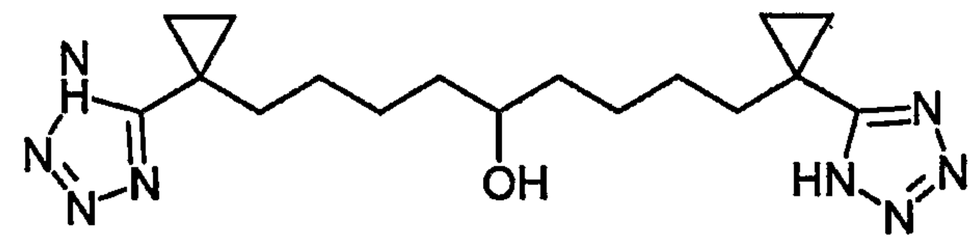
1,7-Bis-(1-phosphonamido-cyclopropyl)-5-hydroxy-nonane

Compound 509



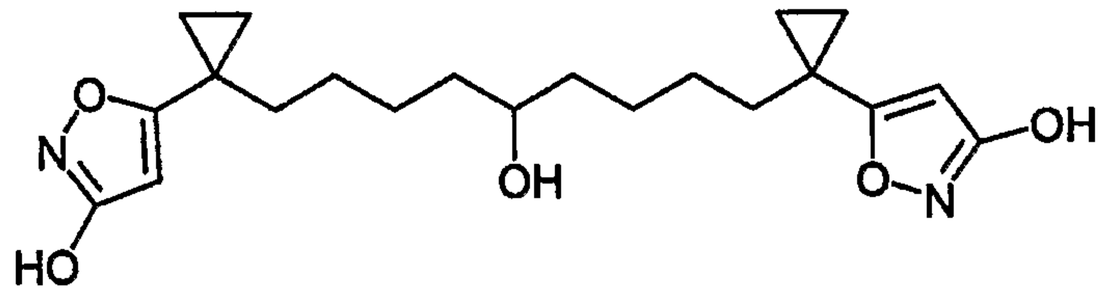
1,9-Bis-(1-tetrazol-l-yl-cyclopropyl)-nonan-5-ol

Compound 510



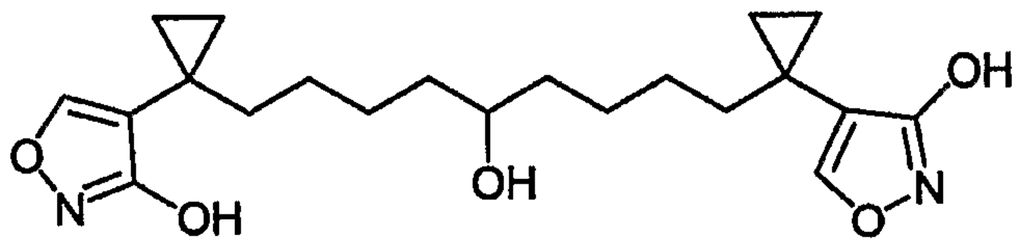
1,9-Bis-[I-(1H-tetrazol-5-yl)-cyclopropyl]-nonan-5-ol

Compound 511



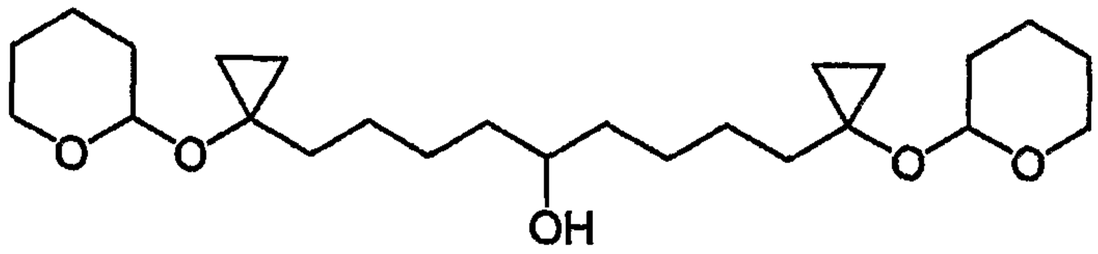
1,9-Bis-[l-(3-hydroxy-isoxazol-5-yl)-cyclopropyl]-nonan-5-ol

Compound 512



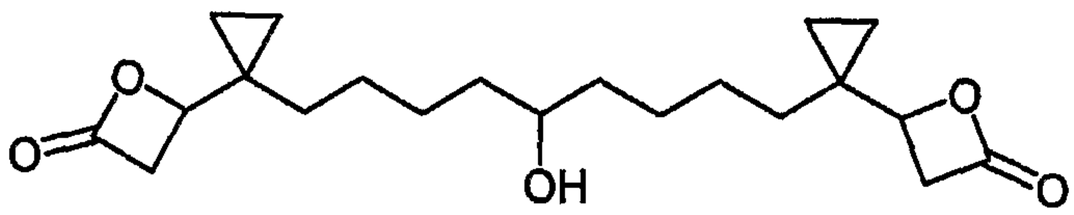
1,9-Bis-[1-(3-hydroxy-isoxazol-4-yl)-cyclopropyl]-nonan-5-ol

Compound 513



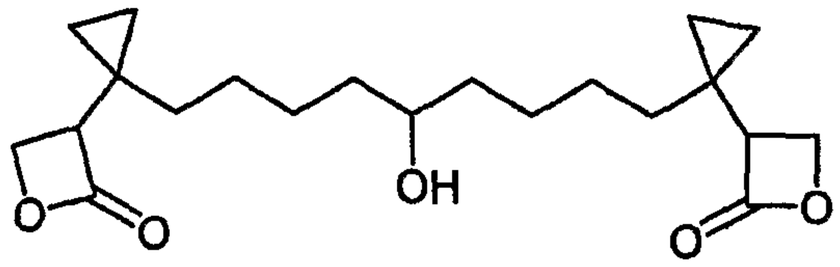
1,9-Bis-[1-(tetrahydro-pyran-2-yloxy)-cyclopropyl]-nonan-5-ol

Compound 514



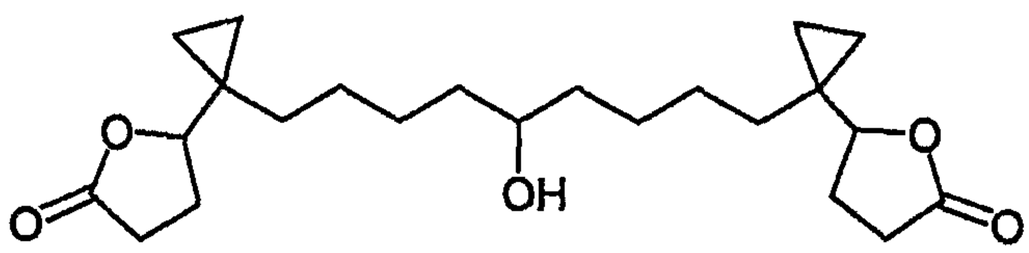
1,9-Bis-[l-(2-oxo-oxoethan-3-yl)-cyclopropyl]-nonan-5-o1

Compound 515



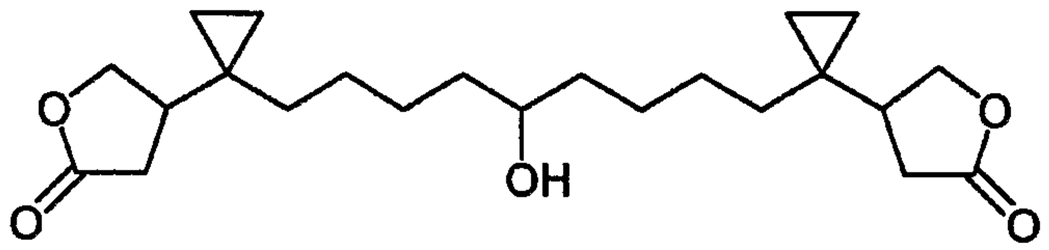
1,9-Bis-[l-(2-oxo-oxoethan-3-yl)-cyclopropyl]-nonan-5-o1

Compound 516



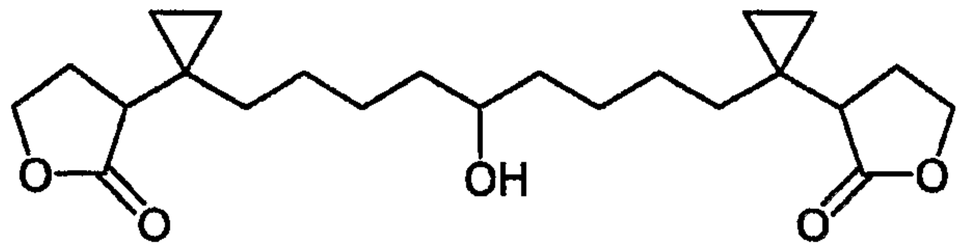
1,9-Bis-[l-(2-oxo-tetrahydrofuran-5-yl)-cyclopropyl]-nonan-5-ol

Compound 517



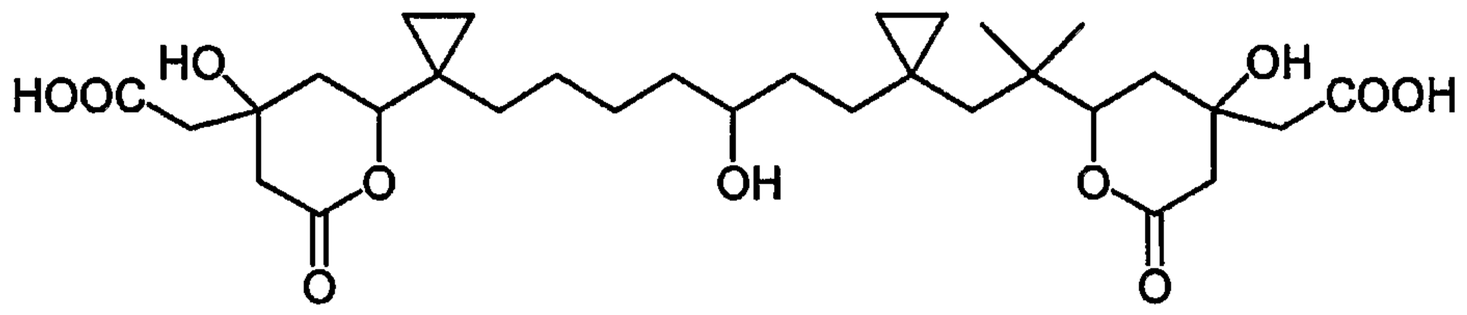
1,9-Bis-[1-(2-oxo-tetrahydrofuran-4-yl)-cyclopropyl]-nonan-5-ol

Compound 518



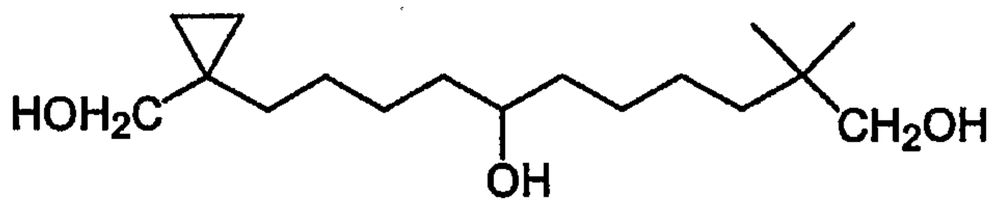
1,9-Bis-[l-(2-oxo-tetrahydrofuran-3-yl)-cyclopropyl]-nonan-5-ol

Compound 519



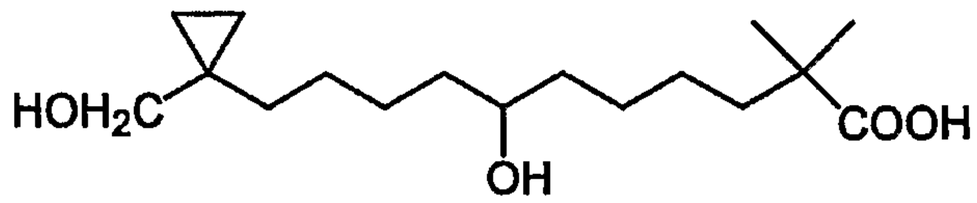
1,9-Bis {1-[9-(4-carboxymethyl-4-hydroxy-6-oxo-tetrahydro-pyran-2-yl)-(cyclopropyl)}-5-hydoxy-nonane

Compound 520



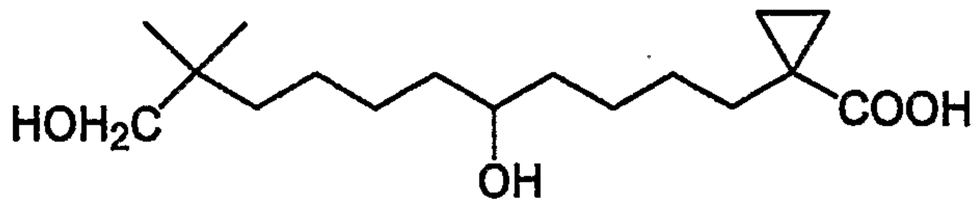
11-(1-Hydroxymethyl-cyclopropyl)-2,2-dimethyl-undecane-l,7-diol

Compound 521



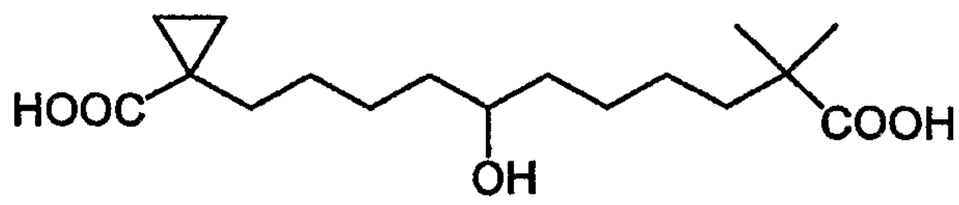
7-Hydroxy-11-(1-hydroxymethyl-cyclopropyl)-2,2-dimethyl-undecanoic acid

Compound 522



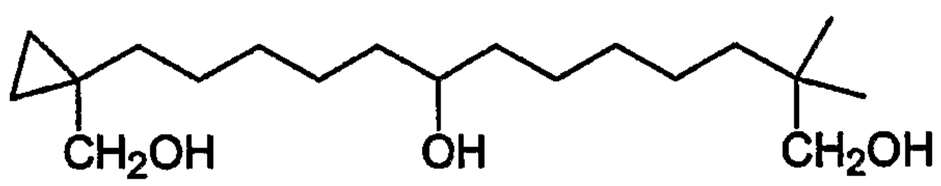
1-(5,11-Dihydroxy- 10,10-dimethyl-undecyl)-cyclopropanecarboxylic acid

Compound 523



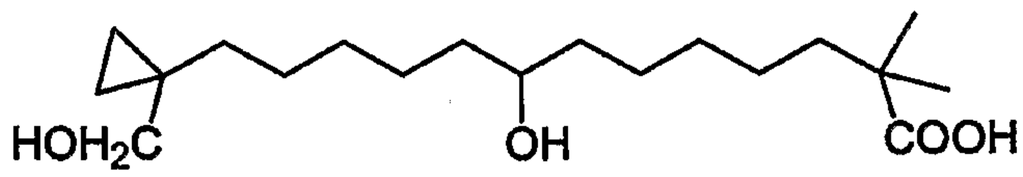
1-(10-Carboxy-5-hydroxy-10-methyl-undecyl)-cyclopropanecarboxylic acid

Compound 524



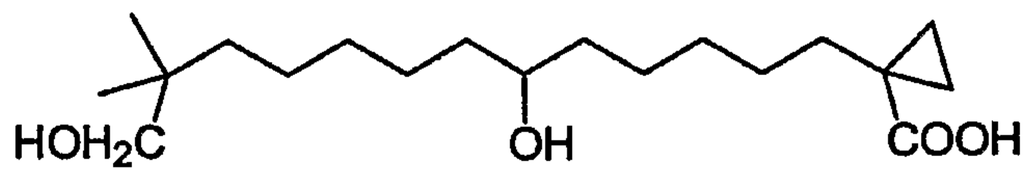
13-(1-Hydroxymethyl-cyclopropyl)-2,2-dimethyl-tridecane-1,8-diol

Compound 525



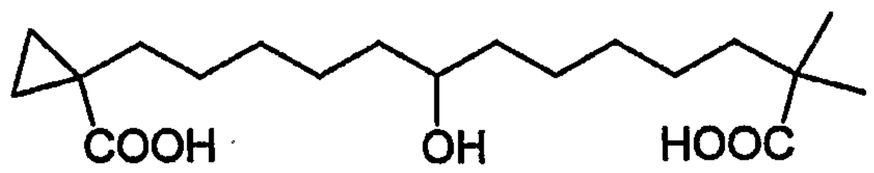
8-Hydroxy-13-(1-hydroxymethyl-cyclopropyl)-2,2-dimethyl-tridecanoic acid

Compound 526



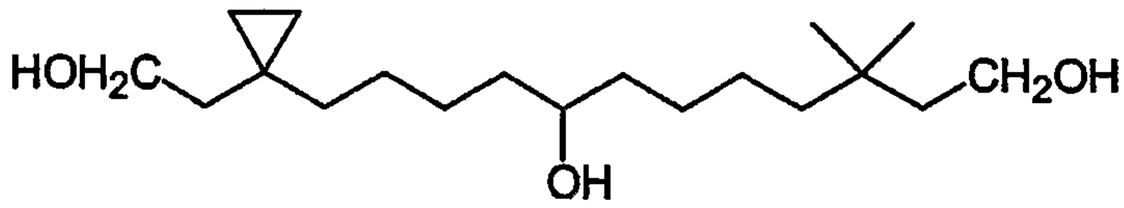
1-(6,13-Dihydroxy-12,12-dimethyl-tridecyl)-cyclopropanecarboxylic acid

Compound 527



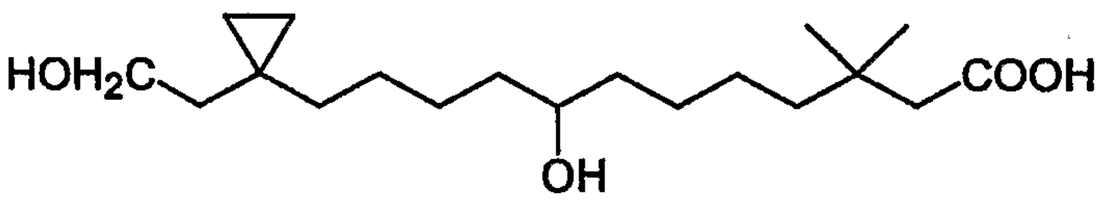
1-(12-Carboxy-6-hydroxy-12-methyl-tridecyl)-cyclopropanecarboxylic acid

Compound 528



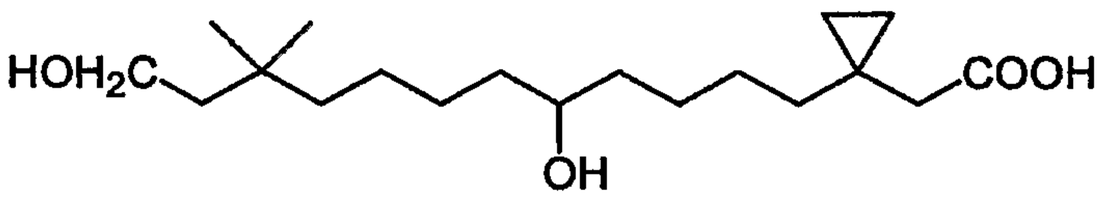
12-[1-(2-Hydroxy-ethyl)-cyclopropyl]-3,3-dimethyl-dodecane-1,8-diol

Compound 529



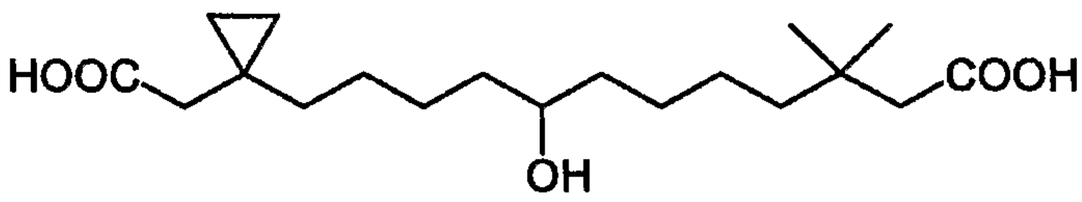
8-Hydroxy-12-[1-(2-hydroxy-ethyl)-cyclopropyl]-3,3-dimethyl-dodecanoic acid

Compound 530



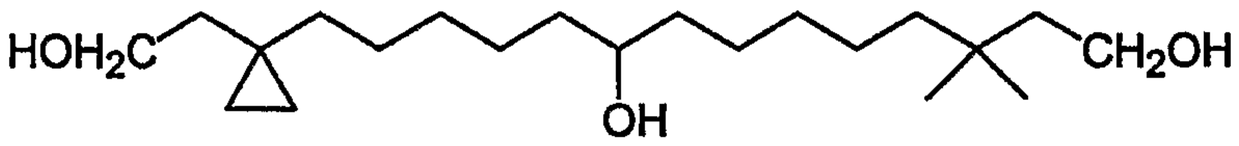
[1-(5,12-Dihydroxy-10,10-dimethyl-dodecyl)-cyclopropyl]-acetic acid

Compound 531



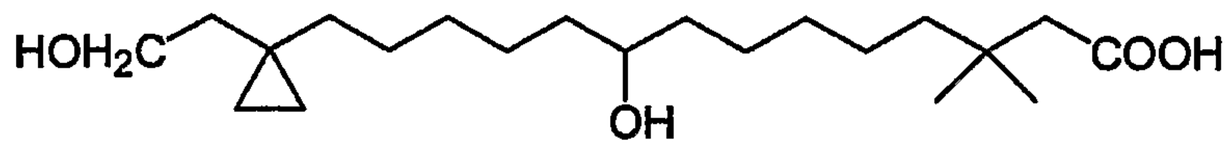
12-(1-Carboxymethyl-cyclopropyl)-8-hydroxy-3,3-dimethyl-dodecanoic acid

Compound 532



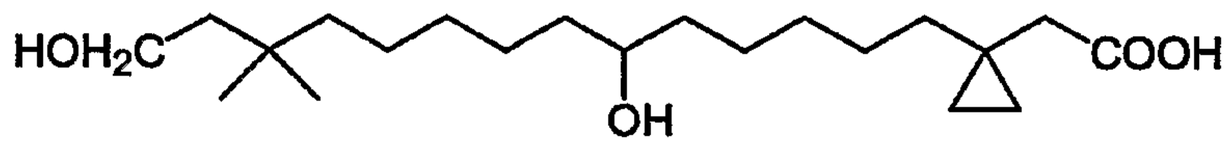
14-[1-(2-Hydroxy-ethyl)-cyclopropyl]-3,3-dimethyl-tetradecane-1,9-diol

Compound 533



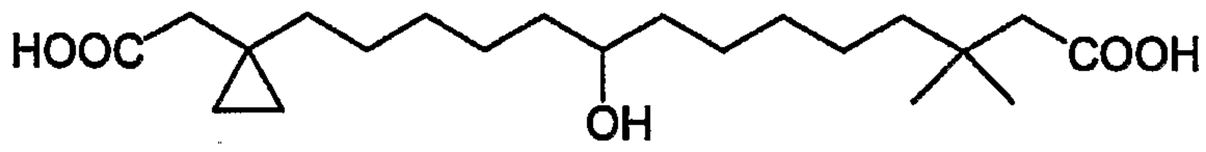
9-Hydroxy-14-[1-(2-hydroxy-ethyl)-cyclopropyl]-3,3-dimethyl-tetradecanoic acid

Compound 534



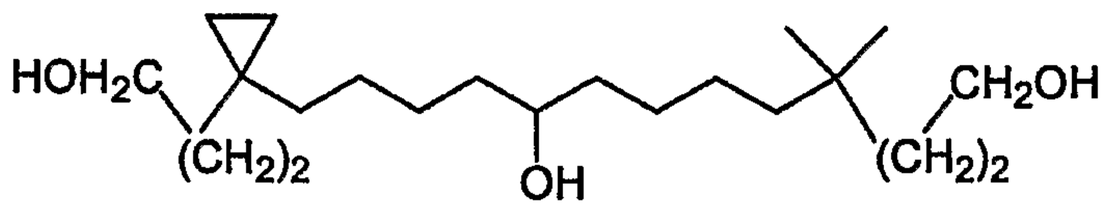
[1-(6,14-Dihydroxy-l2,12-dimethyl-tetradecyl)-cyclopropyl]-acetic acid

Compound 535



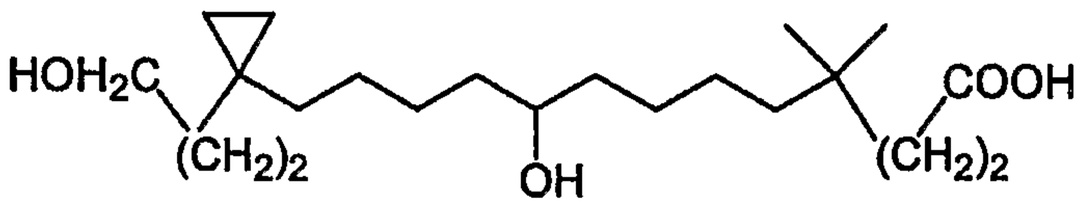
14-(1-Carboxymethyl-cyclopropyl)-9-hydroxy-3,3-dimethyl-tetradecanoic acid

Compound 536



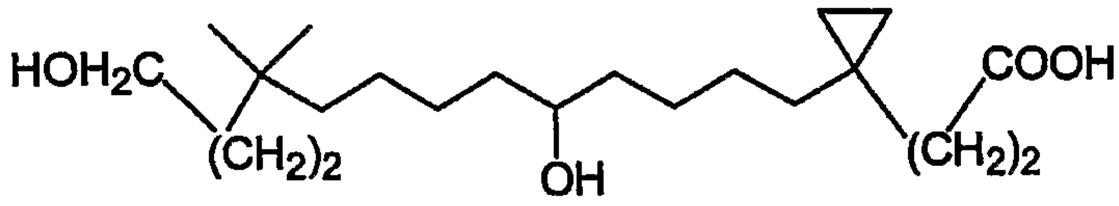
13-[1-(3-Hydroxy-propyl)-cyclopropyl]-4,4-dimethyl-tridecane-l,9-diol

Compound 537



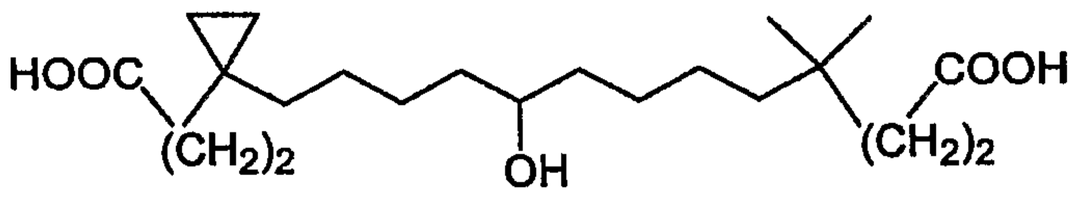
4,4-Dimethyl-9-hydroxy-13-[1-(3-hydroxypropyl)-cyclopropyl]-tridecanoic acid

Compound 538



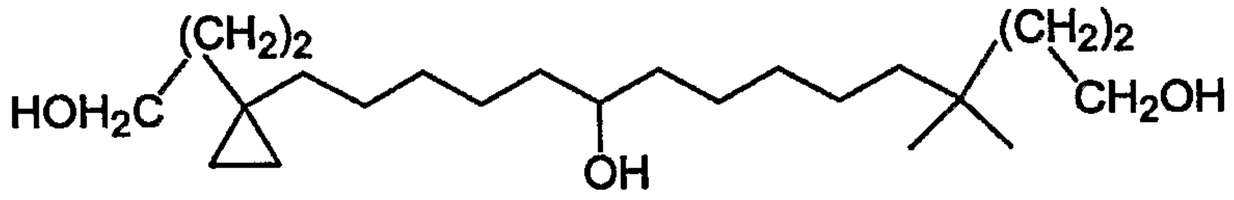
3-[1-(5,13-Dihydroxy-10,10-dimethyl-tridecyl)-cyclopropyl]-propionic acid

Compound 539



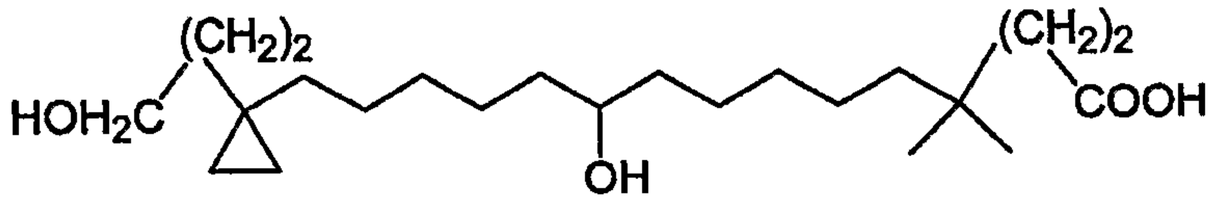
13-[1-(2-Carboxyethyl)-cyclopropyl]-9-hydroxy-4,4-dimethyl-tridecanoic acid

Compound 540



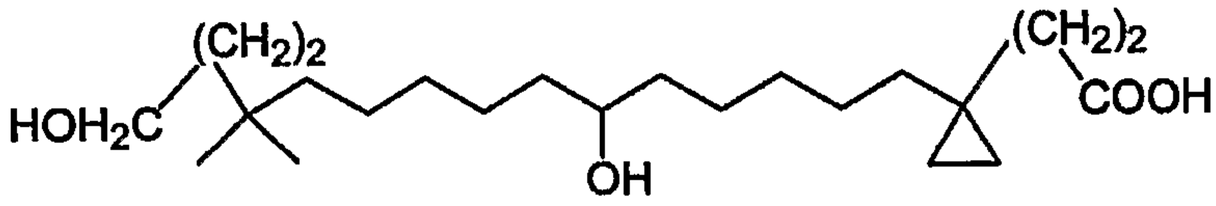
15-[l-(3-Hydroxy-propyl)-cyclopropyl]-4,4-dimethyl-pentadecane-1,10-diol

Compound 541



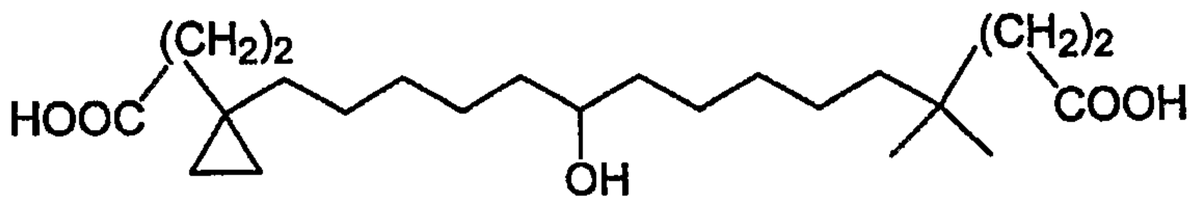
4,4-Dimethyl-l0-hydroxy-15-[1-(3-hydroxy-propyl)-cyclopropyl]-pentadecanoic acid

Compound 542



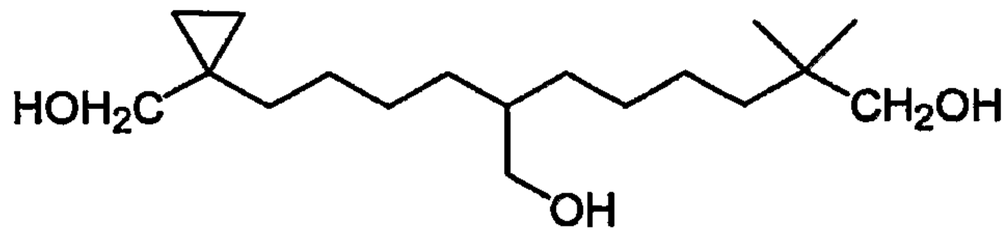
3-[1-(6,15-Dihydroxy-12,12-dimethyl-pentadecyl)-cyclopropyl]-propionic acid

Compound 543



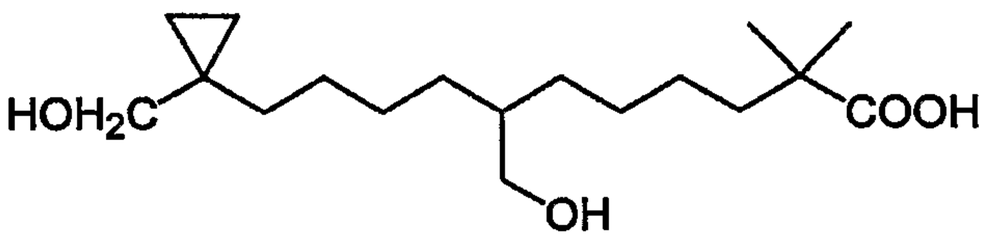
15;-[1-(2-Carboxyethyl)-cyclopropyl]-10-hydroxy-4,4-dimethyl-tridecanoic acid

Compound 544



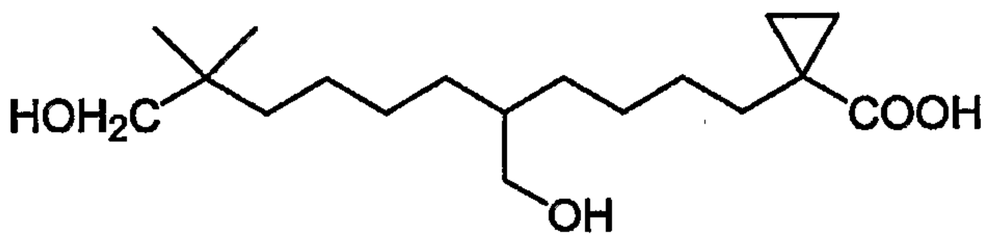
7-[4-(1-Hydroxymethyl-cyclopropyl)-butyl] 2,2-dimethyl-octane-1,8-diol

Compound 545



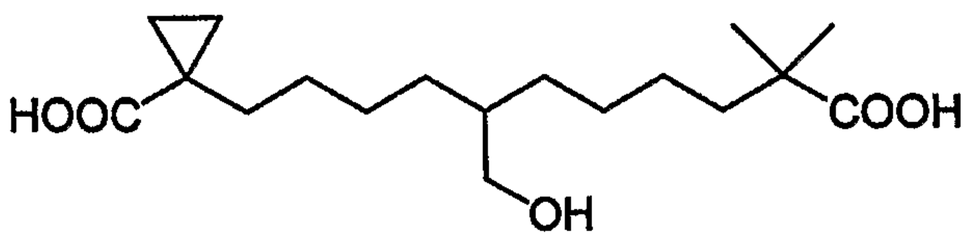
7-Hydroxymethyl-11-(1-hydroxymethyl-cyclopropyl)-2,2-dimethyl-undecanoic acid

Compound 546



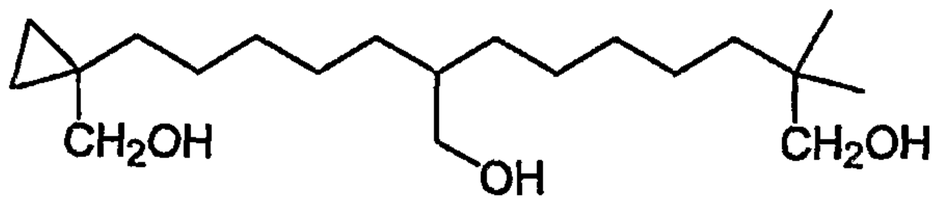
1-(11-Hydroxy-5-hydroxymethyl-10,10-dimethyl-undecyl)-cyclopropanecarboxylic acid

Compound 547



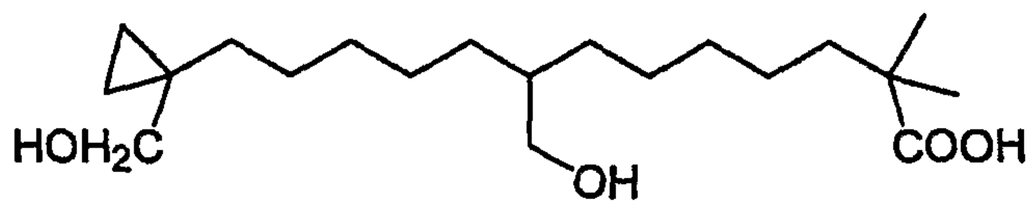
1-(1,0-Carboxy-5-hydroxymethyl-10-methyl-undecyl)-cyclopropanecarboxylic acid

Compound 548



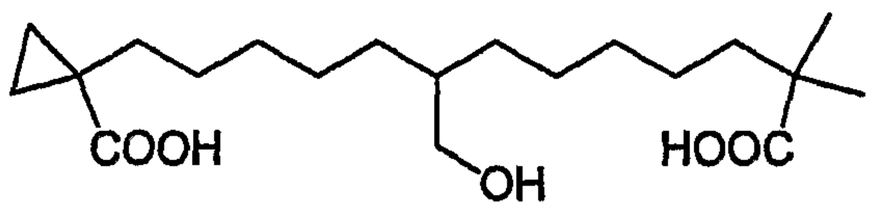
8-[5-(1-Hydroxymethyl-cyclopropyl)-pentyl]-2,2-dimethyl-nonane-1,9-diol

Compound 549



8-Hydroxymethyl-13-(1-hydroxymethyl-cyclopropyl)-2,2-dimethyl-tridecanoic acid

Compound 550



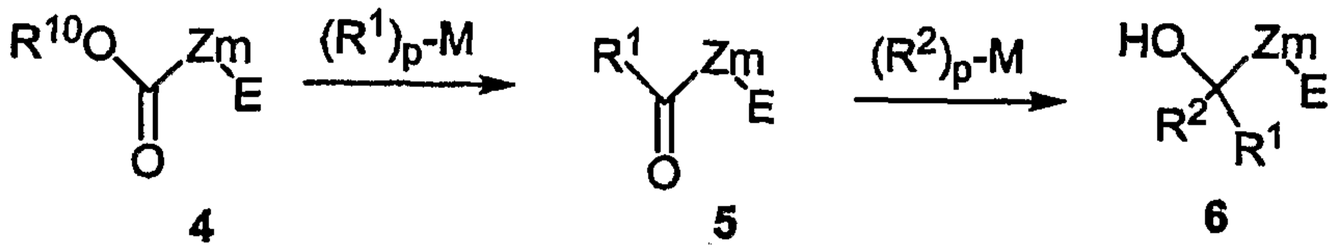
1-(12-Carboxy-6-hydroxymethyl-12-methyl-tridecyl)-cyclopropanecarboxylic acid

Compound 551

5.1 Synthesis of the Compounds of the Invention

The compounds of the invention can be obtained via the synthetic methodology illustrated in Schemes 1-23. Starting materials useful for preparing the compounds of the invention and intermediates thereof, are commercially available or can be prepared from commercially available materials using known synthetic methods and reagents.

Scheme 1: Synthesis of Compounds of Formula X



Scheme 1 illustrates the synthesis of mono-protected diols of the formula **X**, wherein n is an integer ranging from 0 to 4 and R^1 and R^2 are as defined herein, and E is a leaving group as defined herein. Scheme 1 first outlines the synthesis of mono-protected diols **X**, wherein n is 0, where esters **4** are successively reacted with a first ($(R^1)_p$-M) then a second ($(R^2)_p$-M) organometallic reagent providing hydroxys **5** and alcohols **6**, respectively. M is a metal group and p is the metal's valency value (*e.g.*, the valency of Li is 1 and that of Zn is

2). Suitable metals include, but are not limited to, Zn, Na, Li, and –Mg–Hal, wherein Hal is a halide selected from iodo, bromo, or chloro. Preferably, M is –Mg–Hal, in which case the organometallic reagents, $(R^1)_p$–Mg–Hal and $(R^2)_p$–Mg–Hal, are known in the art as a Grignard reagents. Esters 4 are available commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or can be prepared by well-known synthetic methods, for example, *via* esterification of the appropriate 5-halovaleric acid (commercially available, *e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin). Both $(R^1)_p$–M and $(R^2)_p$–M are available commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or can be prepared by well-known methods (see *e.g.*, Kharasch *et al.*, *Grignard Reactions of Non-Metallic Substances*; Prentice-Hall, Englewood Cliffs, NJ, pp. 138-528 (1954) and Hartley; Patai, *The Chemistry of the Metal-Carbon Bond*, Vol. 4, Wiley: New York, pp. 159-306 and pp. 162-175 (1989)). The reaction of a first ($(R^1)_p$-M) then a second ($(R^2)_p$-M) organometallic reagent with esters 4 can be performed using the general procedures referenced in March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 920-929 and Eicher, Patai, *The Chemistry of the Carbonyl Group*, pt. 1, pp. 621-693; Wiley: New York, (1966). For example, the synthetic procedure described in Comins *et al.*, 1981, *Tetrahedron Lett.* 22: 1085 can be used. As one example, the reaction can be performed by adding an organic solution of $(R^1)_p$–M (about 0.5 to about 1 equivalents) to a stirred, cooled (about 0°C to about –80°C) solution comprising esters 4, under an inert atmosphere (*e.g.*, nitrogen) to give a reaction mixture comprising ketones 5. Preferably, $(R^1)_p$–M is added at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. The progress of the reaction can be followed by using an appropriate analytical method, such as thin-layer chromatography or high-performance-liquid chromatography. Next, an organic solution of $(R^2)_p$–M (about 0.5 to about 1 equivalent) is added to the reaction mixture comprising ketones 5 in the same manner used to add $(R^1)_p$–M. After the reaction providing alcohols 6 is substantially complete, the reaction mixture can be quenched and the product can be isolated by workup. Suitable solvents for obtaining alcohols 6 include, but are not limited to, dichloromethane, diethyl ether, tetrahydrofuran, benzene, toluene, xylene, hydrocarbon solvents (*e.g.*, pentane, hexane, and heptane), and mixtures thereof. Preferably, the organic solvent is diethyl ether or tetrahydrofuran. Next, alcohols 6 are converted to mono-protected diols X, wherein n is 0, using the well-known Williamson ether synthesis. This involves reacting alcohols 6 with

–O–PG, wherein –PG is a hydroxy-protecting group. For a general discussion of the Williamson ether synthesis, *See* March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure,* 4th ed., 1992, pp. 386-387, and for a list of procedures and reagents useful in the Williamson ether synthesis, *See, for example,* Larock *Comprehensive Organic Transformations*; VCH: New York, 1989, pp. 446-448. As used herein, the term "hydroxy-protecting group" means a group that is reversibly attached to a hydroxy moiety that renders the hydroxy moiety unreactive during a subsequent reaction(s) and that can be selectively cleaved to regenerate the hydroxy moiety once its protecting purpose has been served. Examples of hydroxy-protecting groups are found in Greene, T.W., *Protective Groups in Organic Synthesis*, 3rd edition 17-237 (1999). Preferably, the hydroxy-protecting group is stable in a basic reaction medium, but can be cleaved by acid. Examples of suitable base-stable acid-labile hydroxy-protecting groups suitable for use with the invention include, but are not limited to, ethers, such as methyl, methoxy methyl, methylthiomethyl, methoxyethoxymethyl, *bis*(2-chloroethoxy)methyl, tetrahydropyranyl, tetrahydrothiopyranyl, tetrahyrofuranyl, tetrahydrothiofuranyl, 1-ethoxyethyl, 1-methyl-1-methoxyethyl, *t*-butyl, allyl, benzyl, *o*-nitrobenzyl, triphenylmethyl, α-naphthyldiphenylmethyl, *p*-methoxyphenyldiphenylmethyl, 9-(9-phenyl-10-oxo)anthranyl, trimethylsilyl, isopropyldimethylsilyl, *t*-butyldimethylsilyl, *t*-butyldiphenylsilyl, tribenzylsilyl, and triisopropylsilyl; and esters, such as pivaloate, adamantoate, and 2,4,6-trimethylbenzoate. Ethers are preferred, particularly straight chain ethers, such as methyl ether, methoxymethyl ether, methylthiomethyl ether, methoxyethoxymethyl ether, *bis*(2-chloroethoxy)methyl ether. Preferably –PG is methoxymethyl (CH_3OCH_2–). Reaction of alcohols 6 with –O–PG under the conditions of the Williamson ether synthesis involves adding a base to a stirred organic solution comprising HO–PG (*e.g.*, methoxymethanol), maintained at a constant temperature within the range of about 0°C to about 80°C, preferably at about room temperature. Preferably, the base is added at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. The base can be added as an organic solution or in undiluted form. Preferably, the base will have a base strength sufficient to deprotonate a proton, wherein the proton has a pK_a of greater than about 15, preferably greater than about 20. As is well known in the art, the pK_a is a measure of the acidity of an acid H–A, according to the equation $pK_a = -\log K_a$, wherein K_a is the equilibrium constant for the proton transfer. The acidity of an acid H–A is proportional to

the stability of its conjugate base –A. For tables listing pK_a values for various organic acids and a discussion on pK_a measurement, see March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 248-272. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*-butyllithium, *tert*-butyllithium, *sec*-butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride. The preferred base is lithium diisopropylamide. Solvents suitable for reacting alcohols **6** with –OPG include, but are not limited, to dimethyl sulfoxide, dichloromethane, ethers, and mixtures thereof, preferably tetrahydrofuran. After addition of the base, the reaction mixture can be adjusted to within a temperature range of about 0°C to about room temperature and alcohols **6** can be added, preferably at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. Alcohols **6** can be diluted in an organic solvent or added in their undiluted form. The resulting reaction mixture is stirred until the reaction is substantially complete as determined by using an appropriate analytical method, preferably by gas chromatography, then the mono-protected diols **X** can be isolated by workup and purification.

Next, Scheme 1 outlines a method useful for synthesizing mono-protected diols **X**, wherein n is 1. First, compounds **7**, wherein E is a suitable leaving group, are reacted with compounds **8**, wherein R^1 and R^2 are as defined above and R^8 is H, $(C_1$-$C_6)$alkyl or (C_6)aryl, providing compounds **9**. Suitable leaving groups are well known in the art, for example, but not limited to halides, such as chloride, bromide, and iodide; aryl- or alkylsulfonyloxy, substituted arylsulfonyloxy (*e.g.*, tosyloxy or mesyloxy); substituted alkylsulfonyloxy (*e.g.*, haloalkylsulfonyloxy); (C_6)aryloxy or subsituted (C_6)aryloxy; and acyloxy groups. Compounds **7** are available commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or can be prepared by well-known methods such as halogenation or sulfonation of butanediol. Compounds **8** are also available commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or by well-known methods, such as those listed in Larock *Comprehensive Organic Transformations*; Wiley-VCH: New York, 1999, pp. 1754-1755 and 1765. A review on alkylation of esters of type **8** is given by J. Mulzer in Comprehensive Organic Functional Transformations, Pergamon, Oxford 1995, pp. 148-151 and exemplary synthetic procedures for reacting compounds **7** with compounds **8** are

described in United States Patent No. 5,648,387, column 6 and Ackerly, *et al.*, *J. Med.* Chem. **1995**, pp. 1608. The reaction requires the presence of a suitable base. Preferably, a suitable base will have a pK_a of greater than about 25, more preferably greater than about 30. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*–butyllithium, *tert*–butyllithium, *sec*–butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; hydride bases such as sodium hydride and potassium hydride. Metal amide bases, such as lithium diisopropylamide are preferred. Preferably, to react compounds **7** with compounds **8**, a solution of about 1 to about 2 equivalents of a suitable base is added to a stirred solution comprising esters **8** and a suitable organic solvent, under an inert atmosphere, the solution maintained at a constant temperature within the range of about –95 °C to about room temperature, preferably at about –78 °C to about –20°C. Preferably, the base is diluted in a suitable organic solvent before addition. Preferably, the base is added at a rate of about 1.5 moles per hour. Organic solvents suitable for the reaction of compounds **7** with the compounds **8** include, but are not limited to, dichloromethane, diethyl ether, tetrahydrofuran, dimethylformamide, dimethyl sulfoxide, benzene, toluene, xylene, hydrocarbon solvents (*e.g.*, pentane, hexane, and heptane), and mixtures thereof. After addition of the base, the reaction mixture is allowed to stir for about 1 to about 2 hours, and a compound **7**, preferably dissolved in a suitable organic solvent, is added, preferably at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. After addition of compounds **7**, the reaction-mixture temperature can be adjusted to within a temperature range of about –20 °C to about room temperature, preferably to about room temperature, and the reaction mixture is allowed to stir until the reaction is substantially complete as determined by using an appropriated analytical method, preferably thin-layer chromatography or high-performance liquid chromatography. Then the reaction mixture is quenched and compounds **9**, wherein n is 1 can be isolated by workup. Compounds **10** are then synthesized by reacting compounds **9** with –O–PG according to the protocol described above for reacting alcohols **6** with –O–PG. Next, compounds **10** can be converted to mono-protected diols **X**, wherein n is 1, by reduction of the ester group of compounds **10** to an alcohol group with a suitable reducing agent. A wide variety of reagents are available for reduction of such esters to alcohols, *e.g.*,

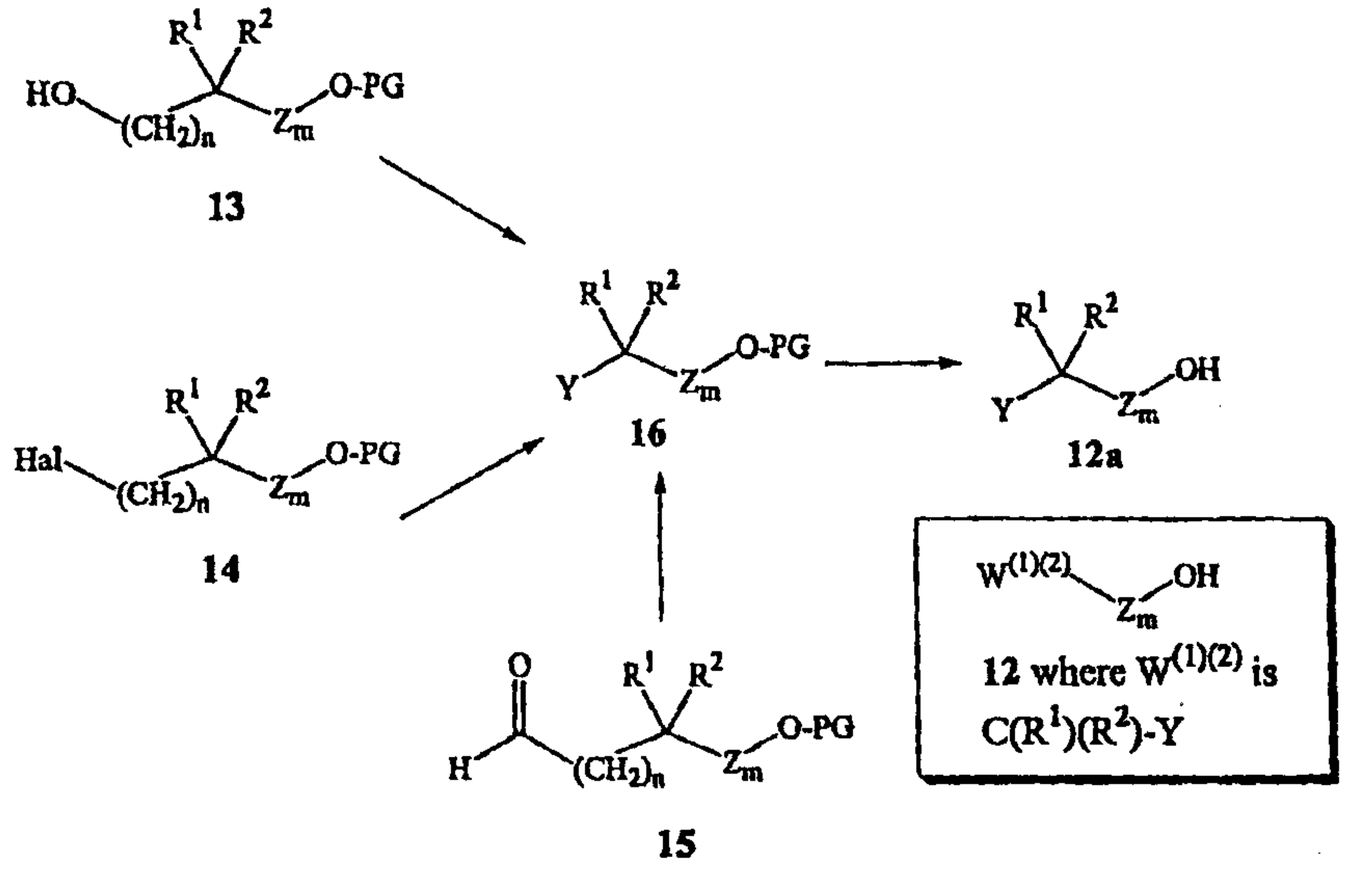
see M. Hudlicky, *Reductions in Organic Chemistry*, 2nd ed., 1996 pp. 212-217. Preferably, the reduction is effected with a hydride type reducing agent, for example, lithium aluminum hydride, lithium borohydride, lithium triethyl borohydride, diisobutylaluminum hydride, lithium trimethoxyaluminum hydride, or sodium *bis*(2-methoxy)aluminum hydride. For exemplary procedures for reducing esters to alcohols, see Nystrom *et al.*, 1947, *J. Am. Chem. Soc.* 69:1197; and Moffet *et al.*, 1963, *Org. Synth., Collect.* 834(4), lithium aluminum hydride; Brown *et al.*, 1965, *J. Am. Chem. Soc.* 87:5614, lithium trimethoxyaluminum hydride; Cerny *et al.*, 1969, *Collect. Czech. Chem. Commun.* 34:1025, sodium *bis*(2-methoxy)aluminum hydride; Nystrom *et al.*, 1949, *J. Am. Chem.* 71:245, lithium borohydride; and Brown *et al.*, 1980, *J. Org. Chem.* 45:1, lithium triethyl borohydride. Preferably, the reduction is conducted by adding an organic solution of compounds **10** to a stirred mixture comprising a reducing agent, preferably lithium aluminum hydride, and an organic solvent. During the addition, the reaction mixture is maintained at a constant temperature within the range of about -20 °C to about 80 °C, preferably at about room temperature. Organic solvents suitable for reacting **9** with –OPG include, but are not limited to, dichloromethane, diethyl ether, tetrahydrofuran or mixtures thereof, preferably tetrahydrofuran. After the addition, the reaction mixture is stirred at a constant temperature within the range of about room temperature to about 60°C, until the reaction is substantially complete as determined by using an appropriate analytical method, preferably thin-layer chromatography or high-performance-liquid chromatography. Then the reaction mixture can be quenched and mono-protected diols **X**, wherein n is 1, can be isolated by workup and purification.

Scheme 1 next illustrates a three step synthetic sequence for homologating mono-protected diols **X** comprising: (a) halogenation (converting –CH_2OH to –CH_2-Hal); (b) carbonylation (replacing –Hal with –CHO); and (c) reduction (converting –CHO to –CH_2OH), wherein a reaction sequence of (a), (b), and (c) increases the value of n by 1. In step (a) protected halo-alcohols **11**, wherein Hal is a halide selected from the group of chloro, bromo, or iodo, preferably iodo, can be prepared by halogenating mono-protected diols **X**, by using well-known methods (for a discussion of various methods for conversion of alcohols to halides see March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 431-433). For example, protected iodo-alcohols **11** can be synthesized starting from mono-protected diols **X** by treatment with Ph_3/I_2/imidazole (Garegg *et al.*, 1980,

J.C.S Perkin I 2866); 1, 2-dipheneylene phosphorochloridite/I_2 (Corey *et al.*, 1967, *J. Org. Chem.* 82:4160); or preferably with Me_3SiCl/NaI (Olah *et al.*, 1979, *J. Org. Chem.* 44:8, 1247). Step (b); **carbonylation of alkyl halides, such as protected halo-alcohols 11, is reviewed in Olah *et al.*, 1987, *Chem Rev.* 87:4, 671; and March, J., *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 483-484).** Protected halo-alcohols **11** can be carbonylated with $Li(BF_3.Et_2O)/HCONMe_2$ using the procedure described in Maddaford *et al.*, 1993, *J. Org. Chem.* 58:4132; Becker *et al.*, 1982, *J. Org. Chem.* 3297; or Myers *et al.*, 1992, *J. Am. Chem. Soc.* 114:9369 or, alternatively, with an organometallic/*N*-formylmorpholine using the procedure described in Olah *et al.*, 1984, *J. Org. Chem.* 49:3856 or Vogtle *et al.*, 1987, *J. Org. Chem.* 52:5560. The method described in Olah *et al.*, 1984, *J. Org. Chem.* 49:3856 is preferred.

Reduction step (c) useful for synthesizing mono-protected diols X from aldehydes 12, can be accomplished by well-known methods in the art for reduction of aldehydes to the corresponding alcohols (for a discussion see M. Hudlicky, *Reductions in Organic Chemistry*, 2nd ed., 1996 pp 137-139), for example, by catalytic hydrogenation (*see e.g.*, Carothers, 1949, *J. Am. Chem .Soc.* 46:1675) or, preferably by reacting aldehydes 12 with a hydride reducing agent, such as lithium aluminum hydride, lithium borohydride, sodium borohydride (*see e.g.*, the procedures described in Chaikin *et al.*, 1949, *J. Am. Chem. Soc.* 71:3245; Nystrom *et al.*, 1947, *J. Am. Chem. Soc.* 69:1197; and Nystrom *et al.*, 1949, *J. Am. Chem.* 71:3245). Reduction with lithium aluminum hydride is preferred.

Scheme 2: Synthesis of Compounds of Formula 12a, which correspond to Compounds $W^{(1)(2)}$–Z_m–OH, Wherein $W^{(1)(2)}$ is $C(R^1)(R^2)$–Y



Scheme 2 outlines the method for the synthesis of protected alcohols **12a** wherein Y, R^1, R^2, Z, and m are defined as above. Protected alcohols **12a** correspond to compounds of the formula $W^{(1)(2)}$–Zm–OPG, wherein $W^{(1)(2)}$ is $C(R^1)(R^2)$–Y.

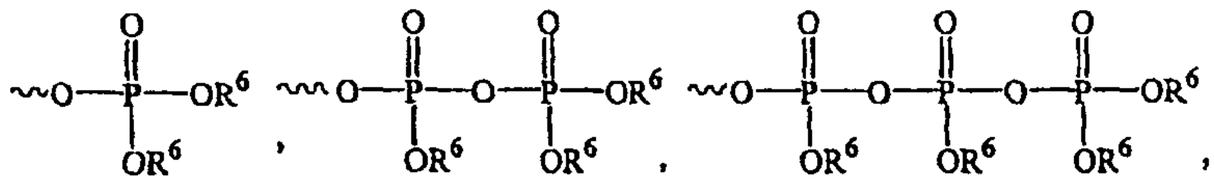
Protected alcohols **16**, wherein Y comprises a –C(O)OH group, can be synthesized by oxidizing mono-protected diols **X** with an agent suitable for oxidizing a primary alcohol to a carboxylic acid (for a discussion see M. Hudlicky, *Oxidations in Organic Chemistry*, ACS Monograph 186, 1990, pp. 127-130). Suitable oxidizing agents include, but are not limited to, pyridinium dichromate (Corey *et al.*, 1979, *Tetrahedron Lett.* 399); manganese dioxide (Ahrens *et al.*, 1967, *J. Heterocycl. Chem.* 4:625); sodium permanganate monohydrate (Menger *et al.* 1981, *Tetrahedron Lett.* 22:1655); and potassium permanganate (Sam *et al.*, 1972, *J. Am. Chem. Soc.* 94:4024). The preferred oxidizing reagent is pyridinium dichromate. In an alternative synthetic procedure, protected alcohols **16**, wherein Y comprises a –C(O)OH group, can be synthesized by treatment of protected halo-alcohols **15**, wherein X is iodo, with CO or CO_2, as described in Bailey *et al.*, 1990, *J. Org. Chem.* 55:5404 and Yanagisawa *et al.*, 1994, *J. Am. Chem. Soc.* 116:6130. Protected alcohols **16**, wherein Y comprises-C(O)OR^5, wherein R^5 is as defined above, can be synthesized by oxidation of mono-protected diols **X** in the presence of R^5OH (see generally, March, *J. Advanced Organic Chemistry; Reactions*

Mechanisms, and Structure, 4th ed., 1992, p. 1196). An exemplary procedure for such an oxidation is described in Stevens *et al.*, 1982, *Tetrahedron Lett.* 23:4647 (HOCl); Sundararaman *et al.*, 1978, *Tetrahedron Lett.* 1627 (O_3/KOH); Wilson *et al.*, 1982, *J. Org. Chem.* 47:1360 (*t*–BuOOH/Et_3N); and Williams *et al.*, 1988, *Tetrahedron Lett.* 29:5087 (Br_2). Preferably, protected alcohols **16**, wherein Y comprises a -C(O)OR^5 group are synthesized from the corresponding carboxylic acid (*i.e.*, **16**, wherein Y comprises –C(O)OH) by esterification with R^5OH (*e.g.*, *see* March, J., *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 393-394). In another alternative synthesis, protected alcohols **16**, wherein Y comprises -C(O)OR^5, can be prepared from protected halo-alcohols **14** by carbonylation with transition metal complexes (*see e.g.*, March, *J. Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 484-486; Urata *et al.*, 1991, *Tetrahedron Lett.* 32:36, 4733) ; and Ogata *et al.*, 1969, *J. Org. Chem.* 3985).

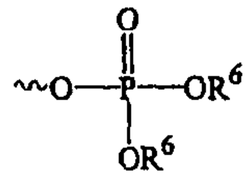
Protected alcohols **16**, wherein Y comprises –OC(O)R^5, wherein R^5 is as defined above, can be prepared by acylation of mono-protected diols **X** with a carboxylate equivalent such as an acyl halide (*i.e.*, $R^5C(O)$–Hal, wherein Hal is iodo, bromo, or chloro, *see e.g.*, March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 392 and *Org. Synth. Coll.* Vol. III, Wiley, NY, pp. 142, 144, 167, and 187 (1955)) or an anhydride (*i.e.*; $R^5C(O)$–O–(O)CR^5, see *e.g.*, March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 392-393 and *Org. Synth. Coll.* Vol. III, Wiley, NY, pp. 11, 127, 141, 169, 237, 281, 428, 432, 690, and 833 (1955)). Preferably the reaction is conducted by adding a base to a solution comprising mono-protected diols **X**, a carboxylate equivalent, and an organic solvent, which solution is preferably maintained at a constant temperature within the range of 0°C to about room temperature. Solvents suitable for reacting mono-protected diols **X** with a carboxylate equivalent include, but are not limited to, dichloromethane, toluene, and ether, preferably dichloromethane. Suitable bases include, but are not limited to, hydroxide sources, such as sodium hydroxide, potassium hydroxide, sodium carbonate, or potassium carbonate; or an amine such as triethylamine, pyridine, or dimethylaminopyridine, amines are preferred. The progress of the reaction can be followed by using an appropriate analytical technique, such as thin layer

chromatography or high performance liquid chromatography and when substantially complete, the product can be isolated by workup and purified if desired.

Protected alcohols **16**, wherein Y comprises one of the following phosphate ester groups



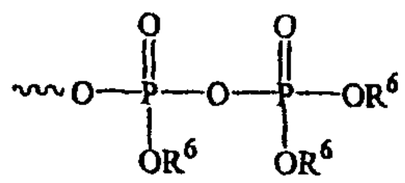
wherein R^6 is defined as above, can be prepared by phosphorylation of mono-protected diols **X** according to well-known methods (for a general reviews, see Corbridge *Phosphorus: An Outline of its Chemistry, Biochemistry, and Uses*, Studies in Inorganic Chemistry, 3rd ed., pp. 357-395 (1985); Ramirez *et al.*, 1978, *Acc. Chem. Res.* 11:239; and Kalckare *Biological Phosphorylations*, Prentice-Hall, New York (1969); J. B. Sweeny in *Comprehensive Organic Functional Group Transformations*, A.R. Katritzky, O. Meth-Cohn and C.W. Rees, Eds. Pergamon: Oxford, 1995, vol 2, pp. 104-109). Protected alcohols **16** wherein Y comprises a monophosphate group of the formula:



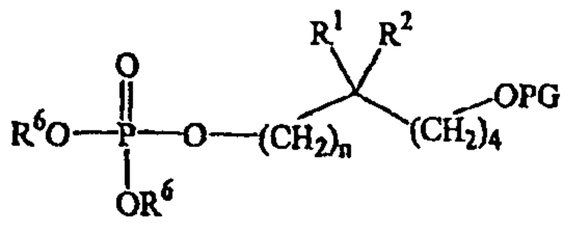
wherein R^6 is defined as above, can be prepared by treatment of mono-protected diol **X** with phosphorous oxychloride in a suitable solvent, such as xylene or toluene, at a constant temperature within the range of about 100°C to about 150°C for about 2 hours to about 24 hours. After the reaction is deemed substantially complete, by using an appropriate analytical method, the reaction mixture is hydrolyzed with R^6-OH. Suitable procedures are referenced in Houben-Weyl, Methoden der Organische Chemie, Georg Thieme Verlag Stuttgart 1964, vol. XII/2, pp. 143-210 and 872-879. Alternatively, when both R^6 are hydrogen, can be synthesized by reacting mono-protected diols X with silyl polyphosphate (Okamoto *et al.*, 1985, *Bull Chem. Soc. Jpn.* 58:3393) or by hydrogenolysis of their benzyl or phenyl esters (Chen *et al.*, 1998, *J. Org. Chem.* 63:6511). In another alternative procedure, when R^6 is $(C_1\text{-}C_6)$ alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2\text{-}C_6)$alkynyl, the monophosphate esters can be prepared by reacting mono-protected diols **X** with appropriately substituted phophoramidites followed

by oxidation of the intermediate with *m*-chloroperbenzoic acid (Yu *et al.*, 1988, *Tetrahedron Lett.* 29:979) or by reacting mono-protected diols **X** with dialkyl or diaryl substituted phosphorochloridates (Pop, *et al*, 1997, *Org. Prep. and Proc. Int.* 29:341). The phosphoramidites are commercially available (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or readily prepared according to literature procedures (*see e.g.*, Uhlmann *et al.* 1986, *Tetrahedron Lett.* 27:1023 and Tanaka *et al.*, 1988, *Tetrahedron Lett.* 29: 199). The phosphorochloridates are also commercially available (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or prepared according to literature methods (*e.g*, Gajda *et al*, 1995, *Synthesis* 25:4099. In still another alternative synthesis, protected alcohols **16**, wherein Y comprises a monophosphate group and R^6 is alkyl or aryl, can be prepared by reacting $IP^+(OR^6)_3$ with mono-protected diols **X** according to the procedure described in Stowell *et al.*, 1995, *Tetrahedron Lett.* 36:11, 1825 or by alkylation of protected halo alcohols **14** with the appropriate dialkyl or diaryl phosphates (*see e.g*, Okamoto, 1985, *Bull Chem. Soc. Jpn.* 58:3393).

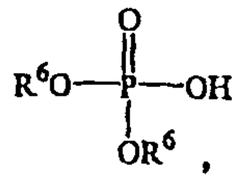
Protected alcohols **16** wherein Y comprises a diphosphate group of the formula



wherein R^6 is defined as above, can be synthesized by reacting the above-discussed monophosphates of the formula:

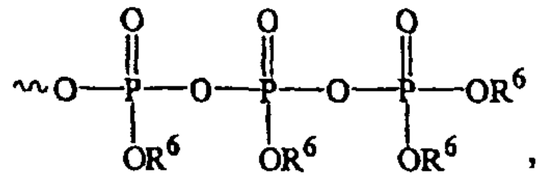


with a phosphate of the formula

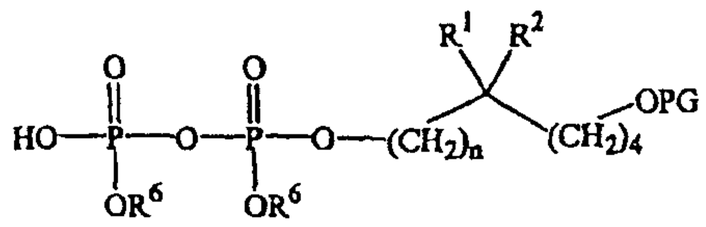


(commercially available, *e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin), in the presence of carbodiimide such as dicyclohexylcarbodiimide, as described in Houben-Weyl, *Methoden der Organische Chemie*, Georg Thieme Verlag Stuttgart 1964, vol. XII/2, pp.

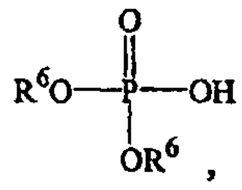
881-885. In the same fashion, protected alcohols **16**, wherein Y comprises a triphosphate group of the formula:



can be synthesized by reacting the above-discussed diphosphate protected alcohols, of the formula:

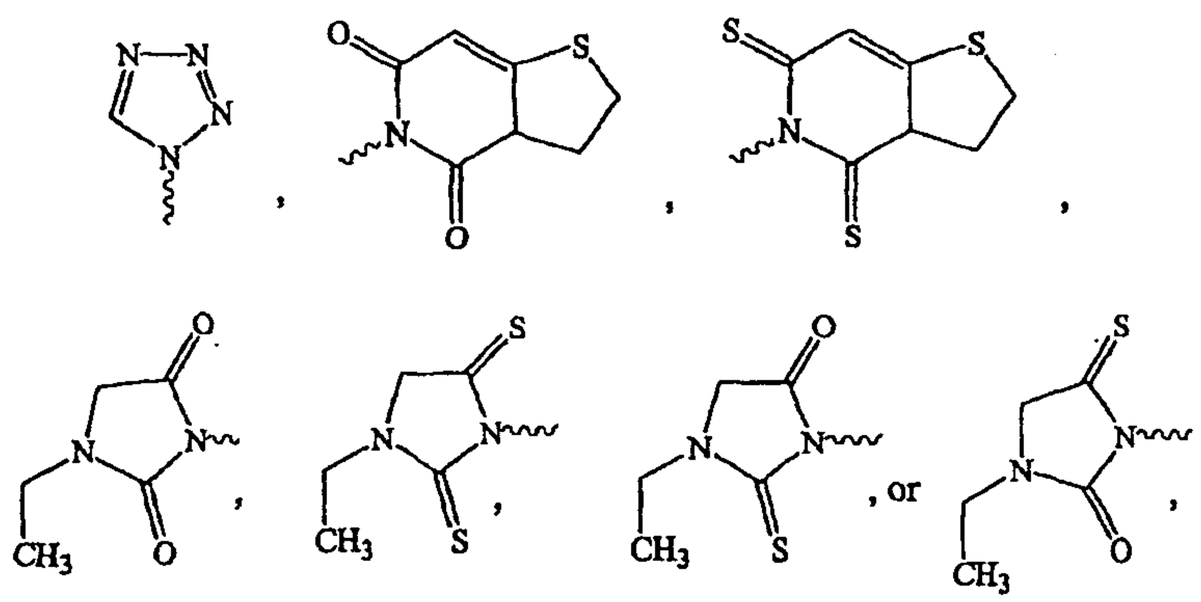


with a phosphate of the formula:



as described above. Alternatively, when R^6 is H, protected alcohols **16** wherein Y comprises the triphosphate group, can be prepared by reacting mono-protected diols **X** with salicyl phosphorochloridite and then pyrophosphate and subsequent cleavage of the adduct thus obtained with iodine in pyridine as described in Ludwig *et al.*, 1989, *J. Org. Chem.* 54:631.

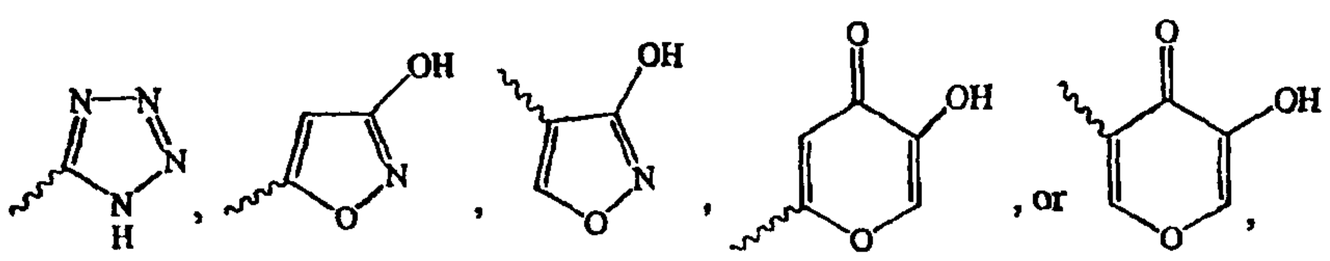
Protected alcohols **16**, wherein Y is $-SO_3H$ or a heterocyclic group selected from the group consisting of:



can be prepared by halide displacement from protected halo-alcohols **14**. Thus, when Y is $-SO_3H$, protected alcohols **16** can by synthesized by reacting protected halo-alcohols **14** with

sodium sulfite as described in Gilbert *Sulfonation and Related Reactions*; Wiley: New York, 1965, pp. 136-148 and pp. 161-163; *Org. Synth. Coll.* Vol. II, Wiley, NY, 558, 564 (1943); and *Org. Synth. Coll.* Vol. IV, Wiley, NY, 529 (1963). When Y is one of the above-mentioned heterocycles, protected alcohols **16** can be prepared by reacting protected halo-alcohols **14** with the corresponding heterocycle in the presence of a base. The heterocycles are available commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or prepared by well-known synthetic methods (see the procedures described in Ware, 1950, *Chem. Rev.* 46:403-470). Preferably, the reaction is conducted by stirring a mixture comprising **14**, the heterocycle, and a solvent at a constant temperature within the range of about room temperature to about 100°C, preferably within the range of about 50°C to about 70°C for about 10 to about 48 hours. Suitable bases include hydroxide bases such as sodium hydroxide, potassium hydroxide, sodium carbonate, or potassium carbonate. Preferably, the solvent used in forming protected alcohols **16** is selected from dimethylformamide; formamide; dimethyl sulfoxide; alcohols, such as methanol or ethanol; and mixtures thereof. The progress of the reaction can be followed by using an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography and when substantially complete, the product can be isolated by workup and purified if desired.

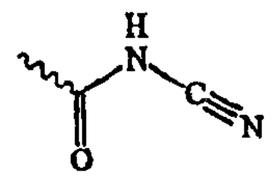
Protected alcohols **16**, wherein Y is a heteroaryl ring selected from



can be prepared by metallating the suitable heteroaryl ring then reacting the resulting metallated heteroaryl ring with protected halo-alcohols **14** (for a review, see Katritzky *Handbook of Heterocyclic Chemistry*, Pergamon Press: Oxford 1985). The heteroaryl rings are available commercially or prepared by well-known synthetic methods (*see e.g.*, Joule *et al., Heterocyclic Chemistry*, 3rd ed., 1995; De Sarlo *et al.*, 1971, *J. Chem. Soc. (C)* 86; Oster *et al.*, 1983, *J. Org. Chem.* 48:4307; Iwai *et al.*, 1966, *Chem. Pharm. Bull.* 14:1277; and United States Patent No. 3,152,148). As used herein, the term "metallating" means the forming of a carbon-metal bond, which bond may be substantially ionic in character. Metallation can be accomplished by adding about 2 equivalents of strong organometallic base, preferably with

a pK_a of about 25 or more, more preferably with a pK_a of greater than about 35, to a mixture comprising a suitable organic solvent and the heterocycle. Two equivalents of base are required: one equivalent of the base deprotonates the –OH group or the –NH group, and the second equivalent metallates the heteroaryl ring. Alternatively, the hydroxy group of the heteroaryl ring can be protected with a base-stable, acid-labile protecting group as described in Greene, T.W., *Protective Groups in Organic Synthesis*, 3rd edition 17-237 (1999). Where the hydroxy group is protected, only one equivalent of base is required. Examples of suitable base-stable, acid-labile hydroxyl-protecting groups, include but are not limited to, ethers, such as methyl, methoxy methyl, methylthiomethyl, methoxyethoxymethyl, *bis*(2-chloroethoxy)methyl, tetrahydropyranyl, tetrahydrothiopyranyl, tetrahyrofuranyl, tetrahydrothiofuranyl, 1-ethoxyethyl, 1-methyl-1-methoxyethyl, *t*-butyl, allyl, benzyl, *o*-nitrobenzyl, triphenylmethyl, α-naphthyldiphenylmethyl, *p*-methoxyphenyldiphenylmethyl, 9-(9-phenyl-10-oxo)anthranyl, trimethylsilyl, isopropyldimethylsilyl, *t*-butyldimethylsilyl, *t*-butyldiphenylsilyl, tribenzylsilyl, triisopropylsilyl; and esters, such as pivaloate, adamantoate, and 2,4,6-trimethylbenzoate. Ethers are preferred, particularly straight chain ethers, such as methyl ether, methoxymethyl ether, methylthiomethyl ether, methoxyethoxymethyl ether, *bis*(2-chloroethoxy)methyl ether. Preferably, the pK_a of the base is higher than the pK_a of the proton of the heterocycle to be deprotonated. For a listing of pK_as for various heteroaryl rings, see Fraser *et al.*, 1985, *Can. J Chem.* 63:3505. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*-butyllithium, *tert*-butyllithium, *sec*-butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride. If desired, the organometallic base can be activated with a complexing agent, such as *N,N,N',N'*–tetramethylethylenediamine or hexamethylphosphoramide (1970, *J. Am. Chem. Soc.* 92:4664). Solvents suitable for synthesizing protected alcohols **16**, wherein Y is a heteroaryl ring include, but are not limited to, diethyl ether; tetrahydrofuran; and hydrocarbons, such as pentane. Generally, metallation occurs alpha to the heteroatom due to the inductive effect of the heteroatom, however, modification of conditions, such as the identity of the base and solvents, order of reagent addition, reagent addition times, and reaction and addition temperatures can be

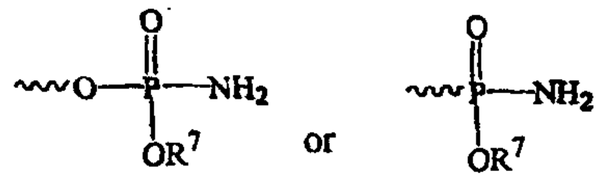
modified by one of skill in the art to achieve the desired metallation position (*see* e.g., Joule *et al.*, *Heterocyclic Chemistry*, 3rd ed., 1995, pp. 30-42). Alternatively, the position of metallation can be controlled by use of a halogenated heteroaryl group, wherein the halogen is located on the position of the heteroaryl ring where metallation is desired *(see e.g.*, Joule *et al.*, *Heterocyclic Chemistry*, 3rd ed., 1995, p. 33 and Saulnier *et al.*, 1982, *J. Org. Chem.* 47:757). Halogenated heteroaryl groups are available commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or can be prepared by well-known synthetic methods (*see e.g.*, Joule *et al.*, *Heterocyclic Chemistry*, 3rd ed., 1995, pp. 78 , 85, 122, 193, 234, 261, 280, 308). After metallation, the reaction mixture comprising the metallated heteroaryl ring is adjusted to within a temperature range of about 0°C to about room temperature and protected halo-alcohols **14** (diluted with a solvent or in undiluted form) are added, preferably at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. After addition of protected halo-alcohols **14**, the reaction mixture is stirred at a constant temperature within the range of about room temperature and about the solvent's boiling temperature and the reaction's progress can be monitored by the appropriate analytical technique, preferably thin-layer chromatography or high-performance liquid chromatography. After the reaction is substantially complete, protected alcohols **16** can be isolated by workup and purification. It is to be understood that conditions, such as the identity of protected halo-alcohol **14**, the base, solvents, orders of reagent addition, times, and temperatures, can be modified by one of skill in the art to optimize the yield and selectivity. Exemplary procedures that can be used in such a transformation are described in Shirley *et al.*, 1995, *J. Org. Chem.* 20:225; Chadwick *et al.*, 1979, *J. Chem. Soc., Perkin Trans. 1* 2845; Rewcastle, 1993, *Adv. Het. Chem.* 56:208; Katritzky *et al.*, 1993, *Adv. Het. Chem.* 56:155; and Kessar *et al.*, 1997, *Chem. Rev.* 97:721. When Y is



,

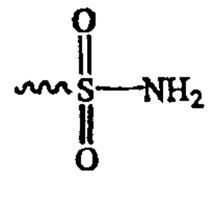
protected alcohols **16** can be prepared from their corresponding carboxylic acid derivatives (**16**, wherein Y is $-CO_2H$) as described in Belletire *et al*, 1988, *Synthetic Commun.* 18:2063 or from the corresponding acylchlorides (**16**, wherein Y is –CO–halo) as described in

Skinner *et al.*, 1995, *J. Am. Chem. Soc.* 77:5440. The acylhalides can be prepared from the carboxylic acids by well known procedures such as those described in March, J., *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 437-438. When Y is



wherein R^7 is as defined above, protected alcohols **16** can be prepared by first reacting protected halo-alcohols **15** with a trialkyl phosphite according to the procedure described in Kosolapoff, 1951, *Org. React.* 6:273 followed by reacting the derived phosphonic diester with ammonia according to the procedure described in Smith *et al.*, 1957, *J. Org. Chem.* 22:265.

When Y is

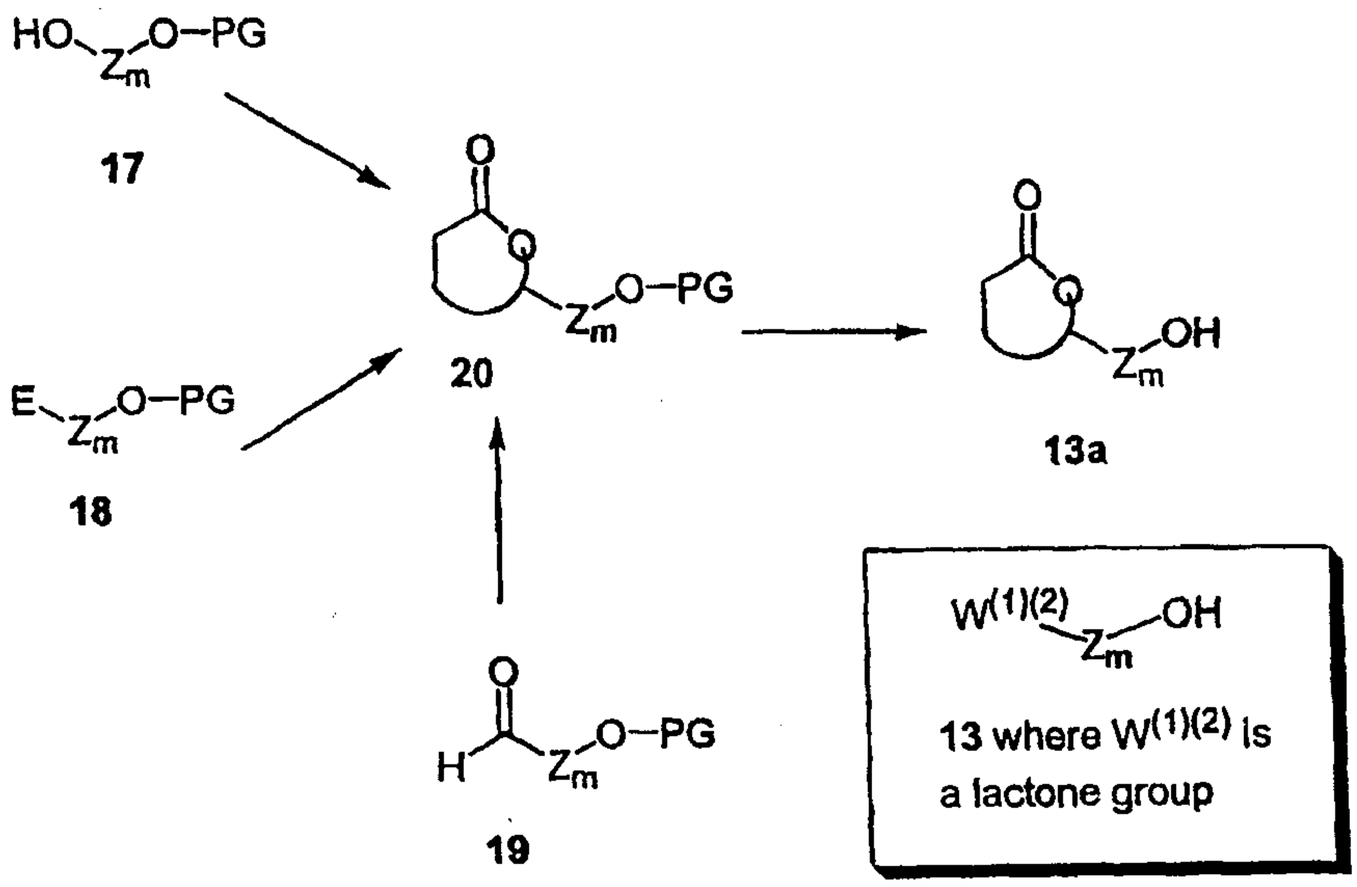


protected alcohols **16** can be prepared by reacting their sulphonic acid derivatives (*i.e.*, **16**, wherein Y is $-SO_3H$) with ammonia as described in Sianesi *et al.*, 1971, *Chem. Ber.* 104:1880 and Campagna *et al.*, 1994, *Farmaco, Ed. Sci.* 49:653).

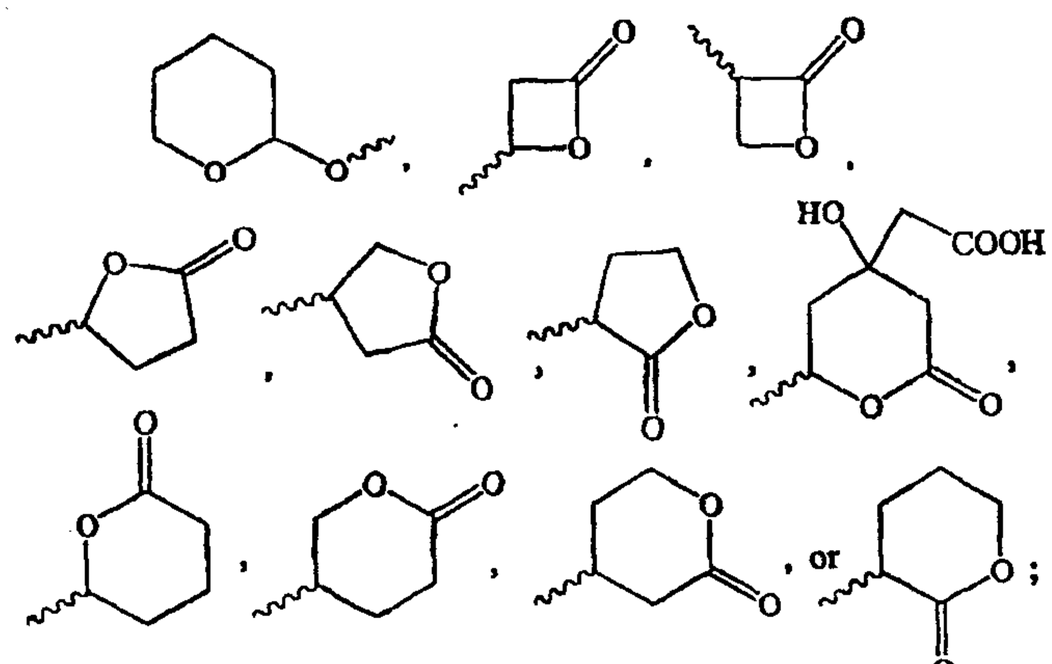
As further illustrated in Scheme 2, protected alcohols **16** can be deprotected providing alcohols **20a**. The deprotection method depends on the identity of the alcohol-protecting group, *see e.g.*, the procedures listed in Greene, T.W., *Protective Groups in Organic Synthesis*, 3rd edition 17-237 (1999), particularly see pages 48-49. One of skill in the art will readily be able to choose the appropriate deprotection procedure. When the alcohol is protected as an ether function (*e.g.*, methoxymethyl ether), the alcohol is preferably deprotected with aqueous or alcoholic acid. Suitable deprotection reagents include, but are not limited to, aqueous hydrochloric acid, *p*-toluenesulfonic acid in methanol, pyridinium-*p*-toluenesulfonate in ethanol, Amberlyst H–15 in methanol, boric acid in ethylene-glycol-monoethylether, acetic acid in a water–tetrahydrofuran mixture, aqueous hydrochloric acid is preferred. Examples of such procedures are described, respectively, in Bernady *et al.*, 1979, *J. Org. Chem.*

44:1438; Miyashita *et al.*, 1977, *J. Org. Chem.* 42:3772; Johnston *et al.*, 1988, *Synthesis* 393; Bongini *et al.*, 1979, *Synthesis* 618; and Hoyer *et al.*, 1986, *Synthesis* 655; Gigg *et al.*, 1967, *J. Chem. Soc. C*, 431; and Corey *et al.*, 1978, *J. Am. Chem. Soc.* 100:1942.

Scheme 3: Synthesis of Compounds of Formula 13a, which correspond to $W^{(1)(2)}$–Z_m–OH, Wherein $W^{(1)(2)}$ is a Lactone Group



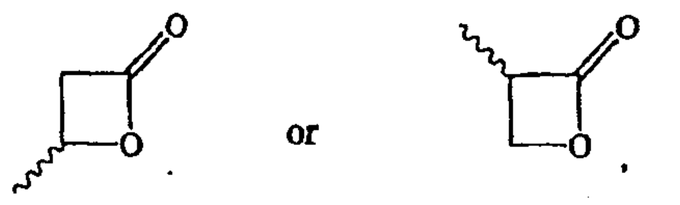
Scheme 3 depicts the synthesis of protected lactone alcohols **20** and lactone alcohols **13a**. Compounds **20** and **13a** correspond to compounds of the formula $W^{(1)(2)}$–Zm–OPG and $W^{(1)(2)}$–Z_m–OH respectively, wherein $W^{(1)(2)}$ is a lactone group selected from:



Protected lactone alcohols **20** can be prepared from compounds of the formula **17**, **18**, or **19** by using well-known condensation reactions and variations of the Michael reaction.

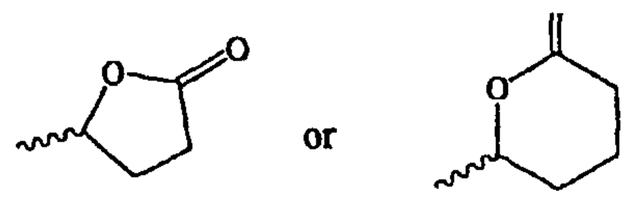
Methods for the synthesis of lactones are disclosed in Multzer in *Comprehensive Organic Functional Group Transformations*, A.R. Katritzky, O. Meth-Cohn and C.W. Rees, Eds. Pergamon: Oxford, 1995, vol 5, pp. 161-173. Mono-protected diols **19**, electrophilic protected alcohols **18**, and aldehydes **19** are readily available either commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, WI) or by well known synthetic procedures.

When $W^{(1)(2)}$ is a beta-lactone group of the formula:



3-beta-lactone or 4-beta-lactone

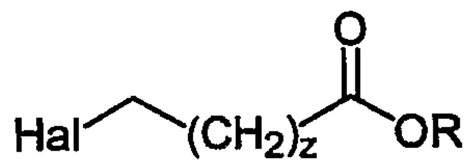
protected lactone alcohols **20** can be prepared from aldehydes **19** and electrophilic protected alcohols **18**, respectively, by a one-pot-addition-lactonization according to the procedure of Masamune *et al.*, 1976, *J. Am. Chem. Soc.* 98:7874 and Danheiser *et al.*, 1991, *J. Org. Chem.* 56:1176. This one-pot-addition-lactonization methodology has been reviewed by Multzer in *Comprehensive Organic Functional Group Transformations*, A.R. Katritzky, O. Meth-Cohn and C.W. Rees, Eds. Pergamon: Oxford, 1995, vol 5, pp. 161. When $W^{(1)(2)}$ is a gamma- or delta-lactone group of the formula:



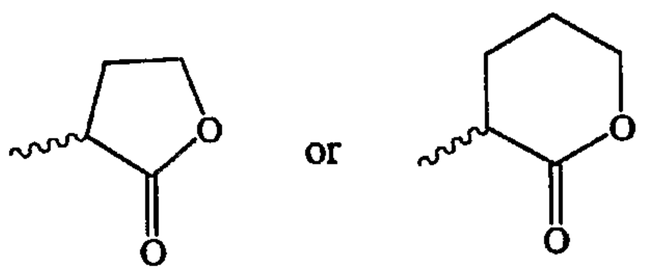
gamma-lactone or delta-lactone

protected lactone alcohols **20** can be prepared from aldehydes **19** according to well known synthetic methodology. For example, the methodology described in Masuyama *et al.*, 2000, *J. Org. Chem.* 65:494; Eisch *et al.*, 1978, *J. Organo. Met. Chem. C8* 160; Eaton *et al.*, 1947, *J. Org. Chem.* 37:1947; Yunker *et al.*, 1978, *Tetrahedron Lett.* 4651; Bhanot *et al.*, 1977, *J. Org. Chem.* 42:1623; Ehlinger *et al.*, 1980, *J. Am. Chem. Soc.* 102:5004; and Raunio *et al.*, 1957, *J. Org. Chem.* 22:570. For instance, as described in Masuyama *et al.*, 2000, *J. Org. Chem.* 65:494

aldehydes **19** can be treated with about 1 equivalent of a strong organometallic base, preferably with a pK_a of about 25 or more, more preferably with a pK_a of greater than about 35, in a suitable organic solvent to give a reaction mixture. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*–butyllithium, *tert*–butyllithium, *sec*–butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride, preferably lithium tetramethylpiperidide. Suitable solvents include, but are not limited to, diethyl ether and tetrahydrofuran. The reaction-mixture temperature is adjusted to within the range of about 0°C to about 100°C, preferably about room temperature to about 50°C, and a halide of the formula:



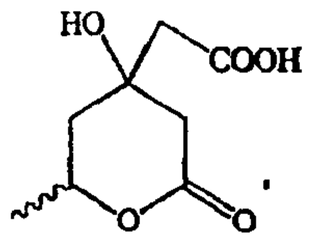
wherein z is 1 or 2 (diluted with a solvent or in undiluted form) is added. The reaction mixture is stirred for a period of about 2 hours to about 48 hours, preferably about 5 to about 10 hours, during which time the reaction's progress can be followed by using an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography. When the reaction is deemed substantially complete, protected lactone alcohols **20** can be isolated by workup and purified if desired. When $W^{(1)(2)}$ is a gamma- or delta-lactone group of the formula:



gamma-lactone delta-lactone

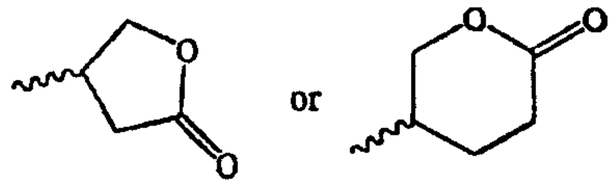
protected lactone alcohols **20** can be synthesized by deprotonating the corresponding lactone with a strong base providing the lactone enolate and reacting the enolate with electrophilic protected alcohols **20** (for a detailed discussion of enolate formation of active methylene compounds such as lactones, see House *Modern Synthetic Reactions*; W. A. Benjamin, Inc. Philippines 1972 pp. 492-570, and for a discussion of reaction of lactone enolates with electrophiles such as carbonyl compounds, see March, J. *Advanced Organic*

Chemistry; Reactions Mechanisms, and Structure, 4th ed., 1992, pp. 944-945). Lactone-enolate formation can be accomplished by adding about 1 equivalent of a strong organometallic base, preferably with a pK_a of about 25 or more, more preferably with a pK_a of greater than about 35, to a mixture comprising a suitable organic solvent and the lactone. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*–butyllithium, *tert*–butyllithium, *sec*–butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride, preferably lithium tetramethylpiperidide. Solvents suitable for lactone-enolate formation include, but are not limited to, diethyl ether and tetrahydrofuran. After enolate formation, the reaction-mixture temperature is adjusted to within the range of about –78°C to about room temperature, preferably about –50°C to about 0°C, and electrophilic protected alcohols **18** (diluted with a solvent or in undiluted form) are added, preferably at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. The reaction mixture is stirred for a period of about 15 minutes to about 5 hours, during which time the reaction's progress can be followed by using an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography. When the reaction is deemed substantially complete, protected lactone alcohols **20** can be isolated by workup and purified if desired. When $W^{(1)(2)}$ is a lactone group of the formula:



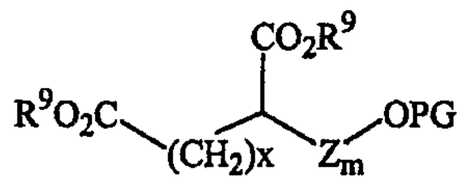
protected lactone alcohols **20** can be prepared from aldehydes **19** according to the procedure described in United States Patent No. 4,622,338.

When $W^{(1)(2)}$ is a gamma- or delta-lactone group of the formula:



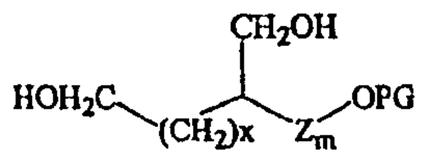
gamma-lactone delta-lactone

protected lactone alcohols **20** can be prepared according to a three step sequence. The first step comprises base-mediated reaction of electrophilic protected alcohols **18** with succinic acid esters (*i.e.*, $R^9O_2CCH_2CH_2CO_2R^9$, wherein R^9 is alkyl) or glutaric acid esters (*i.e.*, $R^9O_2CCH_2CH_2CH_2CO_2R^9$, wherein R^9 is alkyl) providing a diester intermediate of the formula **21**:



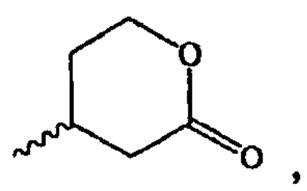
21

wherein x is 1 or 2 depending on whether the gamma or delta lactone group is desired. The reaction can be performed by adding about 1 equivalent of a strong organometallic base, preferably with a pK_a of about 25 or more, more preferably with a pK_a of greater than about 35, to a mixture comprising a suitable organic solvent and the succinic or glutaric acid ester. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*–butyllithium, *tert*–butyllithium, *sec*–butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride, preferably lithium tetramethylpiperidide. Suitable solvents include, but are not limited to, diethyl ether and tetrahydrofuran. After enolate formation, the reaction-mixture temperature is adjusted to within the range of about –78°C to about room temperature, preferably about –50°C to about 0°C, and electrophilic protected alcohols **18** (diluted with a solvent or in undiluted form) are added, preferably at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. The reaction mixture is stirred for a period of about 15 minutes to about 5 hours, during which time the reaction's progress can be followed by using an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography. When the reaction is deemed substantially complete, the diester intermediate be isolated by workup and purified if desired. In the second step, the intermediate diester can be reduced, with a hydride reducing agent, to yield a diol of the formula **22**:



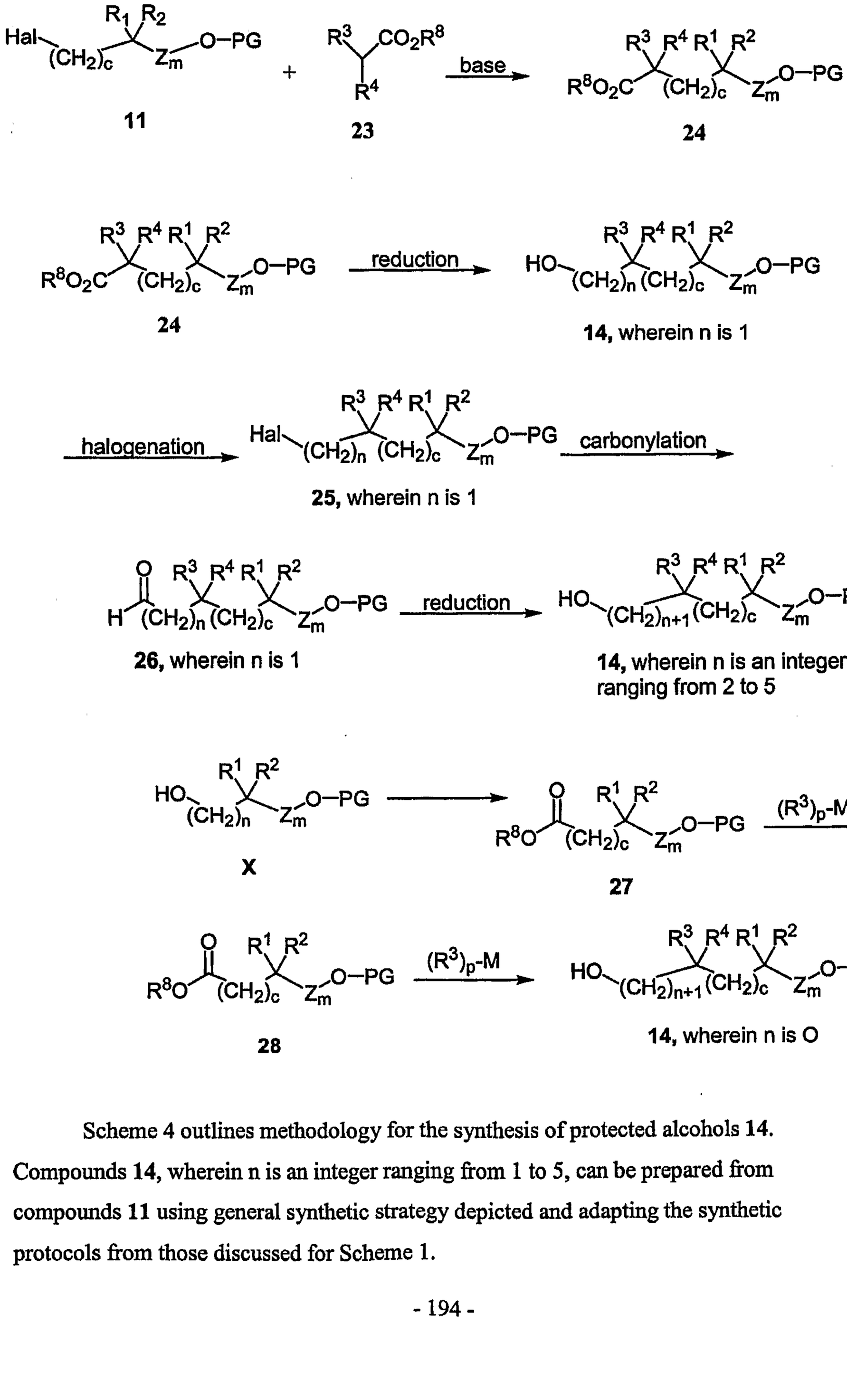
22

The reduction can be performed according to the procedures referenced in March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 1214). Suitable reducing agents include, but are not limited to, lithium aluminum hydride, diisobutylaluminum hydride, sodium borohydride, and lithium borohydride). In the third step, the diol can be oxidatively cyclized with $RuH_2(PPh_3)_4$ to the product protected lactone alcohols **20** according to the procedure of Yoshikawa *et al.*, 1986, *J. Org Chem.* 51:2034 and Yoshikawa *et al.*, 1983, *Tetrahedron Lett.* 26:2677. When $W^{(1)(2)}$ is a lactone group of the formula:



, protected lactone alcohols **20** can be synthesized by reacting the Grignard salts of electrophilic protected alcohols **18**, where E is a halide, with 5,6-dihydro-2*H*-pyran-2-one, commercially available (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin), in the presence of catalytic amounts of a 1-dimethylaminoacetyl)pyrolidine-2yl)methyl-diarylphosphine-copper (I) iodide complex as described in Tomioka *et al.*, 1995, *Tetrahedron Lett.* 36:4275.

Scheme 4: Synthesis of Compounds of Formula 14



11

23

24

24

14, wherein n is 1

25, wherein n is 1

26, wherein n is 1

14, wherein n is an integer ranging from 2 to 5

27

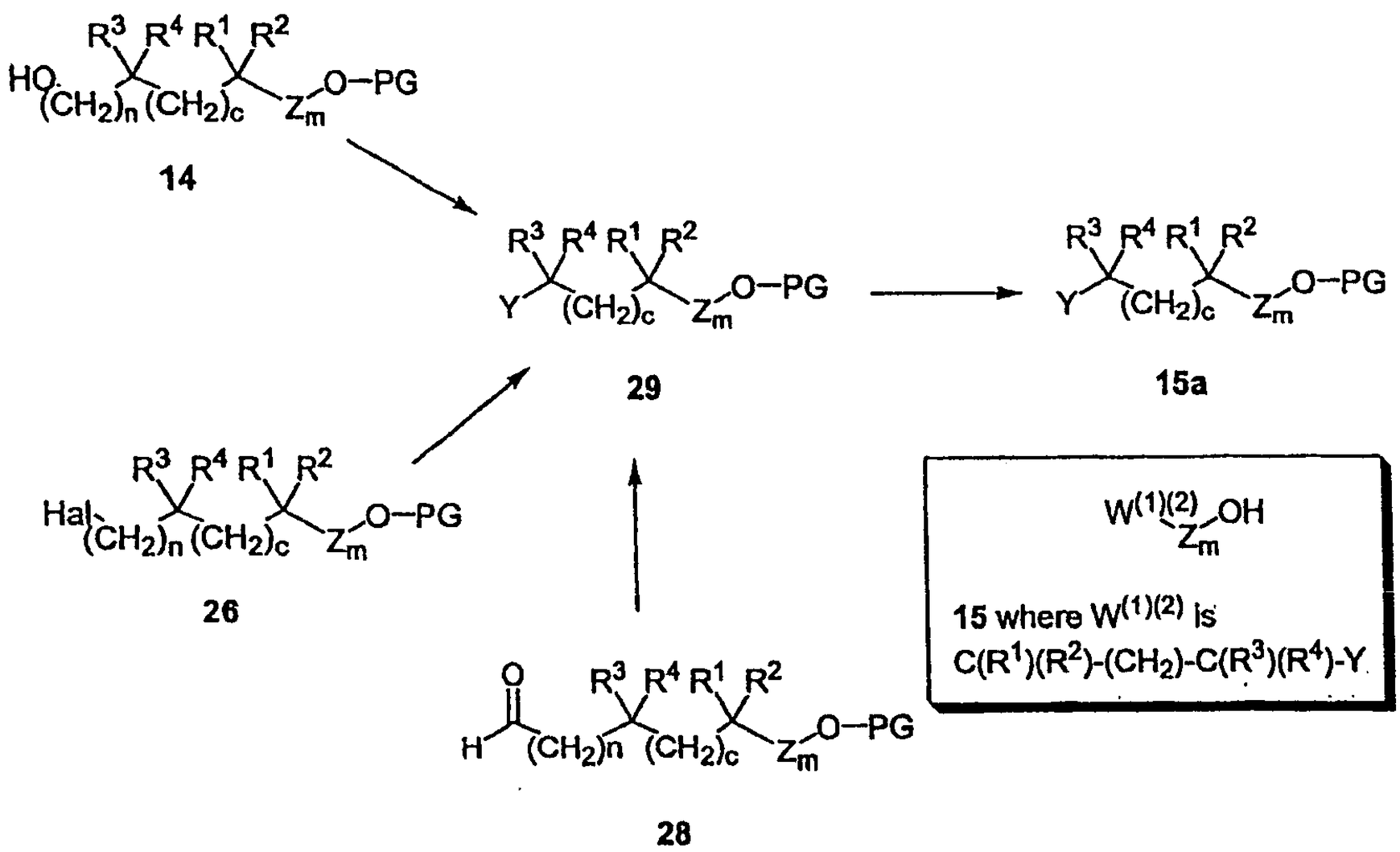
28

14, wherein n is O

Scheme 4 outlines methodology for the synthesis of protected alcohols **14**. Compounds **14**, wherein n is an integer ranging from 1 to 5, can be prepared from compounds **11** using general synthetic strategy depicted and adapting the synthetic protocols from those discussed for Scheme 1.

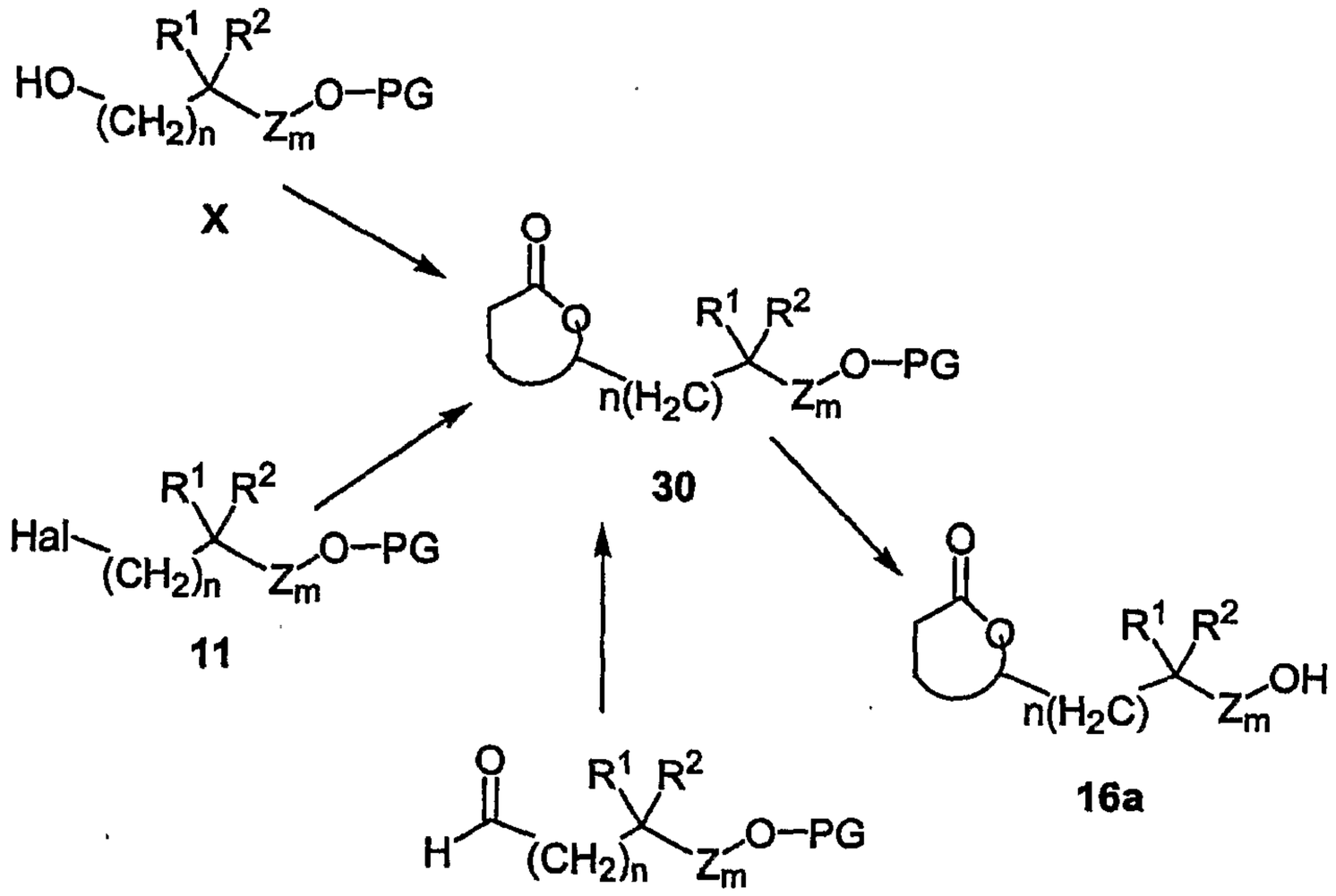
Next, Scheme 4 depicts the general strategy for the synthesis of compounds **14** wherein n is 0. First, Esters **27**, wherein R^8 is as defined above, are synthesized by oxidation of mono-protected diols **X** in the presence of R^8OH (see generally, March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 1196). An exemplary procedure for such an oxidation is described in Stevens *et al.*, 1982, *Tetrahedron Lett.* 23:4647 (HOCl); Sundararaman *et al.*, 1978, *Tetrahedron Lett.* 1627 (O_3/KOH); Wilson *et al.*, 1982, *J. Org. Chem.* 47:1360 (*t*–BuOOH/Et_3N); and Williams *et al.*, 1988, *Tetrahedron Lett.* 29:5087 (Br_2). Compounds **28** are converted to compounds **14** wherein n is 0 by adapting the synthetic procedures depicted in Scheme 1.

Scheme 5: Synthesis of Compounds of Formula 15a, which correspond to compounds $W^{(1)(2)}$–Z_m–OH, Where $W^{(1)(2)}$ is $C(R^1)(R^2)$–$(CH_2)_cC(R^3)(R^4)$–Y

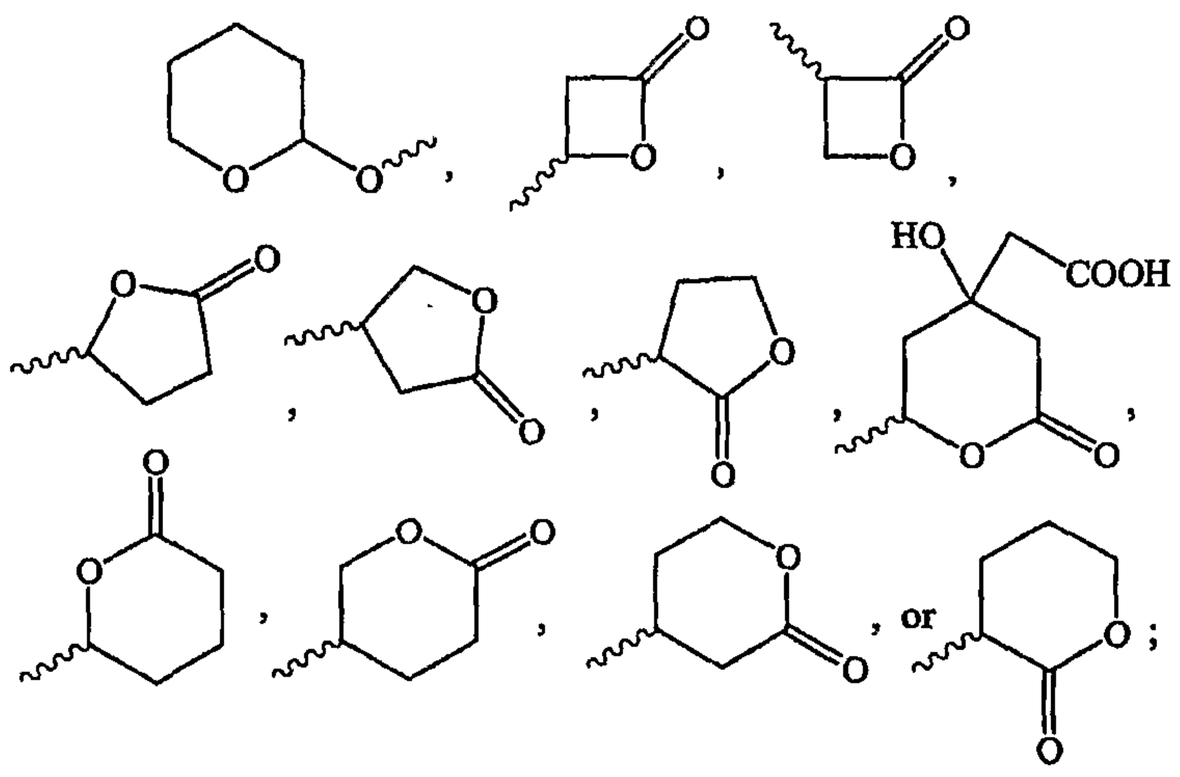


Scheme 5 outlines methodology for the synthesis of protected alcohols **29** and alcohols **15a**, which correspond to $W^{(1)(2)}$–Z_m–OPG and $W^{(1)(2)}$–Z_m–OH, respectively, wherein $W^{(1)(2)}$ is $C(R^1)(R^2)$–$(CH_2)_cC(R^3)(R^4)$–Y. The synthesis of starting materials **14**, **26**, and **28** are depicted in Scheme 4 and the synthetic methods and procedures can be adapted from those described for Scheme 2.

Scheme 6: Synthesis of Compounds of Formula 16, which correspond to compounds $W^{(1)(2)}$-Z_m-OH, Wherein $W^{(1)(2)}$ is $C(R^1)(R^2)(CH_2)_c$-V where V is a Lactone Group



Scheme 6 depicts the synthesis of protected lactone alcohols **30** and lactone alcohols **16a**. Compounds **30** and **16a** correspond to compounds of the formula, which correspond to compounds $W^{(1)(2)}$-Z_m-OH, wherein $W^{(1)(2)}$ is $C(R^1)(R^2)(CH_2)_c$-V and V is a Group selected from:



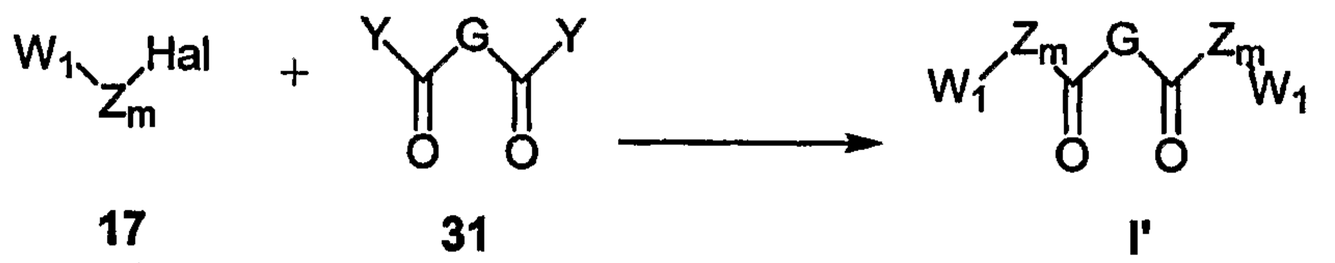
As shown in Scheme 6, protected lactone alcohols **30** and lactone alcohols **16a** can be synthesized from compounds of the formula **X**, **11**, or **12** by adaptation of the methods and procedures discussed above for Scheme 3.

Scheme 7: Conversion of Alcohols 18 to Halides 18e

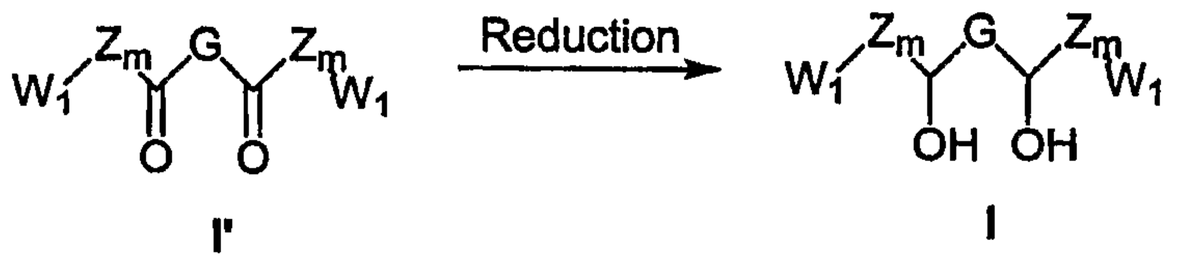
18 **18e**

Scheme 7 depicts the synthesis of halides **18e**. Halides **18** can be synthesized by a variety of methods. One method involves conversion of the alcohol to a leaving group such as a sulfonic ester, such as, for example, tosylate, brosylate, mesylate, or nosylate. This intermediate is then treated with a source of X^-, wherein X^- is I^-, Br^-, or Cl^- in a solvent such as THF or ether. A general method for converting vinyl and phenyl alcohols to thiols involves initially converting the alcohol to a leaving group (*e.g.*, a tosylate) then treating with a halide nucleophile.

Scheme 8: Synthesis of Compounds of Formula I



17 **31** **I'**

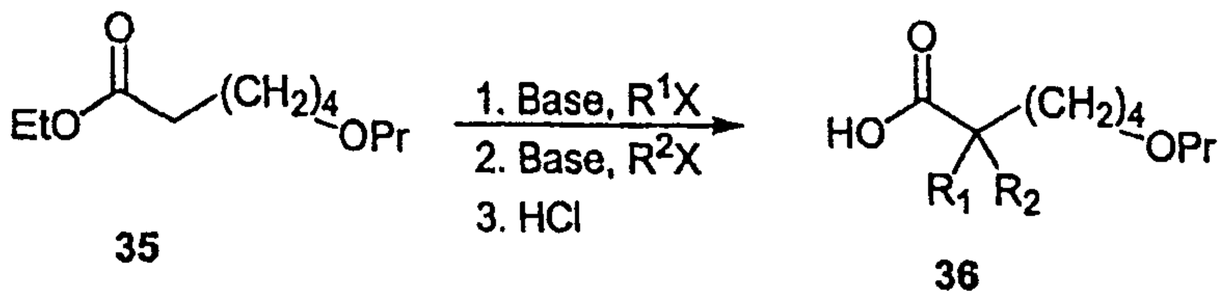


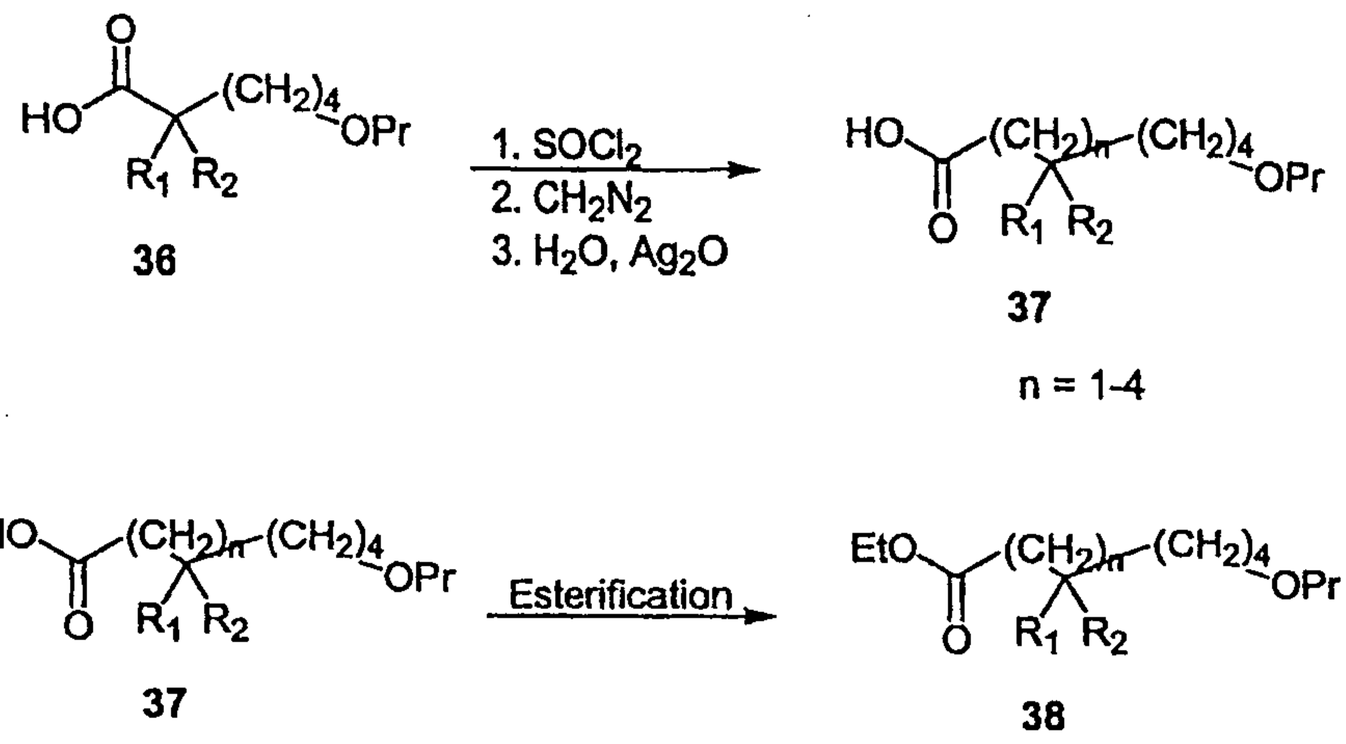
I' **I**

Scheme 8 outlines the synthesis of compounds **I**. In the first step, compounds **I** are synthesized by reacting compounds **17** (compounds **X, 11, 12, 13, 14, 15, and 16** are encompassed by **17**) with compounds **31** under the conditions suitable for the formation of compounds **I'**. The conditions and methods discussed in Scheme **1** above for the synthesis of mono-protected diols **X** from alcohols **6** can be adapted for the synthesis of compounds **17**. Compounds **31**, wherein Y is a suitable leaving group as defined above, preferably an anhydride, an ester, or an amide group, are readily obtained commercially (*e.g.*, Aldrich Chemical Co. Milwaukee WI) or by well known synthetic methods. Compounds **I'** are

obtained by reacting compounds 31 with compounds 17 under the conditions suitable for alkyl-de-acyloxy substitution. Compounds I' can also be prepared as described in U.S. Patent Application No. 09/976,938, filed October 11,2001. (For a review, *See* Kharasch; Reinmuth, *Grignard Reactions of Nonmetallic Substances*; Prentice Hall: Englewood Cliffs, NJ, 1954, pp. 561-562 and 846-908). In a preferred procedure, the conversion of anhydrides, carboxylic esters, or amides to ketones can be accomplished with organometallic compounds. In a particular procedure, anhydrides and carboxylic esters give ketones when treated using inverse addition of Grignard reagents at low temperature with a solvent in the presence of HMPA. *See* Newman, *J. Org. Chem.* **1948**, *13*, 592; Huet; Empotz; Jubier *Tetrahedron* **1973**, *29*, 479; and Larock, *Comprehensive Organic Transformations*; VCH: New York, 1989, pp. 685-686, 693-700. Ketones can also be prepare by the treatment of thioamides with organolithium compounds (alkyl or aryl). *See* Tominaga; Kohra; Hosomi *Tetrahedron Lett.* **1987**, *28*, 1529. Moreover, alkyllithium compounds have been used to give ketones from carboxylic esters. *See* Petrov; Kaplan; Tsir *J. Gen. Chem. USSR* **1962**, *32*, 691. The reaction must be carried out in a high-boiling solvent such as toluene. Di-substituted amides also can be used to synthesize ketones. See Evans J. Chem. Soc. 1956, 4691; and Wakefield *Organolithium Methods*; Academic Press: New York, 1988, pp. 82-88. Finally, compounds I' are reduced using methods known to those of ordinary skill in the art to afford diol I. *See Comprehensive Organic Transformations*; VCH: New York, 1989. It is readily recognized that the diol compound I are stereoisomeric and can therefore exist as enantiomers and diastereomers. Separation of the stereoisomers (*i.e.*, enantiomers or diastereomers) can be achieved by methods known in the art, for example, conversion to a chiral salt and crystallization, chiral chromatography, or chiral HPLC.

Scheme 9; Synthesis of Compounds 38



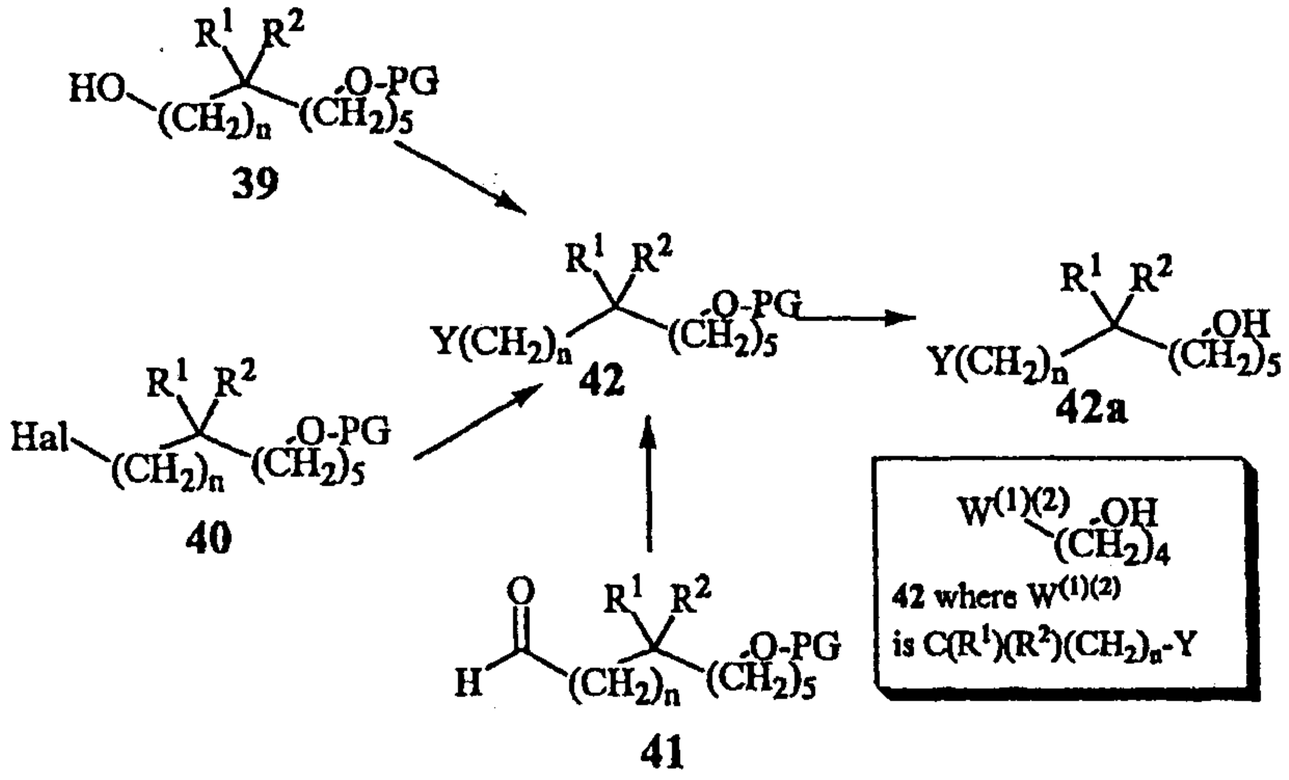


Scheme 9 illustrates the α-disubstitution of an ester containing a terminal protected hydroxyl moiety. Compounds that contain strong electron withdrawing groups are easily converted to the corresponding enolates. These enolate ions can readily attack an electrophile resulting in alpha substitution. For a review see *Some Modern Methods of Organic Synthesis*, 3rd Ed.; Cambridge University Press: Cambridge, 1986, pp. 1-26. Typical procedures are described in Juaristi *et al.*, *J. Org.Chem.*, 56, 1623 (1991) and Julia *et al.*, *Tetrahedron*, 41, 3717 (1985). The reaction is successful for primary and secondary alkyl, allylic, and benzylic. The use of polar aprotic solvents, *e.g.*, dimethylformamide or dimethylsulfoxide, are preferred. Phase transfer catalysts can also be used. *See* Tundo *et al. J. Chem. Soc., Perkin Trans.* 1, 1987, 2159.

The conversion to a carboxylic acid with an additional carbon is achieved by treating an acyl halide with diazomethane to generate an intermediate diazo ketone, which in the presence of water and silver oxide rearranges through a ketene intermediate to a carboxylic acid with an additional carbon aton **37**. If the reaction is done in an alcohol instead of water an ester is recovered. *See Vogel's Textbook of Practical Chemistry*, Longman: London, 1978, pp. 483; Meier *et al. Angew. Chem. Int. Ed. Eng.* 1975, 14, 32-43. Alternatively,

the carboxylic acid can be esterified by known techniques. The reaction can be repeated to generate methylene groups adjacent to the carboxylic acid.

Scheme 10: Synthesis of Compounds of Formula 42a which correspond to Compounds $W^{(1)(2)}$-$(CH_2)_4$-OH, wherein $W^{(1)(2)}$ is $C(R^1)(R^2)(CH_2)_nY$



Scheme 10 outlines methodology for the synthesis of protected alcohols **42a** wherein Y, R^1, R^2, Z, and m are defined as above. Protected alcohols **42a** correspond to compounds of the formula $W^{(1)(2)}$–Zm–OPG, wherein $W^{(1)(2)}$ is $C(R^1)(R^2)$–Y.

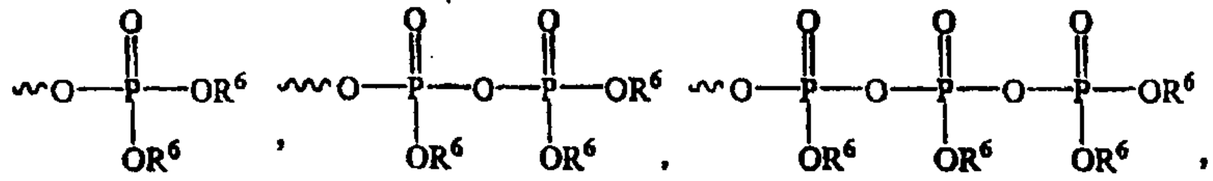
Protected alcohols 42, wherein Y comprises a –C(O)OH group, can be synthesized by oxidizing mono-protected diols 39 with an agent suitable for oxidizing a primary alcohol to a carboxylic acid. (M. Hudlicky, *Oxidations in Organic Chemistry*, ACS Monograph 186, 1990, pp. 127-130). Suitable oxidizing agents include, but are not limited to, pyridinium dichromate (Corey *et al.*, 1979, *Tetrahedron Lett.* 399); manganese dioxide (Ahrens *et al.*, 1967, *J. Heterocycl. Chem.* 4:625); sodium permanganate monohydrate (Menger *et al.*, 1981, *Tetrahedron Lett.* 22:1655); and potassium permanganate (Sam *et al.*, 1972, *J. Am. Chem. Soc.* 94:4024). The preferred oxidizing reagent is pyridinium dichromate. In an alternative synthetic procedure, protected alcohols **42**, wherein Y comprises a -C(O)OH group, can be synthesized by treatment of protected halo-alcohols **40**, wherein X is iodo, with CO or CO_2, as described in Bailey *et al.*, 1990, *J. Org. Chem.* 55:5404 and Yanagisawa *et al.*, 1994, *J. Am. Chem. Soc.* 116:6130. Protected alcohols **42**,

wherein Y comprises –C(O)OR^5, wherein R^5 is as defined above, can be synthesized by oxidation of mono-protected diols **39** in the presence of R^{5}OH (see generally, March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 1196). An exemplary procedure for such an oxidation is described in Stevens *et al.*,1982, *Tetrahedron Lett.* 23:4647 (HOCl); Sundararaman *et al.*,1978, *Tetrahedron Lett.* 1627 (O_3/KOH); Wilson *et al.*,1982, *J. Org. Chem.* 47:1360 (*t*–BuOOH/Et_3N); and Williams *et al.*, 1988, *Tetrahedron Lett.* 29:5087 (Br_2). Preferably, protected alcohols **42**, wherein Y comprises a -C(O)OR^5 group are synthesized from the corresponding carboxylic acid (*i.e.*, **42**, wherein Y comprises –C(O)OH) by esterification with R^{5}OH (*e.g.*, *see* March, J., *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., Wiley, New York, 1992, p. 393-394). In another alternative synthesis, protected alcohols **42**, wherein Y comprises -C(O)OR^5, can be prepared from protected halo-alcohols **40** by carbonylation with transition metal complexes (*see e.g.*, March, *J. Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., Wiley, New York, 1992, p. 484-486; Urata *et al.*, 1991, *Tetrahedron Lett.* 32:36,4733); and Ogata *et al.*, 1969, *J Org. Chem.* 3985).

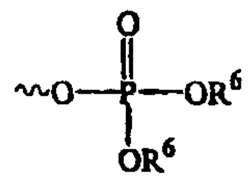
Protected alcohols **42**, wherein Y comprises –OC(O)R^5, wherein R^5 is as defined above, can be prepared by acylation of mono-protected diols **39** with a carboxylate equivalent such as an acyl halide (*i.e.*, R^{5}C(O)–Hal, wherein Hal is iodo, bromo, or chloro, *see e.g.*, March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., Wiley, New York, 1992, p. 392 and *Org. Synth. Coll.* Vol. III, Wiley, NY, pp. 142, 144, 167, and 187 (1955)) or an anhydride (*i.e.*, R^{5}C(O)–O–(O)CR^5, see *e.g.*, March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 392-393 and *Org. Synth. Coll.* Vol. III, Wiley, NY, pp. 11, 127, 141, 169, 237, 281, 428, 432, 690, and 833 (1955)). Preferably, the reaction is conducted by adding a base to a solution comprising mono-protected diols **39**, a carboxylate equivalent, and an organic solvent, which solution is preferably maintained at a constant temperature within the range of 0°C to about room temperature. Solvents suitable for reacting mono-protected diols **39** with a carboxylate equivalent include, but are not limited to, dichloromethane, toluene, and ether, preferably dichloromethane. Suitable bases include, but are not limited to, hydroxide sources, such as sodium hydroxide, potassium hydroxide, sodium carbonate, or potassium carbonate; or an amine such as triethylamine, pyridine, or dimethylaminopyridine. The progress of the reaction can be followed by using

an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography and when substantially complete, the product can be isolated by workup and purified if desired.

Protected alcohols **42**, wherein Y comprises one of the following phosphate ester groups



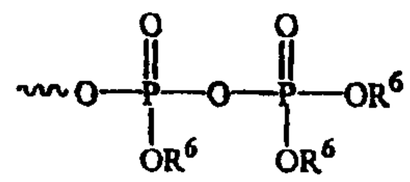
wherein R^6 is defined as above, can be prepared by phosphorylation of mono-protected diols **X** according to well-known methods (for general reviews, see Corbridge *Phosphorus: An Outline of its Chemistry, Biochemistry, and Uses*, Studies in Inorganic Chemistry, 3rd ed., pp. 357-395 (1985); Ramirez *et al.*, 1978, *Acc. Chem. Res.* 11:239; and Kalckare *Biological Phosphorylations*, Prentice-Hall, New York (1969); J. B. Sweeny in *Comprehensive Organic Functional Group Transformations*, A.R. Katritzky, O. Meth-Cohn and C.W. Rees, Eds. Pergamon: Oxford, 1995, vol 2, pp. 104-109). Protected alcohols **42** wherein Y comprises a monophosphate group of the formula:



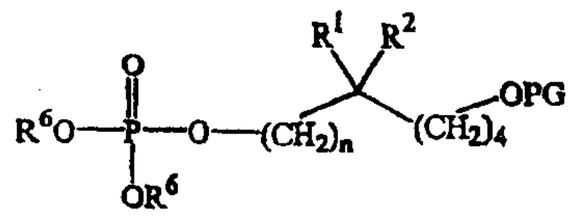
wherein R^6 is defined as above, can be prepared by treatment of mono-protected diol **39** with phosphorous oxychloride in a suitable solvent, such as xylene or toluene, at a constant temperature within the range of about 100°C to about 150°C for about 2 hours to about 24 hours. After the reaction is deemed substantially complete, by using an appropriate analytical method, the reaction mixture is hydrolyzed with R^6-OH. Suitable procedures are referenced in Houben-Weyl, Methoden der Organische Chemie, Georg Thieme Verlag Stuttgart: 1964, vol. XII/2, pp. 143-210 and 872-879. Alternatively, when both R^6 are hydrogen, can be synthesized by reacting mono-protected diols **X** with silyl polyphosphate (Okamoto *et al.*, 1985, *Bull Chem. Soc. Jpn.* 58: 3393) or by hydrogenolysis of their benzyl or phenyl esters (Chen *et al.*, 1998, *J Org. Chem.* 63:6511). In another alternative procedure, when R^6 is (C_1-C_6)alkyl, (C_2 C_6)alkenyl, or (C_2-

C_6)alkynyl, the monophosphate esters can be prepared by reacting mono-protected diols **39** with appropriately substituted phophoramidites followed by oxidation of the intermediate with *m*-chloroperbenzoic acid (Yu *et al.*, 1988, *Tetrahedron Lett.* 29:979) or by reacting mono-protected diols **39** with dialkyl or diaryl substituted phosphorochloridates (Pop, *et al*, 1997, *Org. Prep. and Proc. Int.* 29: 341). The phosphoramidites are commercially available (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or readily prepared according to literature procedures (*see e.g.*, Uhlmann *et al.*1986, *Tetrahedron Lett.* 27:1023 and Tanaka *et al.*, 1988, *Tetrahedron Lett.* 29:199). The phosphorochloridates are also commercially available (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or prepared according to literature methods (*e.g.*, Gajda *et a*l, 1995, *Synthesis* 25:4099. In still another alternative synthesis, protected alcohols **42**, wherein Y comprises a monophosphate group and R^6 is alkyl or aryl, can be prepared by reacting $IP^+(OR^6)_3$ with mono-protected diols **39** according to the procedure described in Stowell *et al.*, 1995, *Tetrahedron Lett.* 36:11, 1825 or by alkylation of protected halo alcohols **40** with the appropriate dialkyl or diaryl phosphates (*see e.g.*, Okamoto, 1985, *Bull Chem. Soc. Jpn.* 58:3393).

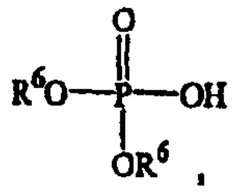
Protected alcohols **42** wherein Y comprises a diphosphate group of the formula



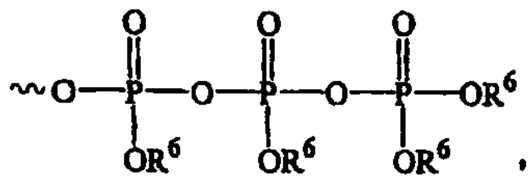
wherein R^6 is defined as above, can be synthesized by reacting the above-discussed monophosphates of the formula:



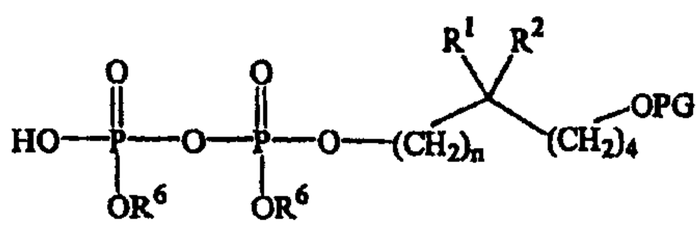
with a phosphate of the formula



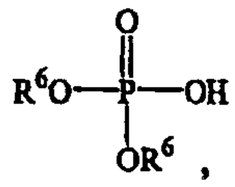
(commercially available, *e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin), in the presence of carbodiimide such as dicyclohexylcarbodiimide, as described in Houben-Weyl, *Methoden der Organische Chemie*, Georg Thieme Verlag Stuttgart 1964, vol. XII/2, pp. 881-885. In the same fashion, protected alcohols **42**, wherein Y comprises a triphosphate group of the formula:



can be synthesized by reacting the above-discussed diphosphate-protected alcohols, of the formula:

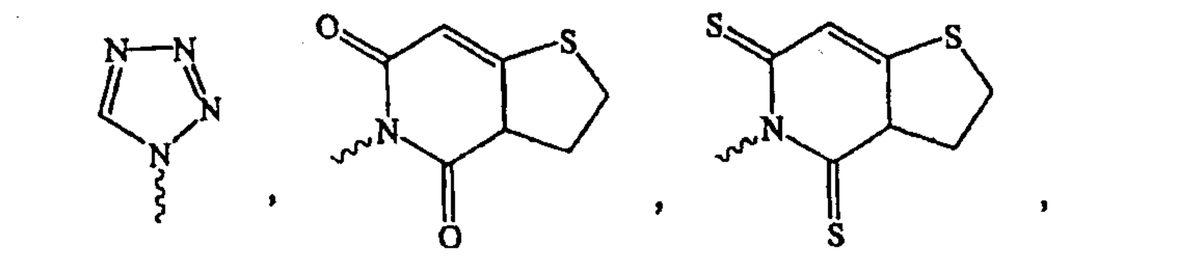
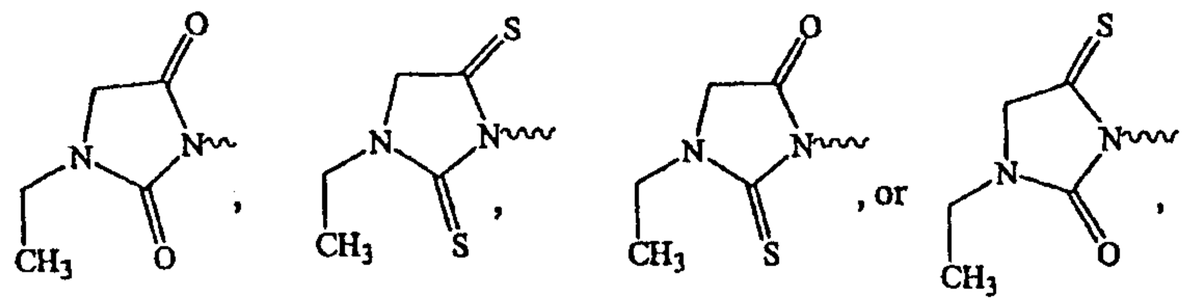


with a phosphate of the formula:



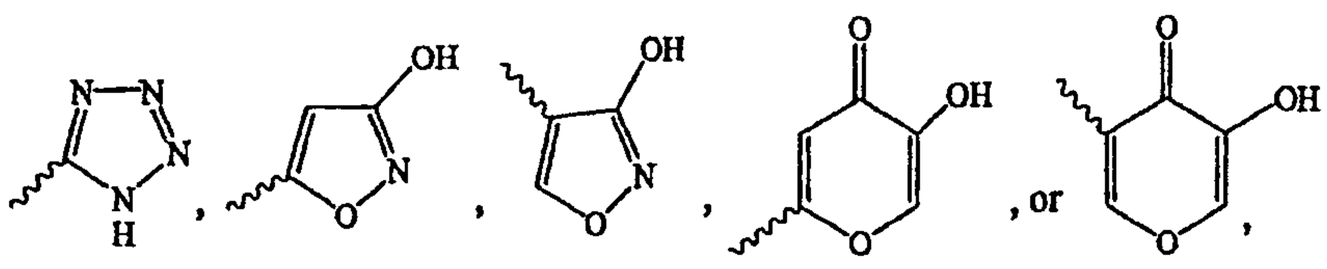
as described above. Alternatively, when R^6 is H, protected alcohols **42** wherein Y comprises the triphosphate group, can be prepared by reacting mono-protected diols **39** with salicyl phosphorochloridite and then pyrophosphate and subsequent cleavage of the adduct thus obtained with iodine in pyridine as described in Ludwig *et al.*, 1989, *J. Org. Chem.* 54:631.

Protected alcohols **42**, wherein Y is $-SO_3H$ or a heterocyclic group selected from the group consisting of:

can be prepared by halide displacement from protected halo-alcohols **40**. Thus, when Y is –SO_3H, protected alcohols **42** can by synthesized by reacting protected halo-alcohols **40** with sodium sulfite as described in Gilbert *Sulfonation and Related Reactions*; Wiley: New York, 1965, pp. 136-148 and pp. 161-163; *Org. Synth. Coll.* Vol. II, Wiley, NY, 558, 564 (1943); and *Org. Synth. Coll.* Vol. IV, Wiley, NY, 529 (1963). When Y is one of the above-mentioned heterocycles, protected alcohols **42** can be prepared by reacting protected halo-alcohols **40** with the corresponding heterocycle in the presence of a base. The heterocycles are available commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or prepared by well-known synthetic methods (see the procedures described in Ware, 1950, *Chem. Rev.* 46:403-470). Preferably, the reaction is conducted by stirring a mixture comprising **40**, the heterocycle, and a solvent at a constant temperature within the range of about room temperature to about 100°C, preferably within the range of about 50°C to about 70°C for about 10 to about 48 hours. Suitable bases include hydroxide bases such as sodium hydroxide, potassium hydroxide, sodium carbonate, or potassium carbonate. Preferably, the solvent used in forming protected alcohols **42** is selected from dimethylformamide; formamide; dimethyl sulfoxide; alcohols, such as methanol or ethanol; and mixtures thereof. The progress of the reaction can be followed by using an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography and when substantially complete, the product can be isolated by workup and purified if desired.

Protected alcohols **42**, wherein Y is a heteroaryl ring selected from

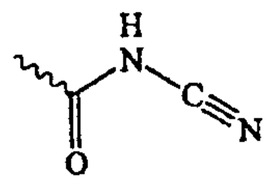


can be prepared by metallating the suitable heteroaryl ring then reacting the resulting metallated heteroaryl ring with protected halo-alcohols **40** (for a review, see Katritzky *Handbook of Heterocyclic Chemistry*, Pergamon Press: Oxford 1985). The heteroaryl rings are available commercially or prepared by well-known synthetic methods (*see e.g.*, Joule *et al., Heterocyclic Chemistry*, 3rd ed., 1995; De Sarlo *et al.*,1971, *J. Chem. Soc. (C)* 86; Oster *et al.*,1983, *J. Org. Chem.* 48:4307; Iwai *et al.*, 1966, *Chem. Pharm. Bull.* 14:1277; and United States Patent No. 3,152,148). As used herein, the term "metallating" means the forming of a carbon-metal bond, which bond may be substantially ionic in character. Metallation can be accomplished **by adding about 2 equivalents of strong organometallic base, preferably with a pK_a of about 25 or more, more preferably with a pK_a of greater than about 35, to a mixture comprising a suitable organic solvent and the heterocycle. Two equivalents of base are required: one equivalent of the base deprotonates the –OH group or the –NH group, and the second equivalent metallates the heteroaryl ring. Alternatively, the hydroxy group of the heteroaryl ring can be protected with a base-stable, acid-labile protecting group as described in Greene,** T.W., *Protective Groups in Organic Synthesis*, 3rd edition 17-237 (1999). Where the hydroxy group is protected, only one equivalent of base is required. Examples of suitable base-stable, acid-labile hydroxyl-protecting groups, include but are not limited to, ethers, such as methyl, methoxy methyl, **methylthiomethyl, methoxyethoxymethyl, *bis*(2-chloroethoxy)methyl, tetrahydropyranyl, tetrahydrothiopyranyl, tetrahyrofuranyl, tetrahydrothiofuranyl, 1-ethoxyethyl, 1-methyl-1-methoxyethyl, *t*-butyl, allyl, benzyl, *o*-nitrobenzyl, triphenylmethyl, α-naphthyldiphenylmethyl, *p*-methoxyphenyldiphenylmethyl, 9-(9-phenyl-10-oxo)anthranyl, trimethylsilyl, isopropyldimethylsilyl, *t*-butyldimethylsilyl, *t*-butyldiphenylsilyl,** tribenzylsilyl, triisopropylsilyl; and esters, such as pivaloate, adamantoate, and 2,4,6-trimethylbenzoate. Ethers are preferred, particularly straight chain ethers, such as methyl ether, methoxymethyl ether, methylthiomethyl ether, methoxyethoxymethyl ether, *bis*(2-chloroethoxy)methyl ether. Preferably, the pK_a of the base is higher than the pK_a of the proton of the heterocycle to be deprotonated. For a listing of pK_as for various heteroaryl rings, see Fraser *et al.*, 1985, *Can. J. Chem.* 63:3505. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*-butyllithium, *tert*-butyllithium, *sec*-butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium

dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride. If desired, the organometallic base can be activated with a complexing agent, such as *N,N,N',N'*–tetramethylethylenediamine or hexamethylphosphoramide (1970, *J. Am. Chem. Soc.* 92: 4664). Solvents suitable for synthesizing protected alcohols **42**, wherein Y is a heteroaryl ring include, but are not limited to, diethyl ether; tetrahydrofuran; and hydrocarbons, such as pentane. Generally, metallation occurs alpha to the heteroatom due to the inductive effect of the heteroatom, however, modification of conditions, such as the identity of the base and solvents, order of reagent addition, reagent addition times, and reaction and addition temperatures can be modified by one of skill in the art to achieve the desired metallation position (*see e.g.*, Joule *et al., Heterocyclic Chemistry*, 3rd ed., 1995, pp. 30-42). Alternatively, the position of metallation can be controlled by use of a halogenated heteroaryl group, wherein the halogen is located on the position of the heteroaryl ring where metallation is desired (*see e.g.*, Joule *et al., Heterocyclic Chemistry*, 3rd ed., 1995, p. 33 and Saulnier *et al.*, 1982, *J.Org. Chem.* 47:757). Halogenated heteroaryl groups are available commercially (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin) or can be prepared by well-known synthetic methods (*see e.g.*, Joule *et al., Heterocyclic Chemistry*, 3rd ed., 1995, pp. 78, 85, 122, 193, 234, 261, 280, 308). After metallation, the reaction mixture comprising the metallated heteroaryl ring is adjusted to within a temperature range of about 0°C to about room temperature and protected halo-alcohols **40** (diluted with a solvent or in undiluted form) are added, preferably at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. After addition of protected halo-alcohols **40**, the reaction mixture is stirred at a constant temperature within the range of about room temperature and about the solvent's boiling temperature and the reaction's progress can be monitored by the appropriate analytical technique, preferably thin-layer chromatography or high-performance liquid chromatography. After the reaction is substantially complete, protected alcohols **42** can be isolated by workup and purification. It is to be understood that conditions, such as the identity of protected halo-alcohol **40**, the base, solvents, orders of reagent addition, times, and temperatures, can be modified by one of skill in the art to optimize the yield and selectivity. Exemplary procedures that can be used in such a transformation are described in Shirley *et al.*, 1995, *J. Org. Chem.* 20:225;

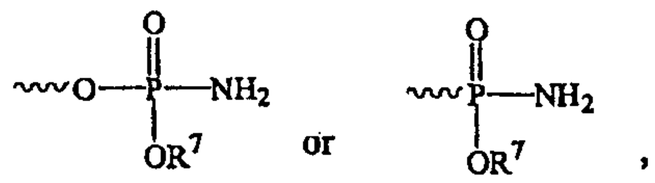
Chadwick *et al.*,1979, *J. Chem. Soc., Perkin Trans. 1* 2845; Rewcastle, 1993, *Adv. Het. Chem.* 56:208; Katritzky *et al.*, 1993, *Adv. Het. Chem.* 56:155; and Kessar *et al.*,1997, *Chem. Rev.* 97:721.

When Y is

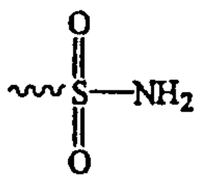


protected alcohols **42** can be prepared from their corresponding carboxylic acid derivatives (**42**, wherein Y is $-CO_2H$) as described in Belletire *et al*,1988, *Synthetic Commun.* 18:2063 or from the corresponding acylchlorides (**42**, wherein Y is –CO–halo) as described in Skinner *et al.*, 1995, *J. Am. Chem. Soc.* 77: 5440. The acylhalides can be prepared from the carboxylic acids by well known procedures such as those described in March, J., *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 437-438.

When Y is



wherein R^7 is as defined above, protected alcohols **42** can be prepared by first reacting protected halo-alcohols **40** with a trialkyl phosphite according to the procedure described in Kosolapoff, 1951, *Org. React.* 6:273 followed by reacting the derived phosphonic diester with ammonia according to the procedure described in Smith *et al.*,1957, *J. Org. Chem.* 22:265. When Y is

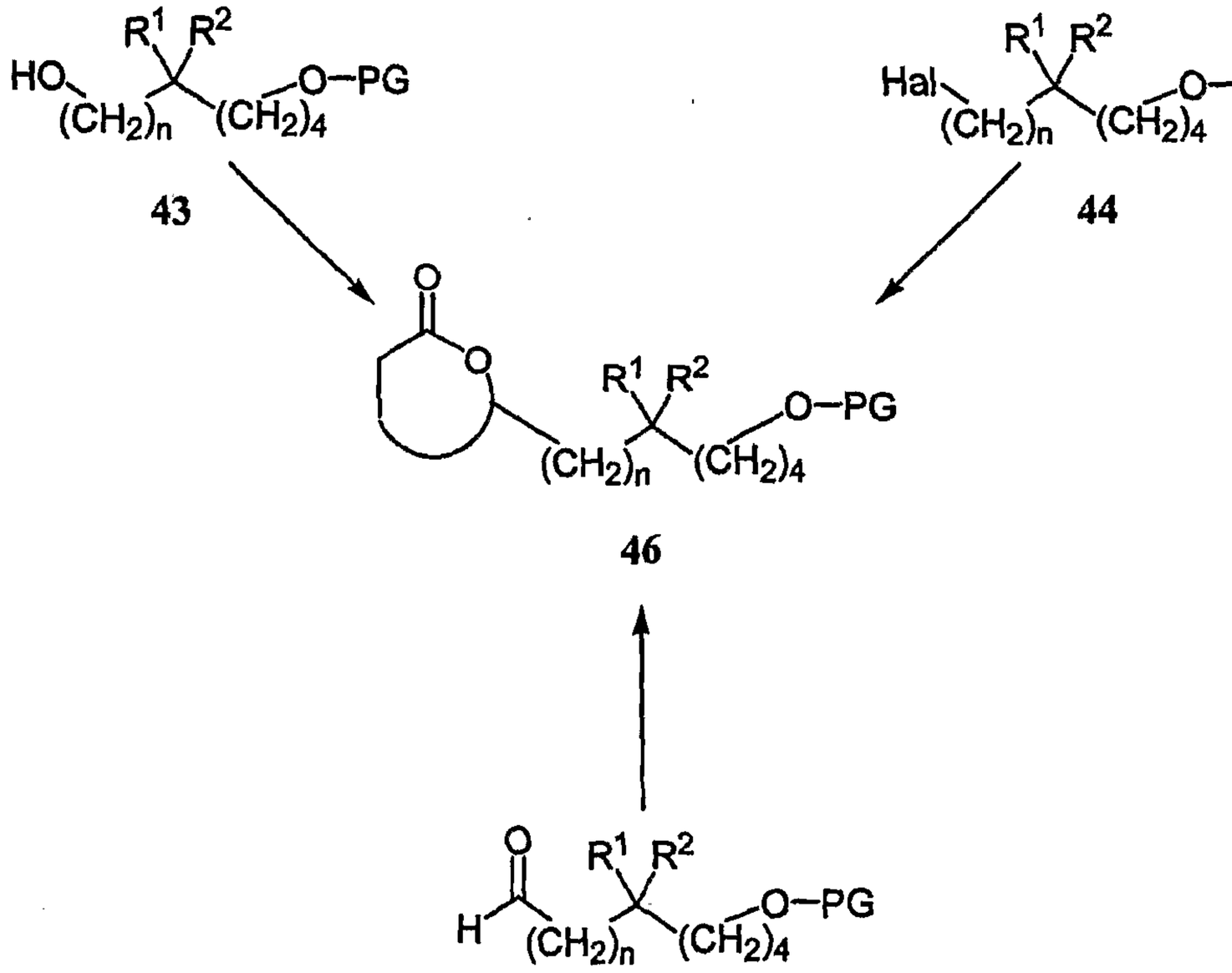


protected alcohols **42** can be prepared by reacting their sulphonic acid derivatives (*i.e.*, **42**, wherein Y is $-SO_3H$) with ammonia as described in Sianesi *et al.*,1971, *Chem. Ber.*

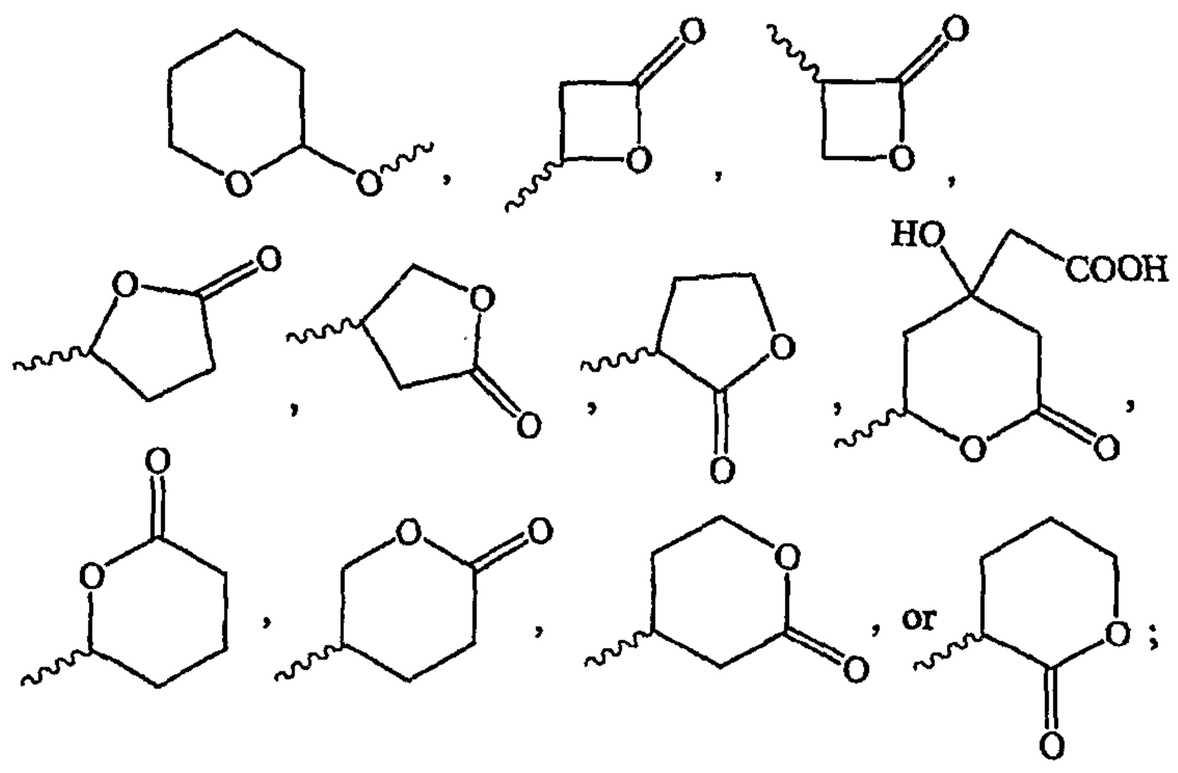
104:1880 and Campagna *et al.*, 1994, *Farmaco, Ed. Sci.* 49:653).

As further illustrated in Scheme 10, protected alcohols **42** can be deprotected providing alcohols **42a**. The deprotection method depends on the identity of the alcohol-protecting group, *see e.g.*, the procedures listed in Greene, T.W., *Protective Groups in Organic Synthesis*, 3rd edition 17-237 (1999), particularly see pages 48-49. One of skill in the art will readily be able to choose the appropriate deprotection procedure. When the alcohol is protected as an ether function (*e.g.*, methoxymethyl ether), the alcohol is preferably deprotected with aqueous or alcoholic acid. Suitable deprotection reagents include, but are not limited to, aqueous hydrochloric acid, *p*-toluenesulfonic acid in methanol, pyridinium-*p*-toluenesulfonate in ethanol, Amberlyst H–15 in methanol, boric acid in ethylene-glycol-monoethylether, acetic acid in a water–tetrahydrofuran mixture, aqueous hydrochloric acid is preferred. Examples of such procedures are described, respectively, in Bernady *et al.*, 1979, *J. Org. Chem.* 44:1438; Miyashita *et al.*, 1977, *J. Org. Chem.* 42:3772; Johnston *et al.*, 1988, *Synthesis* 393; Bongini *et al.*, 1979, *Synthesis* 618; and Hoyer *et al.*, 1986, *Synthesis* 655; Gigg *et al.*, 1967, *J. Chem. Soc. C*, 431; and Corey *et al.*, 1978, *J. Am. Chem. Soc.* 100:1942.

Scheme 11: Synthesis of Compounds of Formula 46 which correspond to Compounds $W^{(1)(2)}$-$(CH_2)_4$-OH, wherein $W^{(1)(2)}$ is $C(R^1)(R^2)(CH_2)_4$-Lactone

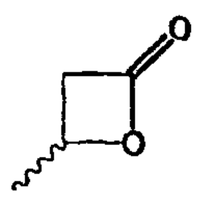


Scheme 11 depicts the synthesis of protected lactone alcohols **46** and lactone. Compound **46** corresponds to compounds of the formula $W^{(1)(2)}$–Zm–OPG and , wherein $W^{(1)(2)}$ is a lactone group selected from:



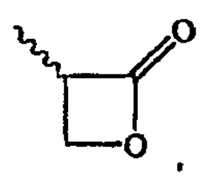
Protected lactone alcohols **46** can be prepared from compounds of the formula **43**, **44**, or **45** by using well-known condensation reactions and variations of the Michael reaction. Methods for the synthesis of lactones are disclosed in Multzer in *Comprehensive Organic Functional Group Transformations*, A.R. Katritzky, O. Meth-Cohn and C.W. Rees, Eds. Pergamon: Oxford, 1995, vol 5, pp. 161-173. Mono- protected diols **43**, electrophilic protected alcohols **44**, and aldehydes **45** are readily available either commercially (e.g., Aldrich Chemical Co., Milwaukee, WI) or can be prepared by well known synthetic procedures.

When $W^{(1)(2)}$ is a beta-lactone group of the formula:



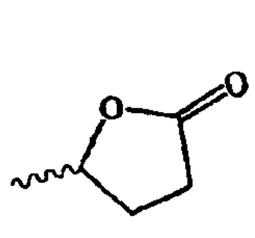
3-beta-lactone

or



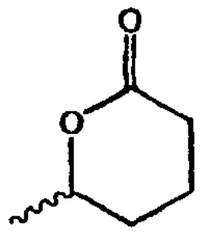
4-beta-lactone

protected lactone alcohols **46** can be prepared from aldehydes **45** and electrophilic protected alcohols **44**, respectively, by a one-pot-addition-lactonization according to the procedure of Masamune *et al.*, 1976, *J. Am. Chem. Soc.* 98:7874 and Danheiser *et al.*, 1991, *J. Org. Chem.* 56:1176. This one-pot-addition-lactonization methodology has been reviewed by Multzer in *Comprehensive Organic Functional Group Transformations*, A.R. Katritzky, O. Meth-Cohn and C.W. Rees, Eds. Pergamon: Oxford, 1995, vol 5, pp. 161. When $W^{(1)(2)}$ is a gamma- or delta-lactone group of the formula:



gamma-lactone

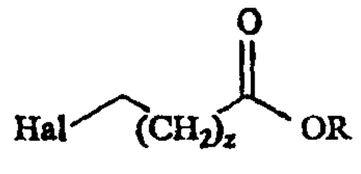
or



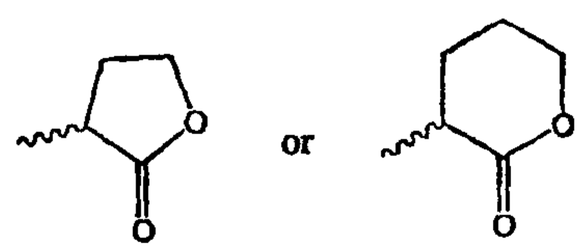
delta-lactone

protected lactone alcohols **46** can be prepared from aldehydes **45** according to well known synthetic methodology. For example, the methodology described in Masuyama *et al.*, 2000, *J. Org. Chem.* 65:494; Eisch *et al.*, 1978, *J. Organomet. Chem. C8* 160; Eaton *et al.*, 1947, *J. Org. Chem.* 37:1947; Yunker *et al.*, 1978, *Tetrahedron Lett.* 4651; Bhanot *et al.*, 1977, *J. Org. Chem.* 42:1623; Ehlinger *et al.*, 1980, *J. Am. Chem. Soc.* 102:5004; and Raunio *et al.*,

1957, *J. Org. Chem.* 22:570. For instance, as described in Masuyama *et al.*, 2000, *J. Org. Chem.* 65:494, aldehydes **45** can be treated with about 1 equivalent of a strong organometallic base, preferably with a pK_a of about 25 or more, more preferably with a pK_a of greater than about 35, in a suitable organic solvent to give a reaction mixture. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*–butyllithium, *tert*–butyllithium, *sec*–butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride, preferably lithium tetramethylpiperidide. Suitable solvents include, but are not limited to, diethyl ether and tetrahydrofuran. The reaction-mixture temperature is adjusted to within the range of about 0°C to about 100°C, preferably about room temperature to about 50°C, and a halide of the formula:



wherein z is 1 or 2 (diluted with a solvent or in undiluted form) is added. The reaction mixture is stirred for a period of about 2 hours to about 48 hours, preferably about 5 to about 10 hours, during which time the reaction's progress can be followed by using an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography. When the reaction is deemed substantially complete, protected lactone alcohols **46** can be isolated by workup and purified if desired. When $W^{(1)(2)}$ is a gamma- or delta-lactone group of the formula:

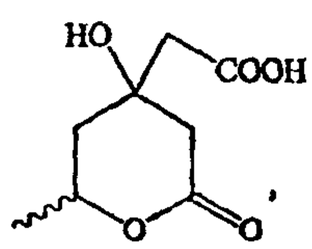


gamma-lactone delta-lactone

protected lactone alcohols **46** can be synthesized by deprotonating the corresponding lactone with a strong base providing the lactone enolate and reacting the enolate with

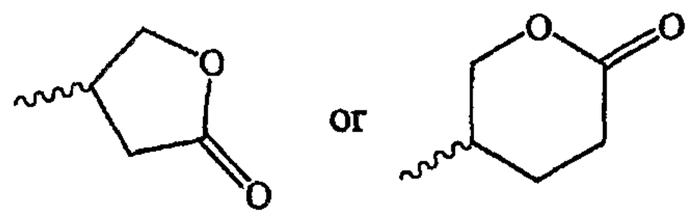
electrophilic protected alcohols **44** (for a detailed discussion of enolate formation of active methylene compounds such as lactones, see House *Modern Synthetic Reactions*; W. A. Benjamin, Inc. Philippines 1972 pp. 492-570, and for a discussion of reaction of lactone enolates with electrophiles such as carbonyl compounds, see March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 944-945).

Lactone-enolate formation can be accomplished by adding about 1 equivalent of a strong organometallic base, preferably with a pK_a of about 25 or more, more preferably with a pK_a of greater than about 35, to a mixture comprising a suitable organic solvent and the lactone. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*–butyllithium, *tert*–butyllithium, *sec*–butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride, preferably lithium tetramethylpiperidide. Solvents suitable for lactone-enolate formation include, but are not limited to, diethyl ether and tetrahydrofuran. After enolate formation, the reaction-mixture temperature is adjusted to within the range of about –78°C to about room temperature, preferably about –50°C to about 0°C, and electrophilic protected alcohols **44** (diluted with a solvent or in undiluted form) are added, preferably at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. The reaction mixture is stirred for a period of about 15 minutes to about 5 hours, during which time the reaction's progress can be followed by using an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography. When the reaction is deemed substantially complete, protected lactone alcohols **46** can be isolated by workup and purified if desired. When $W^{(1)(2)}$ is a lactone group group of the formula:



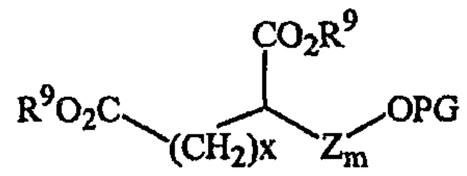
protected lactone alcohols **46** can be prepared from aldehydes **45** according to the procedure described in United States Patent No. 4,622,338.

When $W^{(1)(2)}$ is a gamma- or delta-lactone group of the formula:



gamma-lactone or delta-lactone

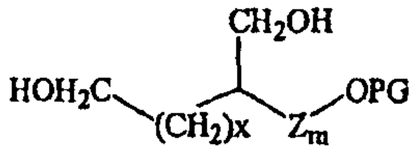
protected lactone alcohols **46** can be prepared according to a three step sequence. The first step comprises base-mediated reaction of electrophilic protected alcohols **44** with succinic acid esters (*i.e.*, $R^9O_2CCH_2CH_2CO_2R^9$, wherein R^9 is alkyl) or glutaric acid esters (*i.e.*, $R^9O_2CCH_2CH_2CH_2CO_2R^9$, wherein R^9 is alkyl) providing a diester intermediate of the formula **44i**:



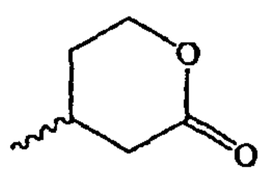
44i

wherein x is 1 or 2 depending on whether the gamma or delta lactone group is desired. The reaction can be performed by adding about 1 equivalent of a strong organometallic base, preferably with a pK_a of about 25 or more, more preferably with a pK_a of greater than about 35, to a mixture comprising a suitable organic solvent and the succinic or glutaric acid ester. Suitable bases include, but are not limited to, alkylmetal bases such as methyllithium, *n*–butyllithium, *tert*–butyllithium, *sec*–butyllithium, phenyllithium, phenyl sodium, and phenyl potassium; metal amide bases such as lithium amide, sodium amide, potassium amide, lithium tetramethylpiperidide, lithium diisopropylamide, lithium diethylamide, lithium dicyclohexylamide, sodium hexamethyldisilazide, and lithium hexamethyldisilazide; and hydride bases such as sodium hydride and potassium hydride, preferably lithium tetramethylpiperidide. Suitable solvents include, but are not limited to, diethyl ether and tetrahydrofuran. After enolate formation, the reaction-mixture temperature is adjusted to within the range of about –78°C to about room temperature, preferably about –50°C to about 0°C, and electrophilic protected alcohols **44** (diluted with a solvent or in undiluted form) are added, preferably at a rate such that the reaction-mixture temperature remains within about one to two degrees of the initial reaction-mixture temperature. The reaction mixture is stirred for a period of about 15 minutes to about 5 hours, during which time the reaction's

progress can be followed by using an appropriate analytical technique, such as thin layer chromatography or high performance liquid chromatography. When the reaction is deemed substantially complete, the diester intermediate can be isolated by work-up and purified if desired. In the second step, the intermediate diester can be reduced, with a hydride reducing agent, to yield a diol:

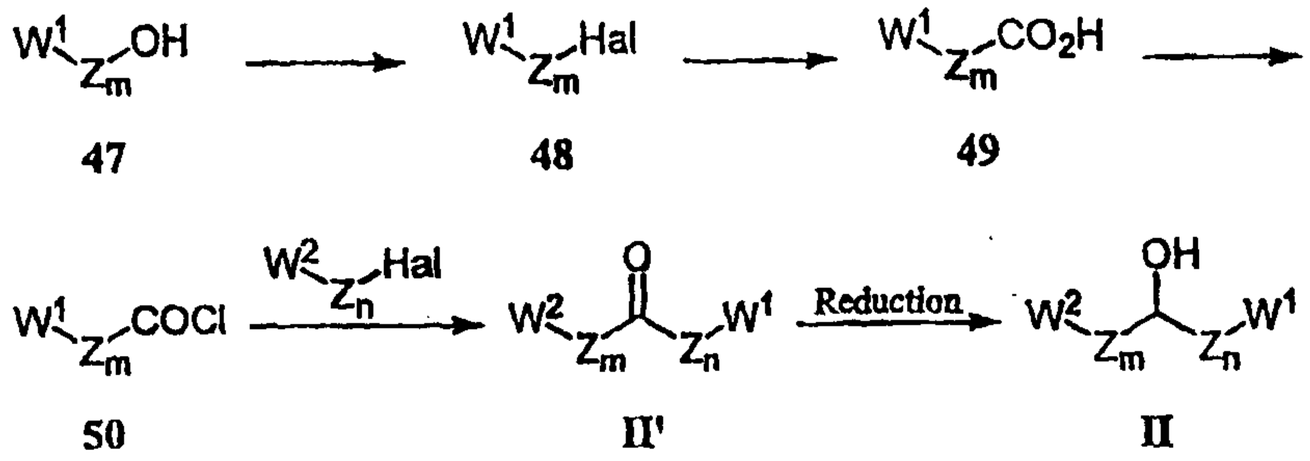


The reduction can be performed according to the procedures referenced in March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, p. 1214). Suitable reducing agents include, but are not limited to, lithium aluminum hydride, diisobutylaluminum hydride, sodium borohydride, and lithium borohydride). In the third step, the diol can be oxidatively cyclized with $RuH_2(PPh_3)_4$ to the product protected lactone alcohols **46** according to the procedure of Yoshikawa *et al.*, 1986, *J.Org. Chem.* 51:2034 and Yoshikawa *et al.*, 1983, *Tetrahedron Lett.* 26:2677. When $W^{(1)(2)}$ is a lactone group of the formula:



protected lactone alcohols **46** can be synthesized by reacting the Grignard salts of electrophilic protected alcohols **44**, where E is a halide, with 5,6-dihydro-2*H*-pyran-2-one, commercially available (*e.g.*, Aldrich Chemical Co., Milwaukee, Wisconsin), in the presence of catalytic amounts of a 1-dimethylaminoacetyl)pyrolidine-2yl)methyl-diarylphosphine-copper (I) iodide complex as described in Tomioka *et al.*, 1995, *Tetrahedron Lett.* 36:4275.

Scheme 12: Synthesis of Compounds of Formula II

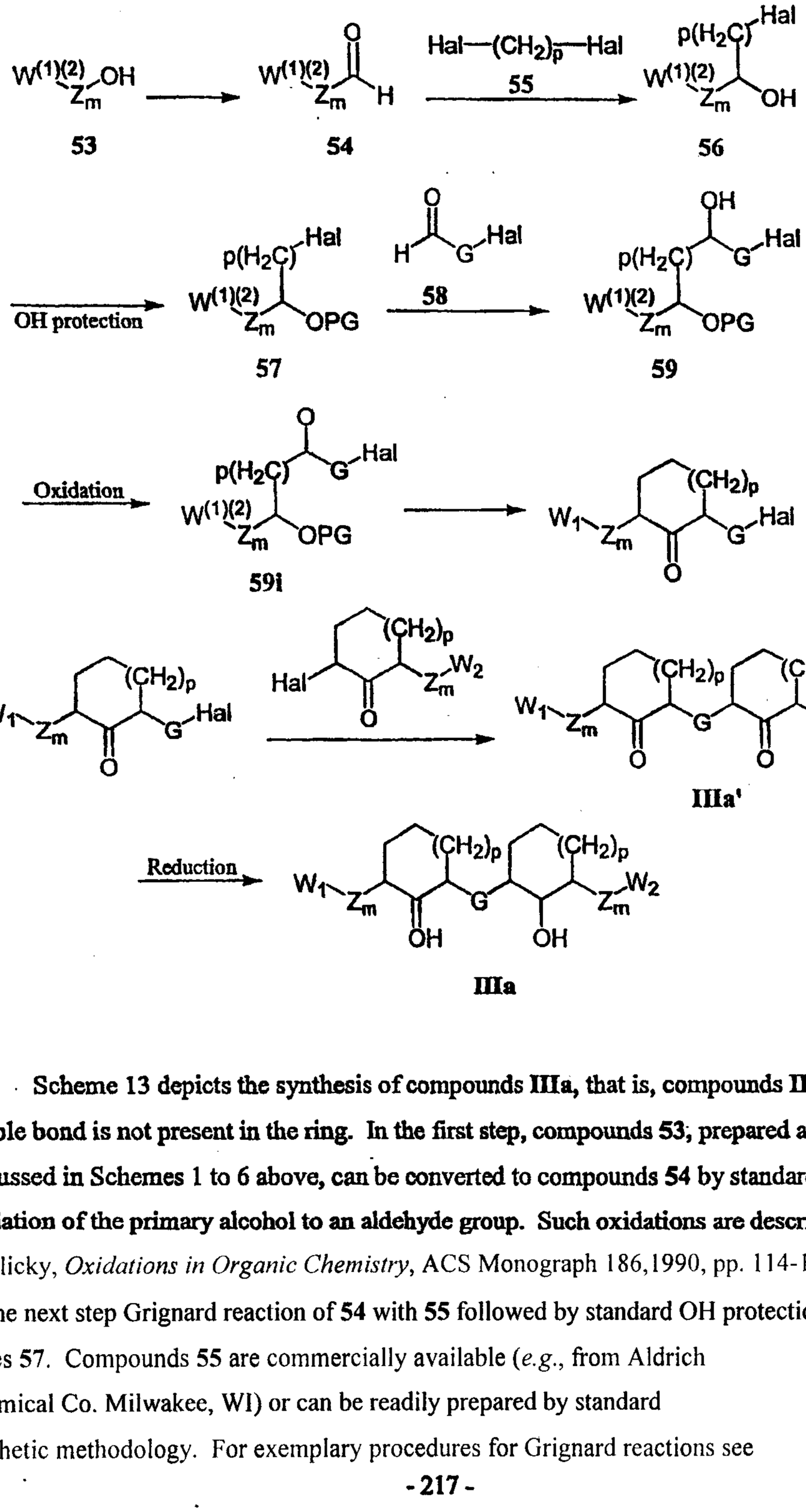


50 **II'** **II**

Scheme 12 illustrates the synthesis of alcohol II. The alcohol 47 is intiallly converted to a halogen 48. *See* Larock, *Comprehensive Organic Transformations*, VCH: New York, 1989, pp. 360-362. The halide **48** is then converted to a carboxylic acid **49** with subsequent conversion to a acyl halide **50**. *See* Larock, *Comprehensive Organic Transformations*, VCH: New York, 1989, pp. 850-851 ,855-856, 859-860, 977, 980, and 985. The acyl halide **50** is then coupled with the halide to afford compound **II'**. *See* Rappoport, *The Chemistry of the Functional Groups, Supp. D*, pt. 2; Wiley: New York, 1983; House, *Modern Synthetic Reactions*, 2nd Ed. Benjamin: New York, 1972, pp. 691-694, 734-765. Finally, compounds **II'** are reduced using methods known to those of ordinary skill in the art to afford alcohol **II**. *See* Larock, *Comprehensive Organic Transformations*; VCH: New York, 1989.

In a typical procedure, the ketone **II'** is dissolved in an organic solvent such as, but not limited to, toluene, xylene, diethyl ether, t-butyl methyl ether, diglyme, methanol, ethanol, dichloromethane, chloroform, dichloroethane, preferably diethyl ether, and it is then treated with a reducing agent such as, but not limited to, lithium aluminum hydride, sodium borohydride, lithium borohydride, preferably sodium borohydride. When the reaction is complete, as determined by an analytical method such as HPLC, gas chromatography, thin layer chromatography, or NMR, the mixture is subjected to work-up. The compound thus obtained can be purified by various purification methods known in the field, such as chromatography or recrystallization. It is readily recognized that the alcohol compound **II** can exist as enantiomers. Separation of the stereoisomers (*i.e.*, enantiomers) can be achieved by methods known in the art, for example, conversion to a chiral salt and crystallization, chiral chromatography, or chiral HPLC.

Scheme 13: Synthesis of Compounds III



Scheme 13 depicts the synthesis of compounds **IIIa**, that is, compounds **III** where a double bond is not present in the ring. In the first step, compounds **53**, prepared as discussed in Schemes 1 to 6 above, can be converted to compounds **54** by standard oxidation of the primary alcohol to an aldehyde group. Such oxidations are described in M. Hudlicky, *Oxidations in Organic Chemistry*, ACS Monograph 186,1990, pp. 114-127. In the next step Grignard reaction of **54** with **55** followed by standard OH protection gives **57**. Compounds **55** are commercially available (*e.g.*, from Aldrich Chemical Co. Milwakee, WI) or can be readily prepared by standard synthetic methodology. For exemplary procedures for Grignard reactions see

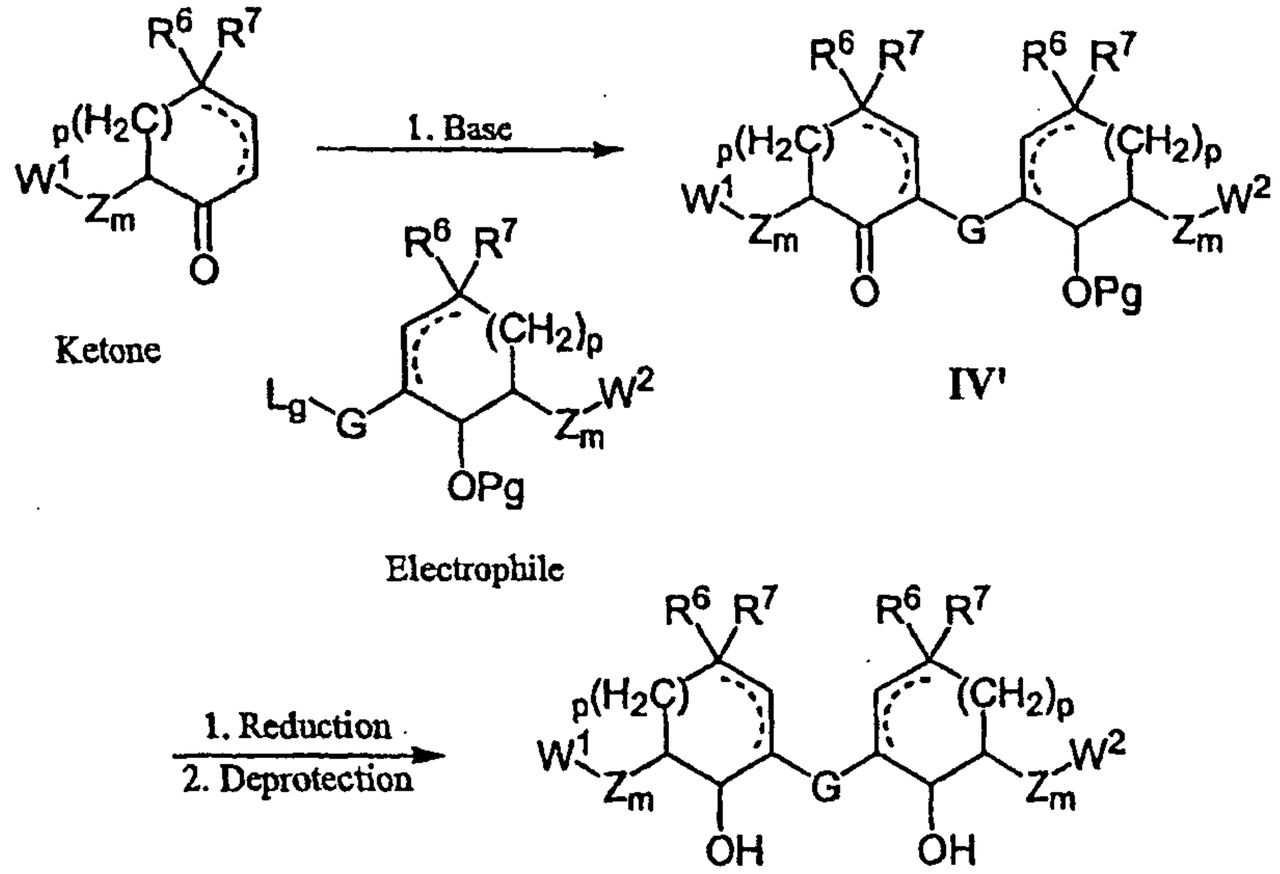
March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 920-929. Similarly, in the next step, the Grignard salt of **57** is condensed with **58** to provide **59**. Next **59** is oxidized and then cyclized to **60**. When p is one, exemplary cyclization procedures are found in Friedrichsen, W. in *Comprehensive Heterocyclic Chemistry II*; Katritzky, A.R.; Rees, W.C.; Scriven, E. F. V. Eds.; Pergamon Press: Oxford, 1996; Vol.2, p 351, and *Comprehensive Heterocyclic Chemistry*; Katritzky, A. R.; Rees, W. C. Eds.; Pergamon Press: Oxford, 1986; Vol.3. When p is 0, cyclization procedures are found in Hepworth, J. D. in *Comprehensive Heterocyclic Chemistry II*; Katritzky, A. R.; Rees, W. C.; Scriven, E. F. V. Eds.; Pergamon Press: Oxford, 1996; Vol.5, p 351 and *Comprehensive Heterocyclic Chemistry*; Katritzky, A.R.; Rees, W.C. Eds.; Pergamon Press: Oxford, 1986; Vol. 3.

The hydroxy ketone is subjected to cyclization, as described in the above Hepworth, J. D. in *Comprehensive Heterocyclic Chemistry II*; Katritzky, A. R.; Rees, W. C.; Scriven, E. F. V. Eds.; Pergamon Press: Oxford, 1996; Vol.5, p 386. For compounds **III** where $W^{(1)(2)}$ is $HO(CH_2)_n$-R^1R^2: The hydroxy group is first deprotected as described in Greene, T.W., *Protective Groups in Organic Synthesis*, 3rd edition (1999). For other structures, where Y is a group such as an acid, aldehydes, *etc.*, protection is needed (acids as esters, preferably pivaloyl, aldehydes as silyl derivatives such as TIPS, stable in both basic and acidic conditions). When $W^{(1)(2)}$ is a lactone it can be introduced as discussed in Scheme 3 above. The compounds are then coupled to afford compound of the formula **IIIa**.

The reactions are performed under similar conditions for substituted cyclic compounds. After the formation of the monocyclic compounds, they are reacted *in situ* with electrophiles (*e.g.*, MeI) at temperatures between –40 °C to +60 °C, for a reaction time of 1 hr to 5 days. In addition, double bonds can be selectively added or reduced or otherwise manipulated by well known synthetic methods to give compounds **III** having one or two selectively-placed double bonds (*i.e.*, the double bond(s) can be positioned in the desired location within the ring), for example, the methods disclosed in March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 771-780. Finally, compounds **IIIa** are reduced using methods known to those of ordinary skill in the art to afford alcohol **IIIa**. *See Comprehensive Organic Transformations*; VCH: New York, 1989. It is readily recognized that the alcohol compound **IIIa** is stereoisomeric and can therefore exist as enantiomers and diastereomer. Separation of the stereoisomers (*i.e.*, enantiomers or diastereomers) can be achieved by

methods known in the art, for example, conversion to a chiral salt and crystallization, chiral chromatography, or chiral HPLC.

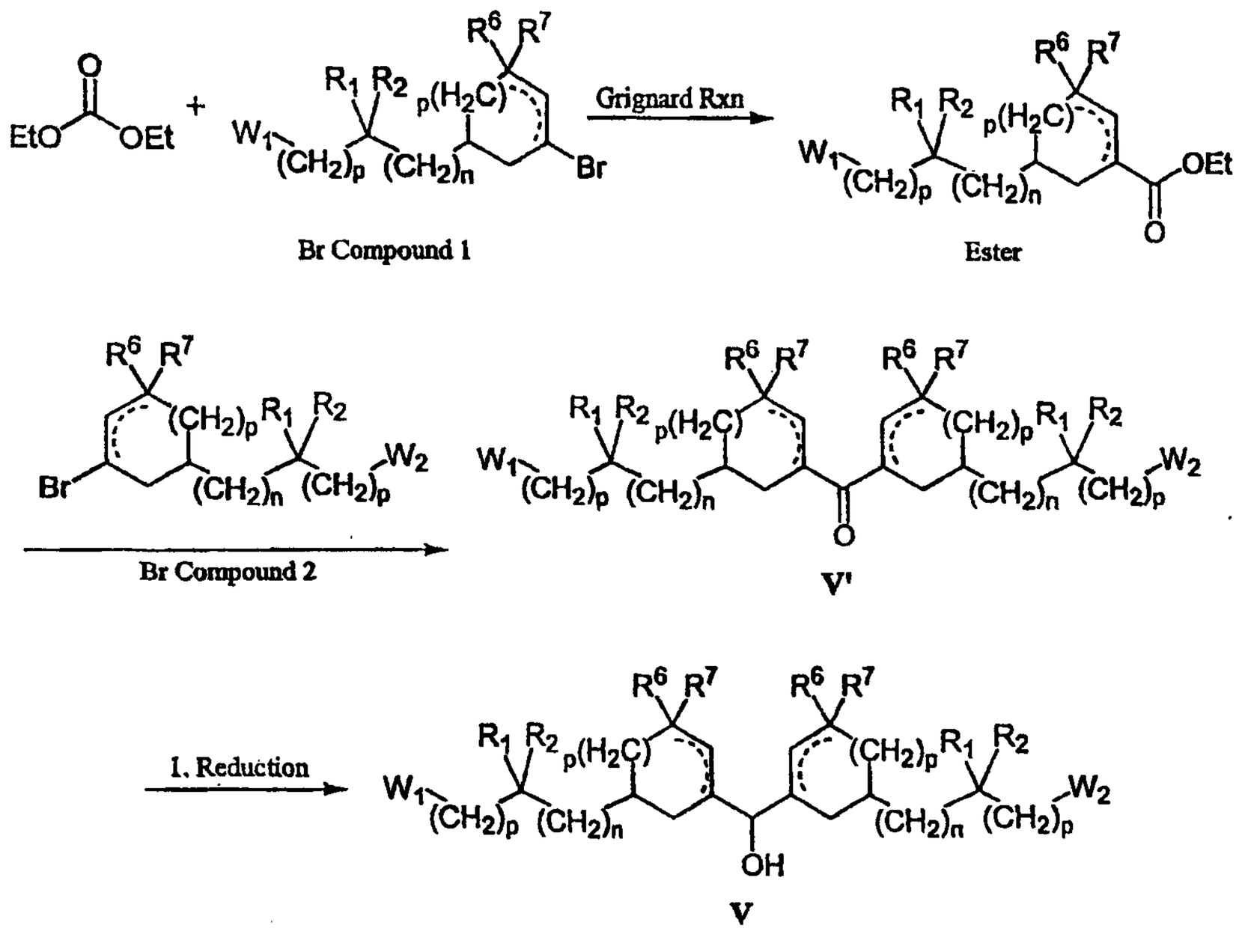
Scheme 14: Synthesis of Compounds IV



Scheme 14 depicts the synthesis of compounds **IV**. In the first step, ketone compounds can be converted to compounds **IV'** by treating with a strong base (*e.g.*, LiHMDS, LDA) to generate the kinetic enolate followed by addition of the electrophile. In the next step, the ketone moiety of compound **IV'** is reduced using standard methods known to those of ordinary skill in the art. For exemplary procedures for Grignard reaction see March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992. *See also Comprehensive Heterocyclic Chemistry II*; Katritzky, A.R.; Rees, W.C.; Scriven, E.F.V. Eds.; Pergamon Press: Oxford, 1996; Vol. 2, and *Comprehensive Heterocyclic Chemistry*; Katritzky, A.R.; Rees, W.C. Eds.; Pergamon Press: Oxford, 1986 ; Vol. 3. Press: Oxford, 1996; Vol. 5.

It is readily recognized that the diol compound **IV** is stereoisomeric and can therefore exist as enantiomers and diastereomers. Separation of the stereoisomers (*i.e.*, enantiomers or diastereomers) can be achieved by methods known in the art, for example, conversion to a chiral salt and crystallization, chiral chromatography, or chiral HPLC.

Scheme 15: Synthesis of Compounds V

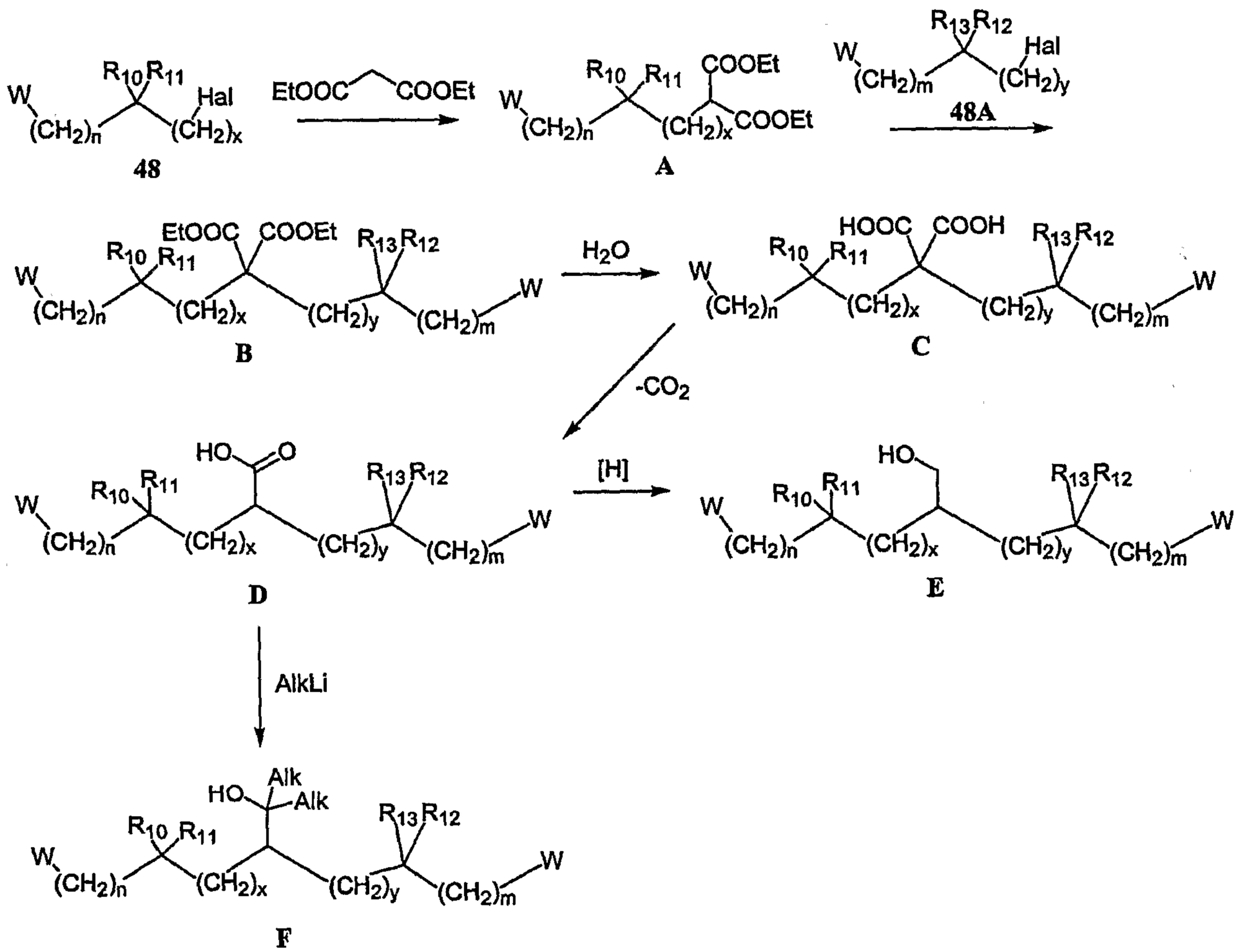


Scheme 15 depicts the synthesis of compounds IV. In the first step, compounds of the type Br-compound 1, undergoes a Grignard reaction with diethylorthoformate to give the ester compound. For exemplary procedures for Grignard reaction see March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, pp. 920-929. Similarly, in the next step, the Grignard salt of Br-compound 2 is condensed with the ester compound to provide ketone V'.

The ketone is then reduced under standard conditions known in the art to afford compound V, for example, the methods disclosed in *Organikum, Organisch-Chemisches Grundpraktikum*, VEB Deutscher Verlag der Wissenschaften, Berlin, 1984, p. 616; March, J. *Advanced Organic Chemistry; Reactions Mechanisms, and Structure*, 4th ed., 1992, and Larock *Comprehensive Organic Transformations*; VCH: New York, 1989. It is readily recognized that the alcohol compound is stereoisomeric and can therefore exist as enantiomers and diastereomer. Separation of the stereoisomers (*i.e.*, enantiomers or diastereomers) can be achieved by methods known in the

art, for example, conversion to a chiral salt and crystallization, chiral chromatography, or chiral HPLC. In a typical procedure, the alcohol compounds are dissolved in the appropriate solvent, such as methanol, ethanol, isopropanol, preferably isopropanol, and is treated with a reducing agent, preferably sodium borohydride at temperatures between about -20 °C and solvent reflux, preferably at about -5 °C to about 10 °C. When the reaction is considered complete by an analytical method such as HPLC, GC, TLC, or NMR, the reaction is subject to work-up known in the art.

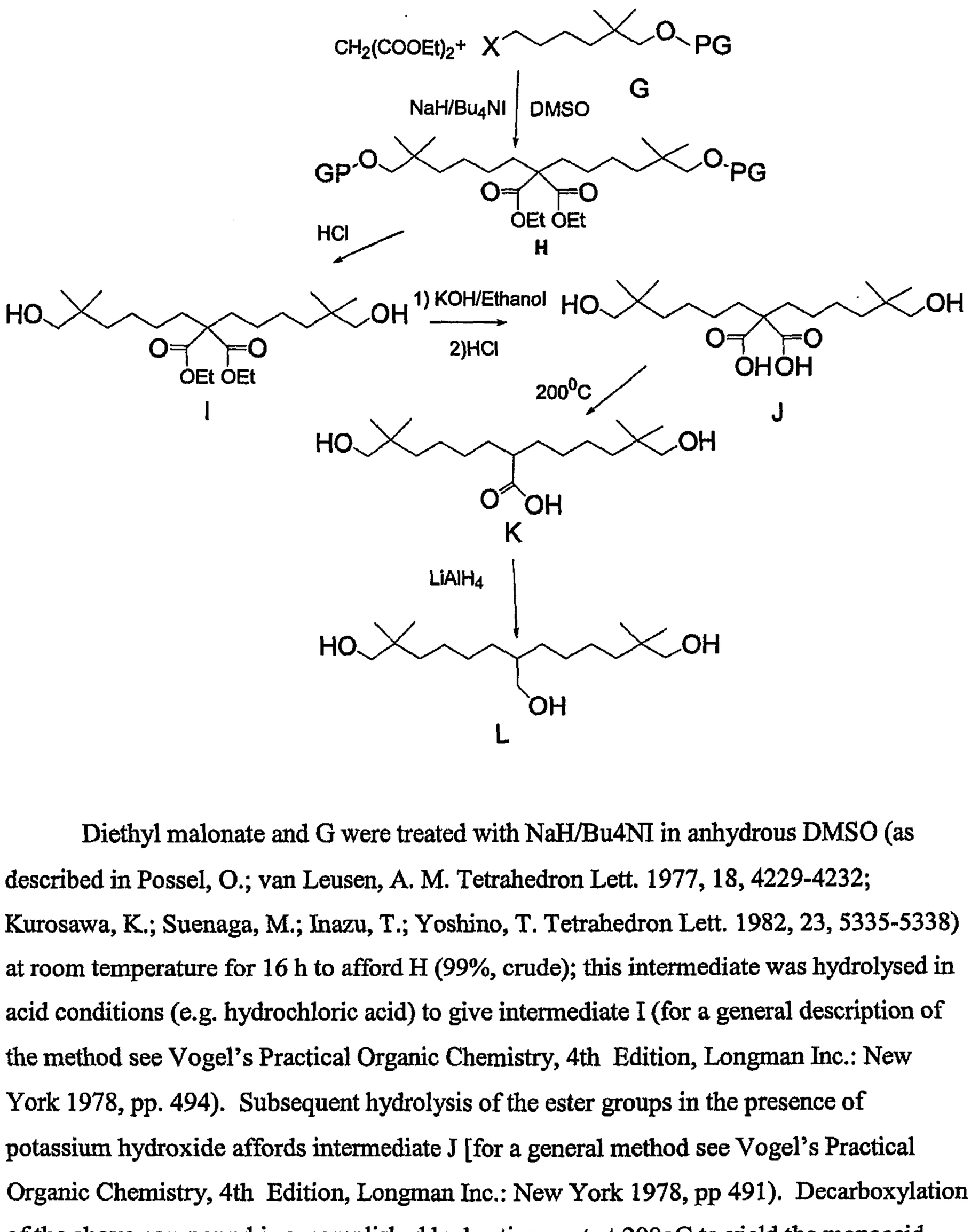
Scheme 16



Halides **48** (prepared as described in Dasseux and Oniciu, US 6,410,802, 2002) are treated with diethyl malonate anion (obtained from diethyl malonate and a dehydration agent such as sodium hydride, sodium or potassium methoxide, ethoxide or t-butoxide) in an anhydrous solvent such as DMSO, alcohol (methanol, ethanol or t-butanol) or a hydrocarbon (heptane, xylene, toluene) or an ether (THF, diethyl ether), preferably sodium hydride in DMSO, at room temperature or at temperatures up to the reflux of the solvent,

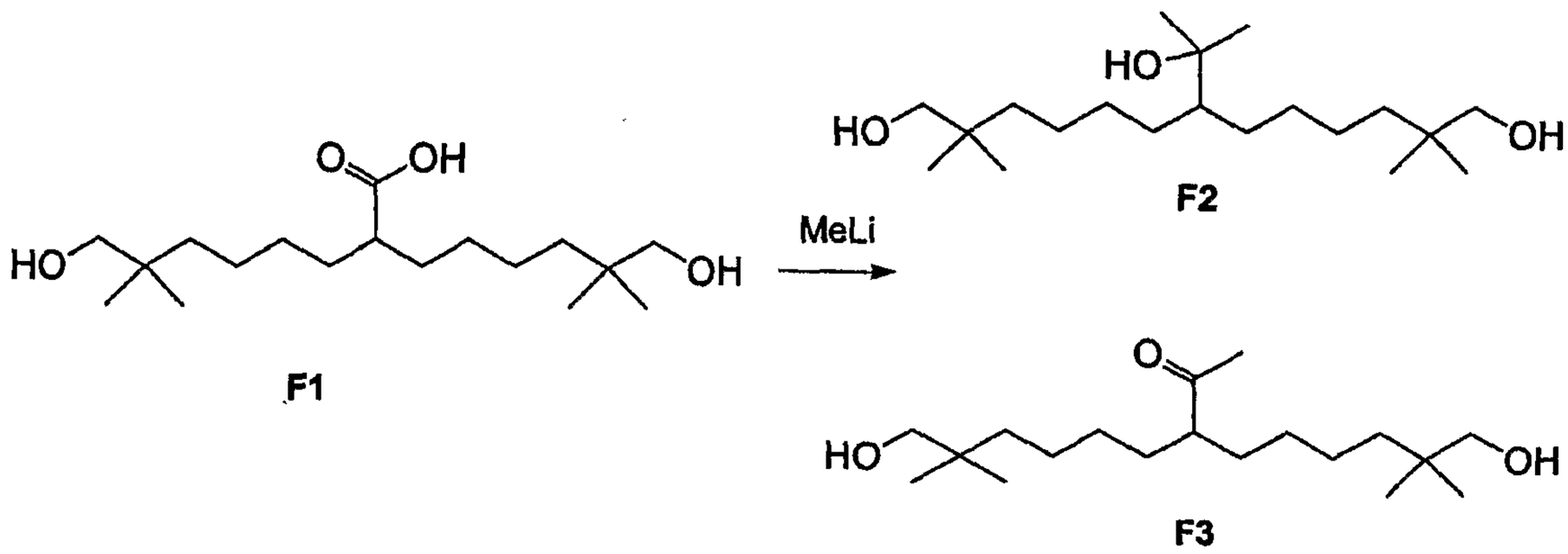
for two hours up to 72 hours. The reaction is monitored by usual analytical methods such as tlc, GC and HPLC, and it is stopped when no significant change of the reaction mixture is seen by one of these methods. The reaction is performed sequentially when an unsymmetrical derivative is desired. Intermediates of type **A** are prepared as described above by using 1 to 1.2 equivalents of dehydrating agent and halide **48**; in order to afford compounds of type **B**, when this reaction is deemed complete by one of the analytical methods mentioned above, a second mole of dehydrating agent is added followed by 1 to 1.2 equivalents of the second halide **48A**. This type of compounds may be purified by column chromatography or by HPLC, or use as crude in the next step. The ester moieties in intermediate **B** thus obtained are hydrolysed by usual methods such as basic hydrolysis, to afford diacids of type **C** that could be either purified by usual methods, e.g. column chromatography or preparative HPLC, or decarboxilated as crude. The decarboxilation is performed either neat at temperatures from 150 to 220 °C, or in a solvent. Monoacid **D** thus obtained is finally reduced more commonly with metals and proton donors or with reducing agents such as lithium aluminum hydride in ether or tetrahydrofuran to give the desired compounds of type **E**. Symmetrical derivatives may be prepared similarly, by using 2.2 to 3 equivalents halide **48**, when intermediate **B** is formed directly. If intermediate **D** is treated with an alkyl lithium alcohol **F** is then obtained.

Scheme 17: Synthesis of 7-hydroxymethyl-2,2,12,12-tetramethyl-tridecane-1,13-diol



Diethyl malonate and G were treated with NaH/Bu4NI in anhydrous DMSO (as described in Possel, O.; van Leusen, A. M. Tetrahedron Lett. 1977, 18, 4229-4232; Kurosawa, K.; Suenaga, M.; Inazu, T.; Yoshino, T. Tetrahedron Lett. 1982, 23, 5335-5338) at room temperature for 16 h to afford H (99%, crude); this intermediate was hydrolysed in acid conditions (e.g. hydrochloric acid) to give intermediate I (for a general description of the method see Vogel's Practical Organic Chemistry, 4th Edition, Longman Inc.: New York 1978, pp. 494). Subsequent hydrolysis of the ester groups in the presence of potassium hydroxide affords intermediate J [for a general method see Vogel's Practical Organic Chemistry, 4th Edition, Longman Inc.: New York 1978, pp 491). Decarboxylation of the above compound is accomplished by heating neat at 200oC to yield the monoacid intermediate K that is reduced by LiAlH4 in tetrahydrofuran to the target compound L.

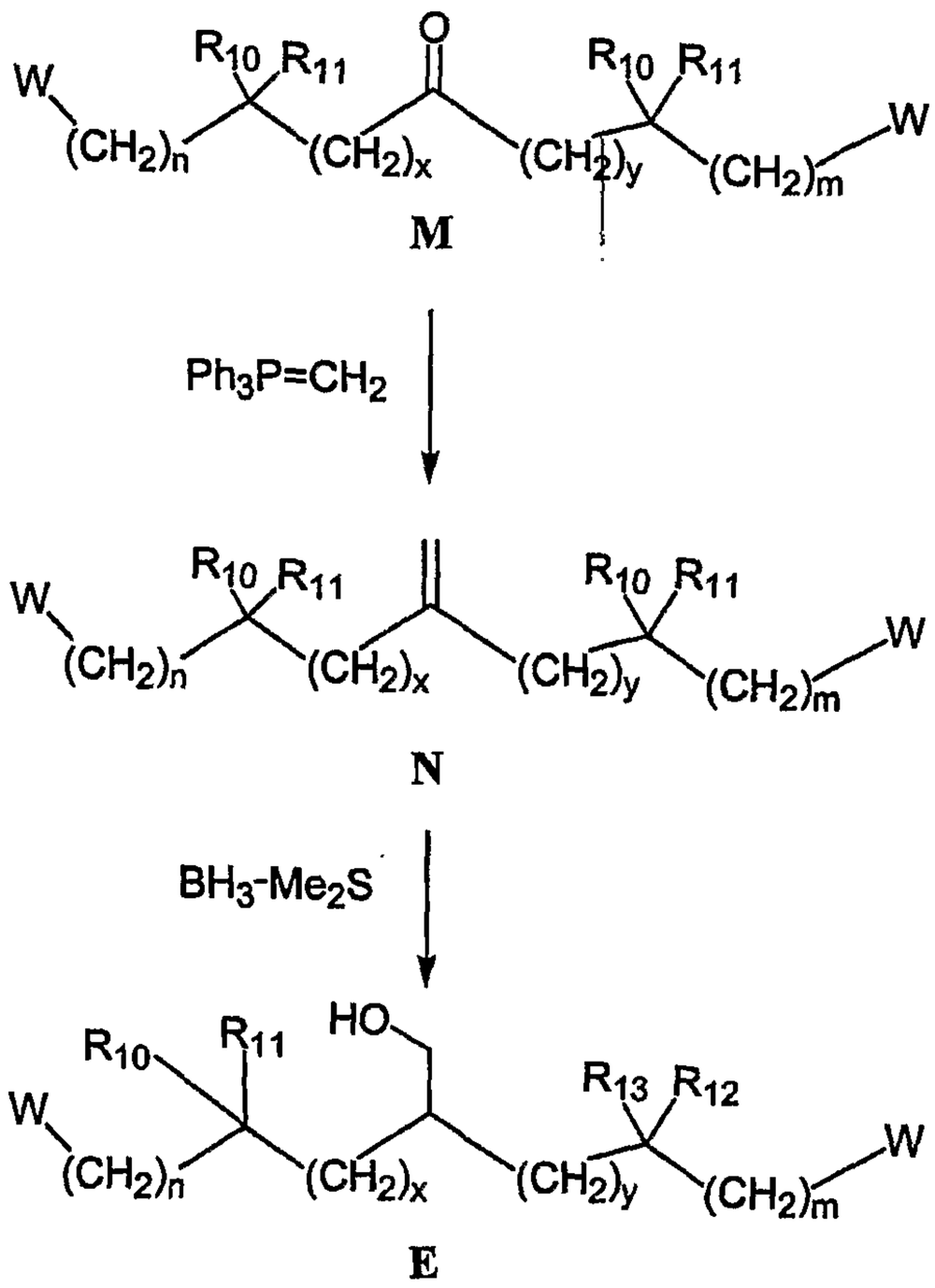
Scheme 18



The intermediate **F1** synthesized as described above was reacted with methyl lithium to give 7-(1-hydroxy-1-methyl-ethyl)-2,2,12,12-tetramethyl-tridecane-1,13-diol (**F2**) together with **F3.** The two compounds were separated by column chromatography.

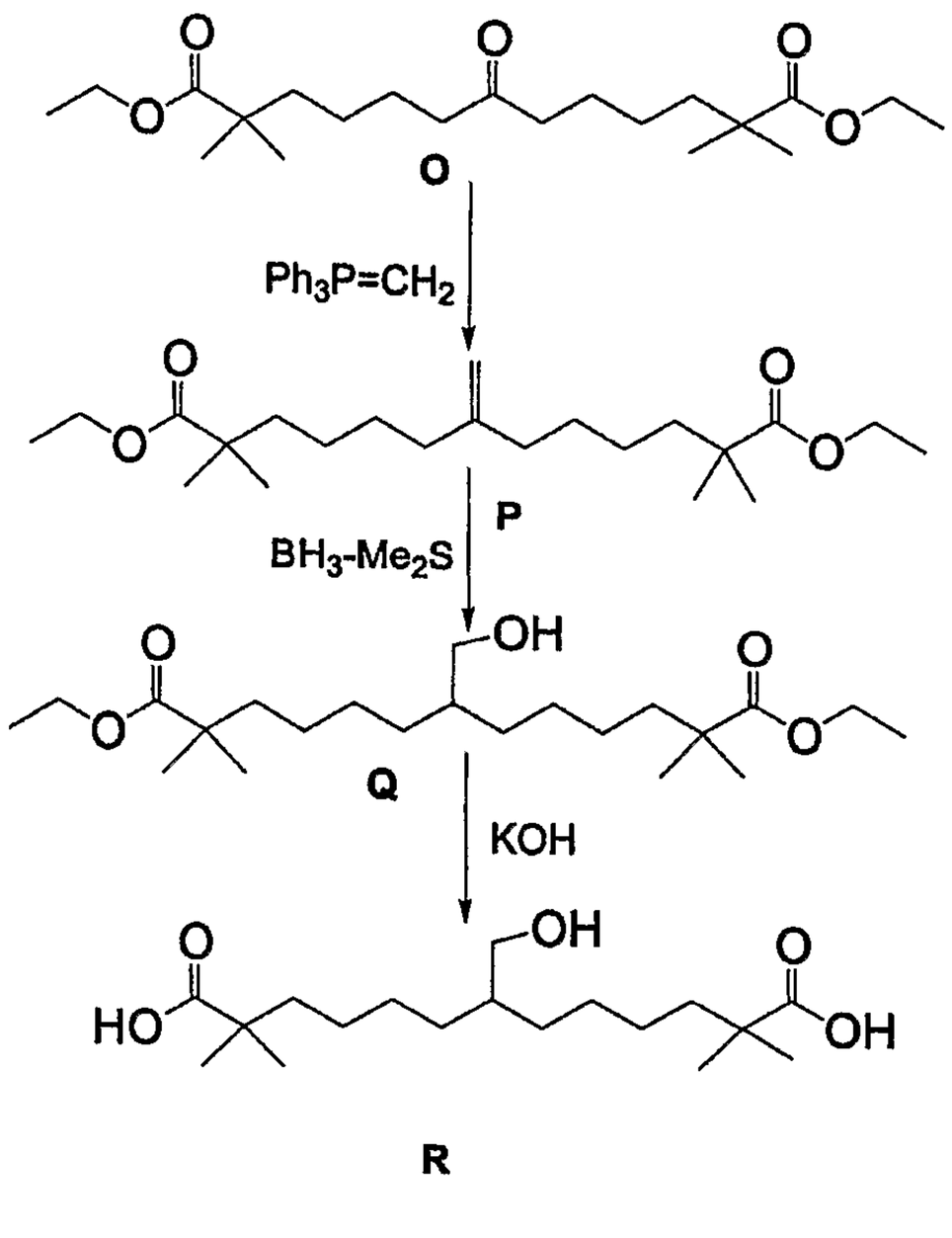
Compounds of type **E** are also obtained as described in Scheme 19 by treating the ketones of type **M** with a Wittig reagent, followed by an anti-Markovnikov addition of water to the marginal double bond thus created or by hydroboration with a Brown reagent.

Scheme 19



Scheme 20 presents an example for the above method in the synthesis of 7-hydroxymethyl-2,2,12,12-tetramethyl-tridecanedioic acid (**R**).

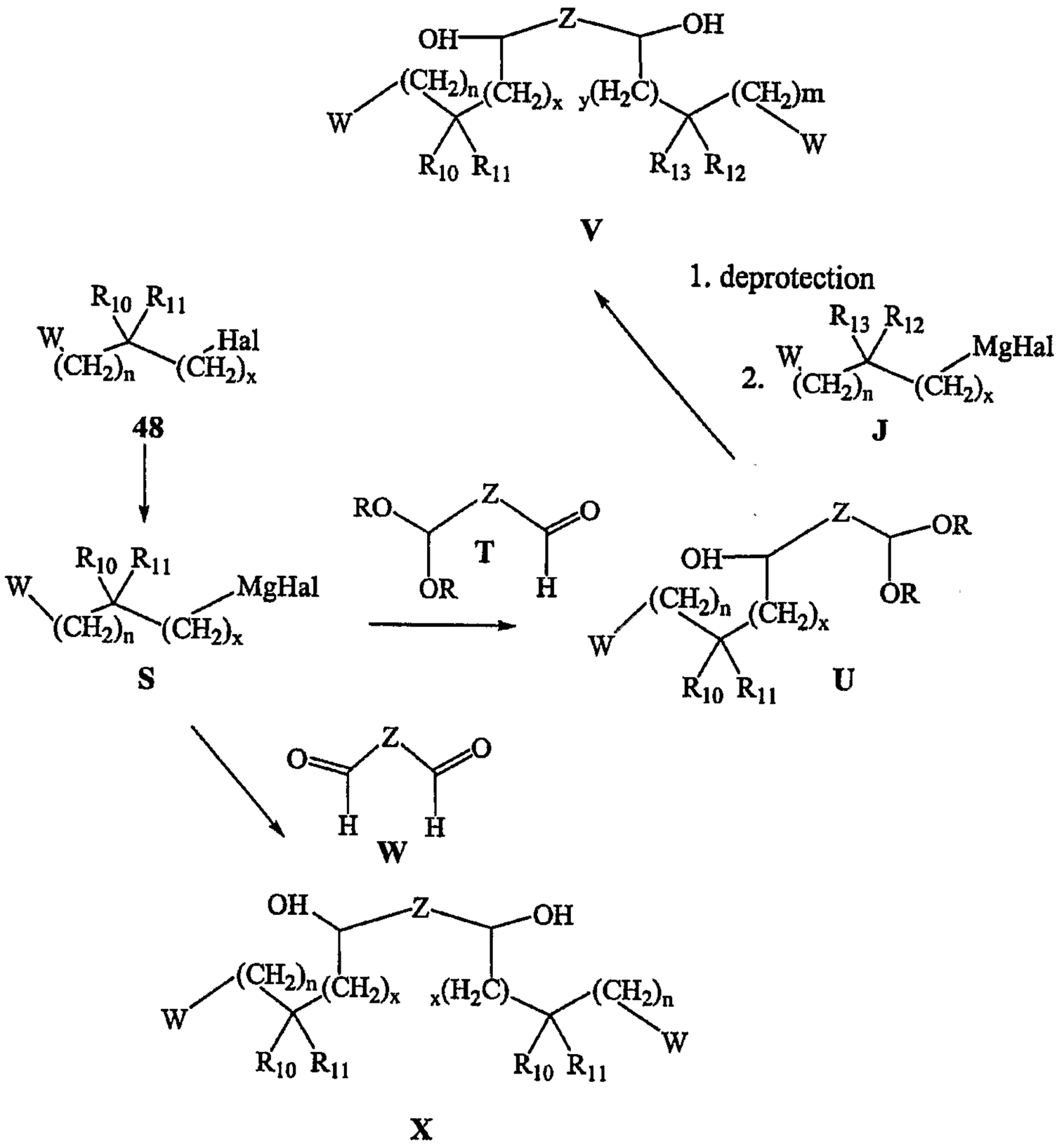
Scheme 20



2,2,12,12-Tetramethyl-7-oxo-tridecanedioic acid diethyl ester **O** (Dasseux and Oniciu, US Pat. Appl. 09/976,938, October 11, 2001was treated with Wittig reagent (methyltriphenylphosphonium iodide and phenyllithium) [Leopold, E. J. Organic Syntheses Collective Volume VII, Wiley: New York 1986, pp 258.] to produce **P**. Compound Q was prepared by treatment of compound **P** with BH_3-Me_2S [Dalko, P.I.; Langlois, Y. J.Org. Chem. 1998, 63, 8107]. Other selective hydroboration method for the preparation of primary alcohol **Q** is performed by treating the alkene with disiamylborane (prepared from diborane and 2-methyl-2-butene in THF at -30 °C) in THF, as reported in Leopold, E. J. Organic Syntheses Collective Volume VII, Wiley: New York 1986, pp 258. Hydrolysis of **Q** by treatment with KOH in ethanol gave the final compound **R** [Vogel's Practical Organic Chemistry, 4th Edition, Longman Inc.: New York 1978, pp 492].

Scheme 21 refers to the synthesis of diols of type **V** (unsymmetrical) and **X** (symmetrical).

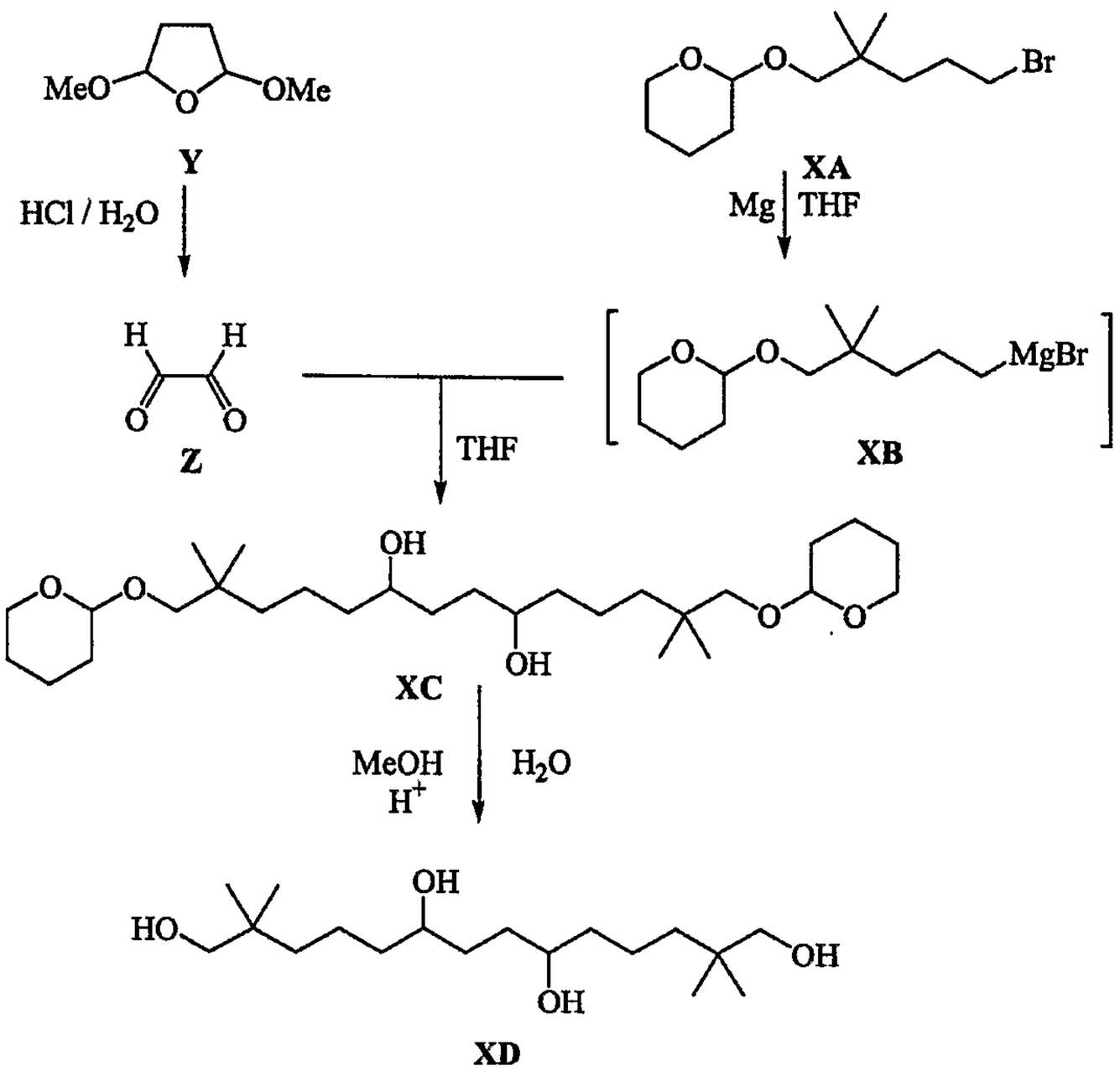
Scheme 21



Grignard reagents obtained from halides **48** are treated with an aldehyde in conditions well-known for reactions of organo magnesium derivatives. Aldehydes **T** and **W** are commercially available (e.g. Aldrich) or can be obtained by methods described in the literature. The reaction could be performed sequentially to give the non-symmetrical derivatives of type **V**, with the formation of the intermediate of type **U**, followed by deprotection of the second aldehyde moiety. Treatment with a second mole of Grignard reagent **S** of the deprotected intermediate of type **U** affords the final compound **V**. If 2 equiv of Grignard reagent are used in the reaction with an aldehyde of type **W**, the symmetrical diol of type **X** is obtained.

Scheme 22 describes the synthesis of 2,2,13,13-tetramethyltetradecan- 1,6,9,14-tetraol (**XD**).

Scheme 22



THP-protected bromo alcohol **XA** was converted into the corresponding Grignard reagent **XB** following the standard procedure (Vogel, A. I. "Vogel's Textbook of Practical Organic Chemistry", 5th Edition, Longman, England, 1989, p.535). Further coupling of this Grignard reagent in situ with succinic dialdehyde **Z** prepared by acid-catalyzed ring-opening of commercially available 2,5-dimethoxytetrahydrofuran **Y** (Fakstorp, J.; Raleigh, D.; Schniepp, L. E. J. Am. Chem. Soc., 1950, 72, 869, House, H. O.; Cronin, T. H. J. Org. Chem., 1965, 30, 1061) at 0 to 5 °C occurs smoothly to give the bis(THP-protected) tetraol **XC** in high yield (92% after flash column chromatography purification). Acidic hydrolysis of **XC** in methanol / aqueous H_2SO_4 was completed in two hours to afford tetraol **XD**. The product is insoluble in dichloromethane and diethyl ether and could be purified by washing with one of these solvents. It is also practically insoluble in chloroform, acetone, acetonitrile, or water, and all can be used for further purifications.

Scheme 23 illustrates the synthesis of cycloalkyl-hydroxyl compounds of the formula **2** and **4** wherein n is an integer in the range from 3-12 and m is an integer in the range from 1-4.

Scheme 23: Synthesis of compounds of formula X2 and X4

Compounds X1 and X3 are prepared as describedin the above Schemes 1-22, as well as in Dasseux *et al*. US Pat. Appl. 09/976,938, filed October 11, 2001. Compounds **X2** and **X4** are prepared from ketones of type **XI** and **X3**, respectively by well-known reductive methods. (See, Larock, R.C. *Comprehensive Organic Transformations; A Guide To Functional Group* ***Preparations*****, 1989, pp 527-548, for a discussion of various methods for conversion of ketones to alcohols see, March, J.** ***Advanced Organic Chemistry; Reactions, Mechanisms, and structure*****,** 4th ed., **1992, pp 910-918). For example, metalhydride reductions (e.g. lithium aluminum hydride, see Takazawa, O.; Kogami, K.; Hayashi, K.,** ***Chem. Lett.*****, 1983,** 63-64, lithium tri-tert-butoxyaluminohydride, see Mander, L. N.; Palmer, L. T., *Aust. J. Chem.*, **1979,** *32*, 823-832 or sodium borohydride (Kishimoto, S.; et al., Chem. Pharm. Bull., **1974,** *22*, 2231-2241, Mohr, P., Tetrahedron Lett., **1995,** *36*, 7221-7224, Metzger, J. O.; Biermann, U., *Liebigs Ann. Chem.*, **1993,** *6*, 645-650, Kennedy, J.; et al., *J. Chem. Soc.*, **1961, 4945-4948)), catalytic hydrogenation catalyzed by transition metals (e.g. Raney nickel, see Zakharkin, L. I.; Guseva, V. V.; Churilova, I. M.;** *J. Org. Chem. USSR*, **1983,** *19*, 1632-1634, platinum, see Ficini, J.; et al., *J. Am. Chem Soc.*, **1974,** *96*, 1213-1214 or ruthenium, see Bowden, R. D.; Cooper, R. D. G.; Harris, C. J.; Moss, G. P.; Weedon, B. C. L.; Jackman, L. M., *J. Chem. Soc. Perkin Trans. 1*, **1983,** *7*, 1465-1474), metal or dissolving metal reductions (e.g. lithium, see Maiti, S. B.; Kundu, A. P.; Chatterjee, A.; Raychaudhuri, S. R., *Indian J. Chem. Sect. B*, **1986,** 15-21) and reductions catalyzed by enzymes (e.g. Baker's yeast, see Utaka, M.; Watabu, H.; Takeda, A., *J. Org. Chem.*, **1987,** *52*, 4363-4368).

In a typical example, compound of formula X2 is prepared starting from the corresponding ketone **XI** by treatment with lithium aluminum hydride (Takazawa, O.; Kogami, K.; Hayashi, K., *Chem. Lett.*, **1983,** 63-64), lithium tri-tert-butoxyaluminohydride

(Mander, L. N.; Palmer, L. T., *Aust. J. Chem.*, **1979**, *32*, 823-832), or preferably sodium borohydride (Kishimoto, S.; et al., Chem. Pharm. Bull., **1974**, *22*, 2231-2241, Mohr, P., Tetrahedron Lett., **1995**, *36*, 7221-7224, Metzger, J. O.; Biermann, U., *Liebigs Ann. Chem.*, **1993**, *6*, 645-650, Kennedy, J.; et al., *J. Chem. Soc.*, **1961**, 4945-4948), preferably though not limited to temperatures between 0 °C and room temperature. Preferably though not limited, the reaction is run in a protic solvent where ethanol or isopropanol are the most preferred ones. Further, the reaction can be performed in the presence of a basic aqueous solution; preferably a solution of sodium hydroxide in water or a Lewis acid catalyst, preferably $CeCl_3$ (Gemal, A. L.; Luche, J.-L., *J. Am Cem. Soc.*, **1981**, *103*, 5454, Cooley, G.; Kirk, D.N., *J.Chem. Soc. Perkin Trans.* 1, 1984, 6, 1205-1212).

5.2 Therapeutic Uses of Compounds or Compositions of the Invention

In accordance with the invention, a compound of the invention or a composition of the invention, comprising a compound of the invention and a pharmaceutically acceptable vehicle, is administered to a patient, preferably a human, with or at risk of aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, enhancing bile production, enhancing reverse lipid transport, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, modulating C reactive protein, obesity, oxysterol elimination in bile, pancreatitis, Parkinson's disease, a peroxisome proliferator activated receptor-associated disorder, phospholipid elimination in bile, renal disease, septicemia, metabolic syndrome disorders (e.g., Syndrome X), a thrombotic disorder, gastrointestinal disease, irritable bowel syndrome (IBS), inflammatory bowel disease (e.g., Crohn's Disease, ulcerative colitis), arthritis (e.g., rheumatoid arthritis, osteoarthritis), autoimmune disease (e.g., systemic lupus erythematosus), scleroderma, ankylosing spondylitis, gout and pseudogout, muscle pain: polymyositis/polymyalgia rheumatica/fibrositis; infection and arthritis, juvenile rheumatoid arthritis, tendonitis, bursitis and other soft tissue rheumatism. In one embodiment, "treatment" or "treating" refers to an amelioration of a disease or disorder, or at least one discernible symptom thereof. In another embodiment, "treatment" or "treating" refers to inhibiting the progression of a disease or disorder, either physically, e.g., stabilization of a discernible symptom, physiologically, e.g., stabilization of a physical parameter, or both.

In certain embodiments, the compounds of the invention or the compositions of the invention are administered to a patient, preferably a human, as a preventative measure

against such diseases. As used herein, "prevention" or "preventing" refers to a reduction of the risk of acquiring a given disease or disorder. In a preferred mode of the embodiment, the compositions of the present invention are administered as a preventative measure to a patient, preferably a human having a genetic predisposition to a aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, enhancing bile production, enhancing reverse lipid transport, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, modulating C reactive protein, obesity, oxysterol elimination in bile, pancreatitis, Parkinson's disease, a peroxisome proliferator activated receptor-associated disorder, phospholipid elimination in bile, renal disease, septicemia, metabolic syndrome disorders (e.g., Syndrome X), a thrombotic disorder, inflammatory processes and diseases like gastrointestinal disease, irritable bowel syndrome (IBS), inflammatory bowel disease (e.g., Crohn's Disease, ulcerative colitis), arthritis (e.g., rheumatoid arthritis, osteoarthritis), autoimmune disease (e.g., systemic lupus erythematosus), scleroderma, ankylosing spondylitis, gout and pseudogout, muscle pain: polymyositis/polymyalgia rheumatica/fibrositis; infection and arthritis, juvenile rheumatoid arthritis, tendonitis, bursitis and other soft tissue rheumatism. Examples of such genetic predispositions include but are not limited to the ϵ4 allele of apolipoprotein E, which increases the likelihood of Alzheimer's Disease; a loss of function or null mutation in the lipoprotein lipase gene coding region or promoter (e.g., mutations in the coding regions resulting in the substitutions D9N and N291S; for a review of genetic mutations in the lipoprotein lipase gene that increase the risk of cardiovascular diseases, dyslipidemias and dyslipoproteinemias, see Hayden and Ma, 1992, Mol. Cell Biochem. 113:171-176); and familial combined hyperlipidemia and familial hypercholesterolemia .

In another preferred mode of the embodiment, the compounds of the invention or compositions of the invention are administered as a preventative measure to a patient having a non-genetic predisposition to a aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, enhancing bile production, enhancing reverse lipid transport, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, modulating C reactive protein, obesity, oxysterol elimination in bile, pancreatitis, Parkinson's disease, a peroxisome proliferator activated receptor-associated disorder, phospholipid elimination in bile, renal disease, septicemia, metabolic syndrome disorders (e.g., Syndrome X), a thrombotic disorder, inflammatory processes and diseases like

gastrointestinal disease, irritable bowel syndrome (IBS), inflammatory bowel disease (e.g., Crohn's Disease, ulcerative colitis), arthritis (e.g., rheumatoid arthritis, osteoarthritis), autoimmune disease (e.g., systemic lupus erythematosus), scleroderma, ankylosing spondylitis, gout and pseudogout, muscle pain: polymyositis/polymyalgia rheumatica/fibrositis; infection and arthritis, juvenile rheumatoid arthritis, tendonitis, bursitis and other soft tissue rheumatism.. Examples of such non-genetic predispositions include but are not limited to cardiac bypass surgery and percutaneous transluminal coronary angioplasty, which often lead to restenosis, an accelerated form of atherosclerosis; diabetes in women, which often leads to polycystic ovarian disease; and cardiovascular disease, which often leads to impotence. Accordingly, the compositions of the invention may be used for the prevention of one disease or disorder and concurrently treating another (e.g., prevention of polycystic ovarian disease while treating diabetes; prevention of impotence while treating a cardiovascular disease).

5.2.1 Treatment of Cardiovascular Diseases

The present invention provides methods for the treatment or prevention of a cardiovascular disease, comprising administering to a patient a therapeutically effective amount of a compound or a composition comprising a compound of the invention and a pharmaceutically acceptable vehicle. As used herein, the term "cardiovascular diseases" refers to diseases of the heart and circulatory system. These diseases are often associated with dyslipoproteinemias and/or dyslipidemias. Cardiovascular diseases which the compositions of the present invention are useful for preventing or treating include but are not limited to arteriosclerosis; atherosclerosis; stroke; ischemia; endothelium dysfunctions, in particular those dysfunctions affecting blood vessel elasticity; peripheral vascular disease; coronary heart disease; myocardial infarcation; cerebral infarction and restenosis.

5.2.2 Treatment of Dyslipidemias

The present invention provides methods for the treatment or prevention of a dyslipidemia comprising administering to a patient a therapeutically effective amount of a compound or a composition comprising a compound of the invention and a pharmaceutically acceptable vehicle.

As used herein, the term "dyslipidemias" refers to disorders that lead to or are manifested by aberrant levels of circulating lipids. To the extent that levels of lipids in the blood are too high, the compositions of the invention are administered to a patient to restore normal levels. Normal levels of lipids are reported in medical treatises known to those of

skill in the art. For example, recommended blood levels of LDL, HDL, free triglycerides and others parameters relating to lipid metabolism can be found at the web site of the American Heart Association and that of the National Cholesterol Education Program of the National Heart, Lung and Blood Institute (http://www.americanheart.org/cholesterol/about_level.html and http://www.nhlbi.nih.gov/health/ public/heart/chol/hbc_what.html, respectively). At the present time, the recommended level of HDL cholesterol in the blood is above 35 mg/dL; the recommended level of LDL cholesterol in the blood is below 130 mg/dL; the recommended LDL:HDL cholesterol ratio in the blood is below 5:1, ideally 3.5:1; and the recommended level of free triglycerides in the blood is less than 200 mg/dL.

Dyslipidemias which the compositions of the present invention are useful for preventing or treating include but are not limited to hyperlipidemia and low blood levels of high density lipoprotein (HDL) cholesterol. In certain embodiments, the hyperlipidemia for prevention or treatment by the compounds of the present invention is familial hypercholesterolemia; familial combined hyperlipidemia; reduced or deficient lipoprotein lipase levels or activity, including reductions or deficiencies resulting from lipoprotein lipase mutations; hypertriglyceridemia; hypercholesterolemia; high blood levels of urea bodies (e.g. β-OH butyric acid); high blood levels of Lp(a) cholesterol; high blood levels of low density lipoprotein (LDL) cholesterol; high blood levels of very low density lipoprotein (VLDL) cholesterol and high blood levels of non-esterified fatty acids.

The present invention further provides methods for altering lipid metabolism in a patient, e.g., reducing LDL in the blood of a patient, reducing free triglycerides in the blood of a patient, increasing the ratio of HDL to LDL in the blood of a patient, and inhibiting saponified and/or non-saponified fatty acid synthesis, said methods comprising administering to the patient a compound or a composition comprising a compound of the invention in an amount effective alter lipid metabolism.

5.2.3 Treatment of Dyslipoproteinemias

The present invention provides methods for the treatment or prevention of a dyslipoproteinemia comprising administering to a patient a therapeutically effective amount of a compound or a composition comprising a compound of the invention and a pharmaceutically acceptable vehicle.

As used herein, the term "dyslipoproteinemias" refers to disorders that lead to or are manifested by aberrant levels of circulating lipoproteins. To the extent that levels of lipoproteins in the blood are too high, the compositions of the invention are administered to a patient to restore normal levels. Conversely, to the extent that levels of lipoproteins in the

blood are too low, the compositions of the invention are administered to a patient to restore normal levels. Normal levels of lipoproteins are reported in medical treatises known to those of skill in the art.

Dyslipoproteinemias which the compositions of the present invention are useful for preventing or treating include but are not limited to high blood levels of LDL; high blood levels of apolipoprotein B (apo B); high blood levels of Lp(a); high blood levels of apo(a); high blood levels of VLDL; low blood levels of HDL; reduced or deficient lipoprotein lipase levels or activity, including reductions or deficiencies resulting from lipoprotein lipase mutations; hypoalphalipoproteinemia; lipoprotein abnormalities associated with diabetes; lipoprotein abnormalities associated with obesity; lipoprotein abnormalities associated with Alzheimer's Disease; and familial combined hyperlipidemia.

The present invention further provides methods for reducing apo C-II levels in the blood of a patient; reducing apo C-III levels in the blood of a patient; elevating the levels of HDL associated proteins, including but not limited to apo A-I, apo A-II, apo A-IV and apo E in the blood of a patient; elevating the levels of apo E in the blood of a patient, and promoting clearance of triglycerides from the blood of a patient, said methods comprising administering to the patient a compound or a composition comprising a compound of the invention in an amount effective to bring about said reduction, elevation or promotion, respectively.

5.2.4 Treatment of Glucose Metabolism Disorders

The present invention provides methods for the treatment or prevention of a glucose metabolism disorder, comprising administering to a patient a therapeutically effective amount of a compound or a composition comprising a compound of the invention and a pharmaceutically acceptable vehicle. As used herein, the term "glucose metabolism disorders" refers to disorders that lead to or are manifested by aberrant glucose storage and/or utilization. To the extent that indicia of glucose metabolism (i.e., blood insulin, blood glucose) are too high, the compositions of the invention are administered to a patient to restore normal levels. Conversely, to the extent that indicia of glucose metabolism are too low, the compositions of the invention are administered to a patient to restore normal levels. Normal indicia of glucose metabolism are reported in medical treatises known to those of skill in the art.

Glucose metabolism disorders which the compositions of the present invention are useful for preventing or treating include but are not limited to impaired glucose tolerance; insulin resistance; insulin resistance related breast, colon or prostate cancer; diabetes,

including but not limited to non-insulin dependent diabetes mellitus (NIDDM), insulin dependent diabetes mellitus (IDDM), gestational diabetes mellitus (GDM), and maturity onset diabetes of the young (MODY); pancreatitis; hypertension; polycystic ovarian disease; and high levels of blood insulin and/or glucose.

The present invention further provides methods for altering glucose metabolism in a patient, for example to increase insulin sensitivity and/or oxygen consumption of a patient, said methods comprising administering to the patient a compound or a composition comprising a compound of the invention in an amount effective to alter glucose metabolism.

5.2.5 Treatment of PPAR-Associated Disorders

The present invention provides methods for the treatment or prevention of a PPAR-associated disorder, comprising administering to a patient a therapeutically effective amount of a compound or a composition comprising a compound of the invention and a pharmaceutically acceptable vehicle. As used herein, "treatment or prevention of PPAR associated disorders" encompasses treatment or prevention of rheumatoid arthritis; multiple sclerosis; psoriasis; inflammatory bowel diseases; breast; colon or prostate cancer; low levels of blood HDL; low levels of blood, lymph and/or cerebrospinal fluid apo E; low blood, lymph and/or cerebrospinal fluid levels of apo A-I; high levels of blood VLDL; high levels of blood LDL; high levels of blood triglyceride; high levels of blood apo B; high levels of blood apo C-III and reduced ratio of post-heparin hepatic lipase to lipoprotein lipase activity. HDL may be elevated in lymph and/or cerebral fluid.

5.2.6 Treatment of Renal Diseases

The present invention provides methods for the treatment or prevention of a renal disease, comprising administering to a patient a therapeutically effective amount of a compound or a composition comprising a compound of the invention and a pharmaceutically acceptable vehicle. Renal diseases that can be treated by the compounds of the present invention include glomerular diseases (including but not limited to acute and chronic glomerulonephritis, rapidly progressive glomerulonephritis, nephrotic syndrome, focal proliferative glomerulonephritis, glomerular lesions associated with systemic disease, such as systemic lupus erythematosus, Goodpasture's syndrome, multiple myeloma, diabetes, neoplasia, sickle cell disease, and chronic inflammatory diseases), tubular diseases (including but not limited to acute tubular necrosis and acute renal failure, polycystic renal diseasemedullary sponge kidney, medullary cystic disease, nephrogenic diabetes, and renal tubular acidosis), tubulointerstitial diseases (including but not limited to pyelonephritis,

drug and toxin induced tubulointerstitial nephritis, hypercalcemic nephropathy, and hypokalemic nephropathy) acute and rapidly progressive renal failure, chronic renal failure, nephrolithiasis, or tumors (including but not limited to renal cell carcinoma and nephroblastoma). In a most preferred embodiment, renal diseases that are treated by the compounds of the present invention are vascular diseases, including but not limited to hypertension, nephrosclerosis, microangiopathic hemolytic anemia, atheroembolic renal disease, diffuse cortical necrosis, and renal infarcts.

5.2.7 Treatment of Cancer

The present invention provides methods for the treatment or prevention of cancer, comprising administering to a patient a therapeutically effective amount of a compound or a composition comprising a compound of the invention and a pharmaceutically acceptable vehicle. Types of cancer that can be treated using a Compound of the Invention include, but are not limited to, those listed in Table 2.

TABLE 2

Solid tumors, including but not limited to

fibrosarcoma

myxosarcoma

liposarcoma

chondrosarcoma

osteogenic sarcoma

chordoma

angiosarcoma

endotheliosarcoma

lymphangiosarcoma

lymphangioendotheliosarcoma

synovioma

mesothelioma

Ewing's tumor

leiomyosarcoma

rhabdomyosarcoma

colon cancer

colorectal cancer

kidney cancer

pancreatic cancer

bone cancer

breast cancer

ovarian cancer

prostate cancer

esophogeal cancer

stomach cancer

oral cancer

nasal cancer

throat cancer

squamous cell carcinoma

basal cell carcinoma

adenocarcinoma

sweat gland carcinoma

sebaceous gland carcinoma

papillary carcinoma

papillary adenocarcinomas

cystadenocarcinoma

medullary carcinoma

bronchogenic carcinoma

renal cell carcinoma

hepatoma

bile duct carcinoma

choriocarcinoma

seminoma

embryonal carcinoma

Wilms' tumor

cervical cancer

uterine cancer

testicular cancer

small cell lung carcinoma

bladder carcinoma

lung cancer

epithelial carcinoma

glioma

glioblastoma multiforme

astrocytoma

medulloblastoma

craniopharyngioma

ependymoma

pinealoma

hemangioblastoma

acoustic neuroma

oligodendroglioma

meningioma

skin cancer

melanoma

neuroblastoma

retinoblastoma

Blood-borne cancers, including but not limited to:

acute lymphoblastic B-cell leukemia

acute lymphoblastic T-cell leukemia

acute myeloblastic leukemia "AML"

acute promyelocytic leukemia "APL"

acute monoblastic leukemia

acute erythroleukemic leukemia

acute megakaryoblastic leukemia

acute myelomonocytic leukemia

acute nonlymphocyctic leukemia

acute undifferentiated leukemia

chronic myelocytic leukemia "CML"

chronic lymphocytic leukemia "CLL"

hairy cell leukemia

multiple myeloma

Acute and chronic leukemias

Lymphoblastic

myelogenous

lymphocytic

myelocytic leukemias

Lymphomas:

Hodgkin's disease

non-Hodgkin's Lymphoma

Multiple myeloma

Waldenström's macroglobulinemia

Heavy chain disease

Polycythemia vera

Cancer, including, but not limited to, a tumor, metastasis, or any disease or disorder characterized by uncontrolled cell growth, can be treated or prevented by administration of a Compound of the Invention.

5.2.8 Treatment of Other Diseases

The present invention provides methods for the treatment or prevention of neurodegenerative disease or disorder, Alzheimer's Disease, Syndrome X, septicemia, thrombotic disorders, obesity, pancreatitis, hypertension, inflammation, and impotence, comprising administering to a patient a therapeutically effective amount of a compound or a composition comprising a compound of the invention and a pharmaceutically acceptable vehicle.

As used herein, "treatment or prevention of Alzheimer's Disease" encompasses treatment or prevention of lipoprotein abnormalities associated with Alzheimer's Disease.

As used herein, "treatment or prevention of Syndrome X or Metabolic Syndrome" encompasses treatment or prevention of a symptom thereof, including but not limited to impaired glucose tolerance, hypertension and dyslipidemia/dyslipoproteinemia.

As used herein, "treatment or prevention of septicemia" encompasses treatment or prevention of septic shock.

As used herein, "treatment or prevention of thrombotic disorders" encompasses treatment or prevention of high blood levels of fibrinogen and promotion of fibrinolysis.

In addition to treating or preventing obesity, the compositions of the invention can be administered to an individual to promote weight reduction of the individual.

As used herein, "treatment or prevention of diabetic nephropathy" encompasses treating or preventing kidney disease that develops as a result of diabetes mellitus (DM). Diabetes mellitus is a disorder in which the body is unable to metabolize carbohydrates (e.g., food starches, sugars, cellulose) properly. The disease is characterized by excessive amounts of sugar in the blood (hyperglycemia) and urine; inadequate production and/or

utilization of insulin; and by thirst, hunger, and loss of weight. Thus, the compounds of the invention can also be used to treat or prevent diabetes mellitus.

As used herein, "treatment or prevention of diabetic retinopathy" encompasses treating or preventing complications of diabetes that lead to or cause blindness. Diabetic retinopathy occurs when diabetes damages the tiny blood vessels inside the retina, the light-sensitive tissue at the back of the eye.

As used herein, "treatment or prevention of impotence" includes treating or preventing erectile dysfunction, which encompasses the repeated inability to get or keep an erection firm enough for sexual intercourse. The word "impotence" may also be used to describe other problems that interfere with sexual intercourse and reproduction, such as lack of sexual desire and problems with ejaculation or orgasm. The term "treatment or prevention of impotence includes, but is not limited to impotence that results as a result of damage to nerves, arteries, smooth muscles, and fibrous tissues, or as a result of disease, such as, but not limited to, diabetes, kidney disease, chronic alcoholism, multiple sclerosis, atherosclerosis, vascular disease, and neurologic disease.

As used herein, "treatment or prevention of hypertension" encompasses treating or preventing blood flow through the vessels at a greater than normal force, which strains the heart; harms the arteries; and increases the risk of heart attack, stroke, and kidney problems. The term hypertension includes, but is not limited to, cardiovascular disease, essential hypertension, hyperpiesia, hyperpiesis, malignant hypertension, secondary hypertension, or white-coat hypertension.

As used herein, "treatment or prevention of inflammation" encompasses treating or preventing inflammation diseases including, but not limited to, chronic inflammatory disorders of the joints including arthritis, e.g., rheumatoid arthritis and osteoarthritis; respiratory distress syndrome, inflammatory bowel diseases such as ileitis, ulcerative colitis and Crohn's disease; and inflammatory lung disorders such as asthma and chronic obstructive airway disease, inflammatory disorders of the eye such as corneal dystrophy, trachoma, onchocerciasis, uveitis, sympathetic ophthalmitis, and endophthalmitis; inflammatory disorders of the gum, e.g., periodontitis and gingivitis; tuberculosis; leprosy; inflammatory diseases of the kidney including glomerulonephritis and nephrosis; inflammatory disorders of the skin including acne, sclerodermatitis, psoriasis, eczema, photoaging and wrinkles; inflammatory diseases of the central nervous system, including AIDS-related neurodegeneration, stroke, neurotrauma, Alzheimer's disease, encephalomyelitis and viral or autoimmune encephalitis; autoimmune diseases including

immune-complex vasculitis, systemic lupus and erythematodes; systemic lupus erythematosus (SLE); and inflammatory diseases of the heart such as cardiomyopathy.

5.3 Combination Therapy

In certain embodiments of the present invention, the compounds and compositions of the invention can be used in combination therapy with at least one other therapeutic agent. The compound of the invention and the therapeutic agent can act additively or, more preferably, synergistically. In a preferred embodiment, a compound or a composition comprising a compound of the invention is administered concurrently with the administration of another therapeutic agent, which can be part of the same composition as the compound of the invention or a different composition. In another embodiment, a compound or a composition comprising a compound of the invention is administered prior or subsequent to administration of another therapeutic agent. As many of the disorders for which the compounds and compositions of the invention are useful in treating are chronic disorders, in one embodiment combination therapy involves alternating between administering a compound or a composition comprising a compound of the invention and a composition comprising another therapeutic agent, e.g., to minimize the toxicity associated with a particular drug. The duration of administration of each drug or therapeutic agent can be, e.g., one month, three months, six months, or a year. In certain embodiments, when a composition of the invention is administered concurrently with another therapeutic agent that potentially produces adverse side effects including but not limited to toxicity, the therapeutic agent can advantageously be administered at a dose that falls below the threshold at which the adverse side is elicited.

The present compositions can be administered together with a statin. Statins for use in combination with the compounds and compositions of the invention include but are not limited to atorvastatin, pravastatin, fluvastatin, lovastatin, simvastatin, and cerivastatin.

The present compositions can also be administered together with a PPAR agonist, for example a thiazolidinedione or a fibrate. Thiazolidinediones for use in combination with the compounds and compositions of the invention include but are not limited to 5 ((4 (2 (methyl 2 pyridinylamino)ethoxy)phenyl)methyl) 2,4 thiazolidinedione, troglitazone, pioglitazone, ciglitazone, WAY 120,744, englitazone, AD 5075, darglitazone, and rosiglitazone. Fibrates for use in combination with the compounds and compositions of the invention include but are not limited to gemfibrozil, fenofibrate, clofibrate, or ciprofibrate. As mentioned previously, a therapeutically effective amount of a fibrate or

thiazolidinedione often has toxic side effects. Accordingly, in a preferred embodiment of the present invention, when a composition of the invention is administered in combination with a PPAR agonist, the dosage of the PPAR agonist is below that which is accompanied by toxic side effects.

The present compositions can also be administered together with a bile acid binding resin. Bile acid binding resins for use in combination with the compounds and compositions of the invention include but are not limited to cholestyramine and colestipol hydrochloride. The present compositions can also be administered together with niacin or nicotinic acid. The present compositions can also be administered together with a RXR agonist. RXR agonists for use in combination with the compounds of the invention include but are not limited to LG 100268, LGD 1069, 9-cis retinoic acid, 2 (1 (3,5,5,8,8 pentamethyl 5,6,7,8 tetrahydro 2 naphthyl) cyclopropyl) pyridine 5 carboxylic acid, or 4 ((3,5,5,8,8 pentamethyl 5,6,7,8 tetrahydro 2 naphthyl)2 carbonyl) benzoic acid. The present compositions can also be administered together with an anti-obesity drug. Anti-obesity drugs for use in combination with the compounds of the invention include but are not limited to β-adrenergic receptor agonists, preferably β-3 receptor agonists, fenfluramine, dexfenfluramine, sibutramine, bupropion, fluoxetine, and phentermine. The present compositions can also be administered together with a hormone. Hormones for use in combination with the compounds of the invention include but are not limited to thyroid hormone, estrogen and insulin. Preferred insulins include but are not limited to injectable insulin, transdermal insulin, inhaled insulin, or any combination thereof. As an alternative to insulin, an insulin derivative, secretagogue, sensitizer or mimetic may be used. Insulin secretagogues for use in combination with the compounds of the invention include but are not limited to forskolin, dibutryl cAMP or isobutylmethylxanthine (IBMX).

The present compositions can also be administered together with a phosphodiesterase type 5 ("PDE5") inhibitor to treat or prevent disorders, such as but not limited to, impotence. In a particular, embodiment the combination is a synergistic combination of a composition of the invention and a PDE5 inhibitor.

The present compositions can also be administered together with a tyrophostine or an analog thereof. Tyrophostines for use in combination with the compounds of the invention include but are not limited to tryophostine 51.

The present compositions can also be administered together with sulfonylurea-based drugs. Sulfonylurea-based drugs for use in combination with the compounds of the invention include, but are not limited to, glisoxepid, glyburide, acetohexamide,

chlorpropamide, glibornuride, tolbutamide, tolazamide, glipizide, gliclazide, gliquidone, glyhexamide, phenbutamide, and tolcyclamide. The present compositions can also be administered together with a biguanide. Biguanides for use in combination with the compounds of the invention include but are not limited to metformin, phenformin and buformin.

The present compositions can also be administered together with an α-glucosidase inhibitor. α-glucosidase inhibitors for use in combination with the compounds of the invention include but are not limited to acarbose and miglitol.

The present compositions can also be administered together with an apo A-I agonist. In one embodiment, the apo A-I agonist is the Milano form of apo A-I (apo A-IM). In a preferred mode of the embodiment, the apo A-IM for administration in conjunction with the compounds of the invention is produced by the method of U.S. Patent No. 5,721,114 to Abrahamsen. In a more preferred embodiment, the apo A-I agonist is a peptide agonist. In a preferred mode of the embodiment, the apo A-I peptide agonist for administration in conjunction with the compounds of the invention is a peptide of U.S. Patent No. 6,004,925 or 6,037,323 to Dasseux.

The present compositions can also be administered together with apolipoprotein E (apo E). In a preferred mode of the embodiment, the apoE for administration in conjunction with the compounds of the invention is produced by the method of U.S. Patent No. 5,834,596 to Ageland.

In yet other embodiments, the present compositions can be administered together with an HDL-raising drug; an HDL enhancer; or a regulator of the apolipoprotein A-I, apolipoprotein A-IV and/or apolipoprotein genes.

In one embodiment, the other therapeutic agent can be an antiemetic agent. Suitable antiemetic agents include, but are not limited to, metoclopromide, domperidone, prochlorperazine, promethazine, chlorpromazine, trimethobenzamide, ondansetron, granisetron, hydroxyzine, acethylleucine monoethanolamine, alizapride, azasetron, benzquinamide, bietanautine, bromopride, buclizine, clebopride, cyclizine, dimenhydrinate, diphenidol, dolasetron, meclizine, methallatal, metopimazine, nabilone, oxyperndyl, pipamazine, scopolamine, sulpiride, tetrahydrocannabinols, thiethylperazine, thioproperazine and tropisetron.

In another embodiment, the other therapeutic agent can be an hematopoietic colony stimulating factor. Suitable hematopoietic colony stimulating factors include, but are not limited to, filgrastim, sargramostim, molgramostim and erythropoietin alfa.

In still another embodiment, the other therapeutic agent can be an opioid or non-opioid analgesic agent. Suitable opioid analgesic agents include, but are not limited to, morphine, heroin, hydromorphone, hydrocodone, oxymorphone, oxycodone, metopon, apomorphine, normorphine, etorphine, buprenorphine, meperidine, lopermide, anileridine, ethoheptazine, piminidine, betaprodine, diphenoxylate, fentanil, sufentanil, alfentanil, remifentanil, levorphanol, dextromethorphan, phenazocine, pentazocine, cyclazocine, methadone, isomethadone and propoxyphene. Suitable non-opioid analgesic agents include, but are not limited to, aspirin, celecoxib, rofecoxib, diclofinac, diflusinal, etodolac, fenoprofen, flurbiprofen, ibuprofen, ketoprofen, indomethacin, ketorolac, meclofenamate, mefanamic acid, nabumetone, naproxen, piroxicam and sulindac.

5.3.1 Combination Therapy of Cardiovascular Diseases

The present compositions can be administered together with a known cardiovascular drug. Cardiovascular drugs for use in combination with the compounds of the invention to prevent or treat cardiovascular diseases include but are not limited to peripheral antiadrenergic drugs, centrally acting antihypertensive drugs (e.g., methyldopa, methyldopa HCl), antihypertensive direct vasodilators (e.g., diazoxide, hydralazine HCl), drugs affecting renin-angiotensin system, peripheral vasodilators, phentolamine, antianginal drugs, cardiac glycosides, inodilators (e.g., amrinone, milrinone, enoximone, fenoximone, imazodan, sulmazole), antidysrhythmic drugs, calcium entry blockers, ranitine, bosentan, and rezulin.

5.3.2 Combination Therapy of Cancer

The present invention includes methods for treating cancer, comprising administering to an animal in need thereof an effective amount of a Compound of the Invention and another therapeutic agent that is an anti-cancer agent. Suitable anticancer agents include, but are not limited to, those listed in Table 3.

TABLE 3

Alkylating agents	
Nitrogen mustards:	Cyclophosphamide
	Ifosfamide
	trofosfamide
	Chlorambucil
	Treos

Nitrosoureas:	carbustine (BCNU)
	Lomustine (CCNU)
Alkylsulphonates	Busulfan
	Treosulfan
Triazenes:	Dacarbazine
Platinum containing compounds:	Cisplatin
	carboplatin
Plant Alkaloids	
Vinca alkaloids:	Vicristine
	Vinblastine
	Vindesine
	Vinorelbine
Taxoids:	paclitaxel
	Docetaxol
DNA Topoisomerase Inhibitors	
Epipodophyllins:	Etoposide
	Teniposide
	Topotecan
	9-aminocamptothecin
	camptothecin
	crisnatol
mitomycins:	Mitomycin C
Anti-metabolites	
Anti-folates:	
DHFR inhibitors:	METHOTREXATE
	Trimetrexate
IMP dehydrogenase Inhibitors:	Mycophenolic acid
	Tiazofurin
	Ribavirin
	EICAR
Ribonuclotide reductase Inhibitors:	Hydroxyurea
	deferoxamine
Pyrimidine analogs:	

Uracil analogs	5-Fluorouracil
	Floxuridine
	Doxifluridine
	Ratitrexed
Cytosine analogs	cytarabine (ara C)
	Cytosine arabinoside
	fludarabine
Purine analogs:	mercaptopurine
	Thioguanine
Hormonal therapies:	
Receptor antagonists:	
Anti-estrogen	Tamoxifen
	Raloxifene
	megestrol
	goscrclin
	Leuprolide acetate
LHRH agonists:	flutamide
	bicalutamide
Retinoids/Deltoids	
Vitamin D3 analogs:	EB 1089
	CB 1093
	KH 1060
Photodynamic therapies:	vertoporfin (BPD-MA)
	Phthalocyanine
	photosensitizer Pc4
	Demethoxy-hypocrellin A (2BA-2-DMHA)
Cytokines:	Interferon-α
	Interferon-γ
	Tumor necrosis factor
Others:	
Isoprenylation inhibitors:	Lovastatin
Dopaminergic neurotoxins:	1-methyl-4-phenylpyridinium ion
Cell cycle inhibitors:	staurosporine

Actinomycines:	Actinomycin D
	Dactinomycin
Bleomycins:	bleomycin A2
	Bleomycin B2
	Peplomycin
Anthracyclines:	daunorubicin
	Doxorubicin (adriamycin)
	Idarubicin
	Epirubicin
	Pirarubicin
	Zorubicin
	Mitoxantrone
MDR inhibitors	verapamil
Ca^{2+}ATPase inhibitors:	thapsigargin

In a specific embodiment, a composition of the invention further comprises one or more chemotherapeutic agents and/or is administered concurrently with radiation therapy. In another specific embodiment, chemotherapy or radiation therapy is administered prior or subsequent to administration of a present composition, preferably at least an hour, five hours, 12 hours, a day, a week, a month, more preferably several months (e.g., up to three months), subsequent to administration of a composition of the invention.

In other embodiments, the invention provides methods for treating or preventing cancer, comprising administering to an animal in need thereof an effective amount of a Compound of the Invention and a chemotherapeutic agent. In one embodiment the chemotherapeutic agent is that with which treatment of the cancer has not been found to be refractory. In another embodiment, the chemotherapeutic agent is that with which the treatment of cancer has been found to be refractory. The Compounds of the Invention can be administered to an animal that has also undergone surgery as treatment for the cancer.

In one embodiment, the additional method of treatment is radiation therapy.

In a specific embodiment, the Compound of the Invention is administered concurrently with the chemotherapeutic agent or with radiation therapy. In another specific embodiment, the chemotherapeutic agent or radiation therapy is administered prior or subsequent to administration of a Compound of the Invention, preferably at least an hour, five hours, 12 hours, a day, a week, a month, more preferably several months (e.g., up to three months), prior or subsequent to administration of a Compound of the Invention.

A chemotherapeutic agent can be administered over a series of sessions, any one or a combination of the chemotherapeutic agents listed in Table 3 can be administered. With respect to radiation, any radiation therapy protocol can be used depending upon the type of cancer to be treated. For example, but not by way of limitation, x-ray radiation can be administered; in particular, high-energy megavoltage (radiation of greater that 1 MeV energy) can be used for deep tumors, and electron beam and orthovoltage x-ray radiation can be used for skin cancers. Gamma-ray emitting radioisotopes, such as radioactive isotopes of radium, cobalt and other elements, can also be administered.

Additionally, the invention provides methods of treatment of cancer with a Compound of the Invention as an alternative to chemotherapy or radiation therapy where the chemotherapy or the radiation therapy has proven or can prove too toxic, e.g., results in unacceptable or unbearable side effects, for the subject being treated. The animal being treated can, optionally, be treated with another cancer treatment such as surgery, radiation therapy or chemotherapy, depending on which treatment is found to be acceptable or bearable.

The Compounds of the Invention can also be used in an in vitro or ex vivo fashion, such as for the treatment of certain cancers, including, but not limited to leukemias and lymphomas, such treatment involving autologous stem cell transplants. This can involve a multi-step process in which the animal's autologous hematopoietic stem cells are harvested and purged of all cancer cells, the patient's remaining bone-marrow cell population is then eradicated via the administration of a high dose of a Compound of the Invention with or without accompanying high dose radiation therapy, and the stem cell graft is infused back into the animal. Supportive care is then provided while bone marrow function is restored and the animal recovers.

5.4 Surgical Uses

Cardiovascular diseases such as atherosclerosis often require surgical procedures such as angioplasty. Angioplasty is often accompanied by the placement of a reinforcing a metallic tube shaped structure known as a "stent" into a damaged coronary artery. For more serious conditions, open heart surgery such as coronary bypass surgery may be required. These surgical procedures entail using invasive surgical devices and/or implants, and are associated with a high risk of restenosis and thrombosis. Accordingly, the compounds and compositions of the invention may be used as coatings on surgical devices (e.g., catheters) and implants (e.g., stents) to reduce the risk of restenosis and thrombosis associated with invasive procedures used in the treatment of cardiovascular diseases.

5.5 Veterinary and Livestock Uses

A composition of the invention can be administered to a non-human animal for a veterinary use for treating or preventing a disease or disorder disclosed herein.

In a specific embodiment, the non-human animal is a household pet. In another specific embodiment, the non-human animal is a livestock animal. In a preferred embodiment, the non-human animal is a mammal, most preferably a cow, horse, sheep, pig, cat, dog, mouse, rat, rabbit, or guinea pig. In another preferred embodiment, the non-human animal is a fowl species, most preferably a chicken, turkey, duck, goose, or quail.

In addition to veterinary uses, the compounds and compositions of the invention can be used to reduce the fat content of livestock to produce leaner meats. Alternatively, the compounds and compositions of the invention can be used to reduce the cholesterol content of eggs by administering the compounds to a chicken, quail, or duck hen. For non-human animal uses, the compounds and compositions of the invention can be administered via the animals' feed or orally as a drench composition.

5.6 Therapeutic/Prophylactic Administration and Compositions

Due to the activity of the compounds and compositions of the invention, they are useful in veterinary and human medicine. As described above, the compounds and compositions of the invention are useful for the treatment or prevention of aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, modulating C reactive protein, obesity, oxysterol elimination in bile, pancreatitis, Parkinson's disease, a peroxisome proliferator activated receptor-associated disorder, phospholipid elimination in bile, renal disease, septicemia, metabolic syndrome disorders (e.g., Syndrome X), a thrombotic disorder, enhancing bile production, enhancing reverse lipid transport, inflammatory processes and diseases like gastrointestinal disease, irritable bowel syndrome (IBS), inflammatory bowel disease (e.g., Crohn's Disease, ulcerative colitis), arthritis (e.g., rheumatoid arthritis, osteoarthritis), autoimmune disease (e.g., systemic lupus erythematosus), scleroderma, ankylosing spondylitis, gout and pseudogout, muscle pain: polymyositis/polymyalgia rheumatica/fibrositis; infection and arthritis, juvenile rheumatoid arthritis, tendonitis, bursitis and other soft tissue rheumatism.

The invention provides methods of treatment and prophylaxis by administration to a patient of a therapeutically effective amount of a compound or a composition comprising a compound of the invention. The patient is an animal, including, but not limited, to an

animal such a cow, horse, sheep, pig, chicken, turkey, quail, cat, dog, mouse, rat, rabbit, guinea pig, etc., and is more preferably a mammal, and most preferably a human.

The compounds and compositions of the invention, are preferably administered orally. The compounds and compositions of the invention may also be administered by any other convenient route, for example, by intravenous infusion or bolus injection, by absorption through epithelial or mucocutaneous linings (e.g., oral mucosa, rectal and intestinal mucosa, etc.) and may be administered together with another biologically active agent. Administration can be systemic or local. Various delivery systems are known, e.g., encapsulation in liposomes, microparticles, microcapsules, capsules, etc., and can be used to administer a compound of the invention. In certain embodiments, more than one compound of the invention is administered to a patient. Methods of administration include but are not limited to intradermal, intramuscular, intraperitoneal, intravenous, subcutaneous, intranasal, epidural, oral, sublingual, intranasal, intracerebral, intravaginal, transdermal, rectally, by inhalation, or topically, particularly to the ears, nose, eyes, or skin. The preferred mode of administration is left to the discretion of the practitioner, and will depend in-part upon the site of the medical condition. In most instances, administration will result in the release of the compounds of the invention into the bloodstream.

In specific embodiments, it may be desirable to administer one or more compounds of the invention locally to the area in need of treatment. This may be achieved, for example, and not by way of limitation, by local infusion during surgery, topical application, e.g., in conjunction with a wound dressing after surgery, by injection, by means of a catheter, by means of a suppository, or by means of an implant, said implant being of a porous, non-porous, or gelatinous material, including membranes, such as sialastic membranes, or fibers. In one embodiment, administration can be by direct injection at the site (or former site) of an atherosclerotic plaque tissue.

In certain embodiments, for example, for the treatment of Alzheimer's Disease, it may be desirable to introduce one or more compounds of the invention into the central nervous system by any suitable route, including intraventricular, intrathecal and epidural injection. Intraventricular injection may be facilitated by an intraventricular catheter, for example, attached to a reservoir, such as an Ommaya reservoir.

Pulmonary administration can also be employed, e.g., by use of an inhaler or nebulizer, and formulation with an aerosolizing agent, or via perfusion in a fluorocarbon or synthetic pulmonary surfactant. In certain embodiments, the compounds of the invention

can be formulated as a suppository, with traditional binders and vehicles such as triglycerides.

In another embodiment, the compounds and compositions of the invention can be delivered in a vesicle, in particular a liposome (see Langer, 1990, Science 249:1527 1533; Treat et al., in Liposomes in the Therapy of Infectious Disease and Cancer, Lopez-Berestein and Fidler (eds.), Liss, New York, pp. 353 365 (1989); Lopez Berestein, ibid., pp. 317 327; see generally ibid.).

In yet another embodiment, the compounds and compositions of the invention can be delivered in a controlled release system. In one embodiment, a pump may be used (see Langer, supra; Sefton, 1987, CRC Crit. Ref. Biomed. Eng. 14:201; Buchwald et al., 1980, Surgery 88:507 Saudek et al., 1989, N. Engl. J. Med. 321:574). In another embodiment, polymeric materials can be used (see Medical Applications of Controlled Release, Langer and Wise (eds.), CRC Pres., Boca Raton, Florida (1974); Controlled Drug Bioavailability, Drug Product Design and Performance, Smolen and Ball (eds.), Wiley, New York (1984); Ranger and Peppas, 1983, J. Macromol. Sci. Rev. Macromol. Chem. 23:61; see also Levy et al., 1985, Science 228:190; During et al., 1989, Ann. Neurol. 25:351; Howard et al., 1989, J. Neurosurg. 71:105). In yet another embodiment, a controlled-release system can be placed in proximity of the target area to be treated, e.g., the liver, thus requiring only a fraction of the systemic dose (see, e.g., Goodson, in Medical Applications of Controlled Release, supra, vol. 2, pp. 115 138 (1984)). Other controlled-release systems discussed in the review by Langer, 1990, Science 249:1527 1533) may be used.

The present compositions will contain a therapeutically effective amount of a compound of the invention, optionally more than one compound of the invention, preferably in purified form, together with a suitable amount of a pharmaceutically acceptable vehicle so as to provide the form for proper administration to the patient.

In a specific embodiment, the term "pharmaceutically acceptable" means approved by a regulatory agency of the Federal or a state government or listed in the U.S. Pharmacopeia or other generally recognized pharmacopeia for use in animals, and more particularly in humans. The term "vehicle" refers to a diluent, adjuvant, excipient, or carrier with which a compound of the invention is administered. Such pharmaceutical vehicles can be liquids, such as water and oils, including those of petroleum, animal, vegetable or synthetic origin, such as peanut oil, soybean oil, mineral oil, sesame oil and the like. The pharmaceutical vehicles can be saline, gum acacia, gelatin, starch paste, talc, keratin, colloidal silica, urea, and the like. In addition, auxiliary, stabilizing, thickening, lubricating

and coloring agents may be used. When administered to a patient, the compounds and compositions of the invention and pharmaceutically acceptable vehicles are preferably sterile. Water is a preferred vehicle when the compound of the invention is administered intravenously. Saline solutions and aqueous dextrose and glycerol solutions can also be employed as liquid vehicles, particularly for injectable solutions. Suitable pharmaceutical vehicles also include excipients such as starch, glucose, lactose, sucrose, gelatin, malt, rice, flour, chalk, silica gel, sodium stearate, glycerol monostearate, talc, sodium chloride, dried skim milk, glycerol, propylene, glycol, water, ethanol and the like. The present compositions, if desired, can also contain minor amounts of wetting or emulsifying agents, or pH buffering agents.

The present compositions can take the form of solutions, suspensions, emulsion, tablets, pills, pellets, capsules, capsules containing liquids, powders, sustained-release formulations, suppositories, emulsions, aerosols, sprays, suspensions, or any other form suitable for use. In one embodiment, the pharmaceutically acceptable vehicle is a capsule (see e.g., U.S. Patent No. 5,698,155). Other examples of suitable pharmaceutical vehicles are described in "Remington's Pharmaceutical Sciences" by E.W. Martin.

In a preferred embodiment, the compounds and compositions of the invention are formulated in accordance with routine procedures as a pharmaceutical composition adapted for intravenous administration to human beings. Typically, compounds and compositions of the invention for intravenous administration are solutions in sterile isotonic aqueous buffer. Where necessary, the compositions may also include a solubilizing agent. Compositions for intravenous administration may optionally include a local anesthetic such as lignocaine to ease pain at the site of the injection. Generally, the ingredients are supplied either separately or mixed together in unit dosage form, for example, as a dry lyophilized powder or water free concentrate in a hermetically sealed container such as an ampoule or sachette indicating the quantity of active agent. Where the compound of the invention is to be administered by intravenous infusion, it can be dispensed, for example, with an infusion bottle containing sterile pharmaceutical grade water or saline. Where the compound of the invention is administered by injection, an ampoule of sterile water for injection or saline can be provided so that the ingredients may be mixed prior to administration.

Compounds and compositions of the invention for oral delivery may be in the form of tablets, lozenges, aqueous or oily suspensions, granules, powders, emulsions, capsules, syrups, or elixirs. Compounds and compositions of the invention for oral delivery can also be formulated in foods and food mixes. Orally administered compositions may contain one

or more optionally agents, for example, sweetening agents such as fructose, aspartame or saccharin; flavoring agents such as peppermint, oil of wintergreen, or cherry; coloring agents; and preserving agents, to provide a pharmaceutically palatable preparation. Moreover, where in tablet or pill form, the compositions may be coated to delay disintegration and absorption in the gastrointestinal tract thereby providing a sustained action over an extended period of time. Selectively permeable membranes surrounding an osmotically active driving compound are also suitable for orally administered compounds and compositions of the invention. In these later platforms, fluid from the environment surrounding the capsule is imbibed by the driving compound, which swells to displace the agent or agent composition through an aperture. These delivery platforms can provide an essentially zero order delivery profile as opposed to the spiked profiles of immediate release formulations. A time delay material such as glycerol monostearate or glycerol stearate may also be used. Oral compositions can include standard vehicles such as mannitol, lactose, starch, magnesium stearate, sodium saccharine, cellulose, magnesium carbonate, etc. Such vehicles are preferably of pharmaceutical grade.

The amount of a compound of the invention that will be effective in the treatment of a particular disorder or condition disclosed herein will depend on the nature of the disorder or condition, and can be determined by standard clinical techniques. In addition, in vitro or in vivo assays may optionally be employed to help identify optimal dosage ranges. The precise dose to be employed in the compositions will also depend on the route of administration, and the seriousness of the disease or disorder, and should be decided according to the judgment of the practitioner and each patient's circumstances. However, suitable dosage ranges for oral administration are generally about 0.001 milligram to 2000 milligrams of a compound of the invention per kilogram body weight. In specific preferred embodiments of the invention, the oral dose is 0.01 milligram to 1000 milligrams per kilogram body weight, more preferably 0.1 milligram to 100 milligrams per kilogram body weight, more preferably 0.5 milligram to 25 milligrams per kilogram body weight, and yet more preferably 1 milligram to 10 milligrams per kilogram body weight. In a most preferred embodiment, the oral dose is 5 milligrams of a compound of the invention per kilogram body weight. The dosage amounts described herein refer to total amounts administered; that is, if more than one compound of the invention is administered, the preferred dosages correspond to the total amount of the compounds of the invention administered. Oral compositions preferably contain 10% to 95% active ingredient by weight..

Suitable dosage ranges for intravenous (i.v.) administration are 0.01 milligram to 1000 milligrams per kilogram body weight, 0.1 milligram to 350 milligrams per kilogram body weight, and 1 milligram to 100 milligrams per kilogram body weight. Suitable dosage ranges for intranasal administration are generally about 0.01 pg/kg body weight to 1 mg/kg body weight. Suppositories generally contain 0.01 milligram to 50 milligrams of a compound of the invention per kilogram body weight and comprise active ingredient in the range of 0.5% to 10% by weight. Recommended dosages for intradermal, intramuscular, intraperitoneal, subcutaneous, epidural, sublingual, intracerebral, intravaginal, transdermal administration or administration by inhalation are in the range of 0.001 milligram to 200 milligrams per kilogram of body weight. Suitable doses of the compounds of the invention for topical administration are in the range of 0.001 milligram to 1 milligram, depending on the area to which the compound is administered. Effective doses may be extrapolated from dose-response curves derived from in vitro or animal model test systems. Such animal models and systems are well known in the art.

The invention also provides pharmaceutical packs or kits comprising one or more containers filled with one or more compounds of the invention. Optionally associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, which notice reflects approval by the agency of manufacture, use or sale for human administration. In a certain embodiment, the kit contains more than one compound of the invention. In another embodiment, the kit comprises a compound of the invention and another lipid-mediating compound, including but not limited to a statin, a thiazolidinedione, or a fibrate.

The compounds of the invention are preferably assayed in vitro and in vivo, for the desired therapeutic or prophylactic activity, prior to use in humans. For example, in vitro assays can be used to determine whether administration of a specific compound of the invention or a combination of compounds of the invention is preferred for lowering fatty acid synthesis. The compounds and compositions of the invention may also be demonstrated to be effective and safe using animal model systems.

Other methods will be known to the skilled artisan and are within the scope of the invention.

The following examples are provided by way of illustration and not limitation.

6. SYNTHETIC EXAMPLES

6.1 2,2,12,12-Tetramethyltridecane-1,7,13-triol

Under nitrogen atmosphere, to a suspension of lithium borohydride (2.65 g, 122 mmol) in dichloromethane (60 mL) was added methanol (4.0 g, 125 mmol) dropwise at room temperature over 30 min. The reaction mixture was heated at reflux and 2,2,12,12-tetramethyl-7-oxo-tridecanedioic acid diethyl ester (10.0 g, 27 mmol) was introduced. Heating at reflux temperature was continued overnight. The reaction mixture was cooled to room temperature and hydrolyzed with saturated ammonium chloride solution (100 mL). The layers were separated and the aqueous layer was extracted with dichloromethane (3 x 50 mL). The combined organic layers were washed with 2 N hydrochloric acid (100 mL) and saturated sodium chloride solution (100 mL), dried over anhydrous sodium sulfate and concentrated in vacuo to afford the crude product. The crude compound was purified by chromatography on silica (hexanes : ethyl acetate = 40 : 60) to yield the pure product (5.8 g, 74 %) as a white solid. M.p.: 72 – 74 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 3.58 (br. m, 1 H), 3.30 (s, 4 H), 1.80 - 1.64 (m, 3 H), 1.56 - 1.15 (m, 16 H), 0.86 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 71.87, 71.72, 38.71, 37.46, 35.11, 26.66, 24.18, 24.05, 23.97. HRMS (LSIMS, gly): Calcd. for $C_{17}H_{37}O_3$ (MH+): 289.2743, found: 289.2756. HPLC: 90.6 % purity.

6.2 2,2-Bis[5,5-dimethyl-6-(tetrahydropyran-2-yloxy)-hexyl]malonic acid diethyl ester

Under nitrogen atmosphere, to a solution of 2-(6-bromo-2,2-dimethylhexyloxy)-tetrahydropyran (17.6 g, 60 mmol) and diethyl malonate (4.8 g, 30 mmol) in anhydrous dimethyl sulfoxide (145 mL) was added sodium hydride (60 % dispersion in mineral oil, 2.9 g, 72 mmol) under cooling with a water bath. Tetra-n-butylammonium iodide (2.1 g, 3.6 mmol) was added and the mixture was stirred for 16 h at room temperature. The reaction mixture was carefully hydrolyzed with water (140 mL) under cooling with a water bath. The mixture was extracted with diethyl ether (3 ′ 60 mL). The combined organic layers were washed with water (4 x 50 mL) and brine (50 mL), dried over sodium sulfate, and concentrated in vacuo, affording 2,2-bis[5,5-dimethyl-6-(tetrahydropyran-2-yloxy)-hexyl]malonic acid diethyl ester (17.3 g, 82 %) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.41 (t, 2 H, J = 3.1 Hz), 4.01 (q, 4 H, J = 7.0 Hz), 3.82 - 3.70 (m, 2 H), 3.50 - 3.30 (m, 4 H), 2.87 (d, 2 H, J = 9.1 Hz), 1.80 - 1.35 (m, 16 H), 1.30 - 0.95 (m, 18 H), 0.88 - 0.74 (m, 12 H). 13C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm):

172.0, 99.1, 76.6, 61.9, 60.9, 57.6, 39.2, 34.3, 32.3, 30.7, 25.7, 25.0, 24.6, 24.6, 24.3, 19.5, 14.2.

6.3 2,2-Bis(6-hydroxy-5,5-dimethylhexyl)malonic acid diethyl ester

A solution of 2,2-bis[5,5-dimethyl-6-(tetrahydropyran-2-yloxy)-hexyl]malonic acid diethyl ester (2.92 g, 5.0 mmol) in concentrated hydrochloric acid (2.4 mL) and water (1.6 mL) was heated at reflux for 1 h. Ethanol (8.2 mL) was added and the reaction mixture was heated at reflux for 3 h. The reaction mixture was diluted with water (20 mL) and extracted with diethyl ether (3 x 20 mL). The combined organic layers were washed with water (20 mL) and brine (20 mL), dried over sodium sulfate, and concentrated in vacuo to afford 2,2-bis(6-hydroxy-5,5-dimethylhexyl)malonic acid diethyl ester (1.74 g, 84 %) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.13 (q, 4 H, J = 7.2 Hz), 3.25 (s, 4 H), 2.42 (s, 2 H), 1.90 - 1.75 (m, 4 H), 1.30 - 1.12 (m, 18 H), 0.84 (s, 12 H). 13C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 172.0, 71.7, 60.9, 57.4, 38.2, 34.9, 32.1, 24.8, 24.0, 23.7, 14.0. HRMS (LSIMS, gly): Calcd. for $C_{23}H_{45}O_6$ (MH+): 417.3216, found: 417.3210.

6.4 2,2-Bis(6-hydroxy-5,5-dimethylhexyl)malonic acid

To a stirred solution of potassium hydroxide (4.83 g, 75 mmol) in water (4.2 mL) and ethanol (15 mL) was added 2,2-bis(6-hydroxy-5,5-dimethylhexyl)malonic acid diethyl ester (15.0 g). The reaction mixture was heated at reflux for 14 h. The ethanol was removed under reduced pressure and the aqueous solution was extracted with chloroform (2 x 50 mL). The aqueous layer was acidified with hydrochloric acid to pH 1 and extracted with diethyl ether (3 x 50 mL). The ethereal phases were dried over magnesium sulfate and concentrated in vacuo to yield 2,2-bis(6-hydroxy-5,5-dimethylhexyl)malonic acid (7.8 g, 82 %) as a yellow solid. M.P.: 178 – 180 °C. ^{1}H NMR (300 MHz, CD_3OD/TMS): δ (ppm): 4.86 (s br., 4 H), 3.22 (s, 4 H), 1.9 - 1.8 (m, 4 H), 1.36 - 1.10 (m, 12 H), 0.84 (s, 12 H). ^{13}C NMR (75 MHz, CD_3OD/TMS): δ (ppm): 176.0, 72.0, 58.7, 39.8, 36.0, 34.1, 26.5, 25.5, 24.5. HRMS (LSIMS, gly): Calcd. for $C_{19}H_{37}O_6$ (MH+): 361.2590, found: 361.2582.

6.5 8-Hydroxy-2-(6-hydroxy-5,5-dimethylhexyl)-7,7-dimethyloctanoic acid

Using an oil-bath, 2,2-bis(6-hydroxy-5,5-dimethylhexyl)malonic acid was heated to 200 °C for 30 min until the effervescence ceased. The product (4.04 g, 98 %) was obtained as an oil. ^{1}H NMR (300 MHz, CD_3OD/TMS): δ (ppm): 4.88 (s br., 3 H), 3.22 (s, 4 H), 2.29 (m, 1 H), 1.70 - 1.40 (m, 4 H), 1.4 - 1.1 (m, 12 H), 0.84 (s, 12 H). ^{13}C NMR (75 MHz, CD_3OD/TMS): δ (ppm): 180.5, 72.1, 47.1, 39.9, 36.0, 33.8, 29.7, 25.0, 24.6. HRMS (LSIMS, gly): Calcd. for $C_{18}H_{37}O_4$ (MH+): 317.2692, found: 317.2689.

6.6 7-Hydroxymethyl-2,2,12,12-tetramethyltridecane-1,13-diol

Under nitrogen atmosphere, to a solution of lithium aluminum hydride (1.09 g, 28.8 mmol) in anhydrous THF (100 mL) was added dropwise a solution of 8-hydroxy-2-(6-hydroxy-5,5-dimethylhexyl)-7,7-dimethyloctanoic acid (3.64 g, 11.5 mmol) in THF (40 mL) at room temperature. The reaction mixture was heated at reflux for 5 h and kept at room temperature overnight. Water (100 mL) was added carefully to the reaction mixture under cooling with a water bath. The pH was adjusted to 1 with 2 N hydrochloric acid. The product was extracted with diethyl ether (3 x 60 mL). The combined organic layers were washed with water (2 x 50 mL) and brine (50 mL). The ethereal solution was dried over sodium sulfate and concentrated in vacuo to furnish the crude product (3.2 g), which was purified by chromatography on silica (hexanes : ethyl acetate = 50 : 50) to yield 7-hydroxymethyl-2,2,12,12-tetramethyltridecane-1,13-diol (3.0 g, 86 %) as a yellow oil. ^{1}H NMR (300 MHz, CD_3OD/TMS): δ (ppm): 4.88 (s, 3 H), 3.44 (d, 2 H, J = 4.8 Hz), 3.23 (s, 4 H), 1.5 - 1.1 (m, 17 H), 0.85 (s, 12 H). ^{13}C NMR (75 MHz, CD_3OD/TMS): δ (ppm): 72.0, 65.7, 41.7, 40.0, 36.0, 32.2, 29.0, 25.4, 24.7, 24.6. HRMS (LSIMS, gly): Calcd. for $C_{18}H_{39}O_3$ (MH+): 303.2899, found 303.2901. HPLC: 94.6 % purity.

6.7 7-Hydroxy-2,2,12,12-tetramethyltridecanedioic acid diethyl ester

7-Oxo-2,2,12,12-tetramethyltridecanedioic acid diethyl ester (9.2 g, 25 mmol) was dissolved in methanol (200 mL) and the solution was cooled in an ice-water bath. Sodium borohydride (0.95 g, 25 mmol) was added. After 2 h, another portion of sodium borohydride (0.95 g, 25 mmol) was added and stirring was continued for 2 h. The reaction mixture was hydrolyzed with water (200 mL). The aqueous solution was extracted with dichloromethane (3 x 150 mL). The combined organic layers were dried over magnesium sulfate and concentrated in vacuo to give the product (8.5 g, 92 %) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.11 (q, 4 H, J = 7.0 Hz), 3.60 - 3.50 (m, 1 H), 1.66 - 1.32 (m, 11 H), 1.24 (pseudo-t, 12 H, J = 7.0 Hz), 1.15 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 178.0, 71.7, 60.1, 42.1, 40.6, 37.3, 26.0, 25.1, 24.9, 14.2. HRMS (LSIMS, nba): Calcd. for $C_{21}H_{41}O_3$ (MH+): 373.2954, found: 373.2936. HPLC: 88.90 % purity.

6.8 7-Hydroxy-2,2,12,12-tetramethyltridecanedioic acid

To a homogeneous solution of potassium hydroxide (3.45 g, 61 mmol) in water (3.3 mL) and ethanol (11.1 mL) was added 7-hydroxy-2,2,12,12-tetramethyltridecanedioic acid diethyl ester (8.2 g, 22 mmol) and the mixture was heated at reflux for 4 h. The mixture was concentrated in vacuo and the residue was extracted with

diethyl ether (3 x 50 mL). The water layer was acidified with concentrated hydrochloric acid (6 mL) to pH 1. The product was extracted with diethyl ether (3 ´ 100 mL). The combined organic layers were dried over sodium sulfate and concentrated in vacuo. The crude product was purified by column chromatography (silica, dichloromethane : methanol = 90 :10) to give the pure product (6.6 g, 95 %) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 8.10 (br., 3 H), 3.58 (br., 1 H), 1.62 - 1.22 (m, 16 H), 1.18 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 184.3, 71.8, 42.1, 40.5, 36.9, 25.9, 25.0, 24.9. HRMS (LSIMS, gly): Calcd. for $C_{17}H_{33}O_5$ (MH+): 317.2328; found 317.2330. HPLC: 90.4 % purity.

6.9 <u>2,2,12,12-Tetramethyl-7-methylene-tridecanedioic acid diethyl ester</u>

Under nitrogen atmosphere, a solution of phenyllithium (in diethyl ether : cyclohexane = 30 : 70, 7.06 mL, 1.8 M, 12.7 mmol) was added dropwise over 10 min to a solution of methyltriphenylphosphonium iodide (5.52 g, 13.3 mmol) in anhydrous THF (40 mL) at room temperature. The reaction mixture was stirred at room temperature for 30 min, before 2,2,12,12-tetramethyl-7-oxo-tridecanedioic acid diethyl ester (4.5 g, 12.2 mmol) was added and the reaction mixture was stirred for 5 h at 50 □C. The resulting light-orange mixture was quenched by adding methanol (0.3 mL), and most of the solvent was removed on a rotary evaporator. The residue was purified by chromatography on silica (hexanes : ethyl acetate = 95 : 5) to furnish the product (2.1 g, 47 %) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.67 (s, 2 H), 4.10 (q, 4 H, J = 7.3 Hz), 1.97 (t, 4 H, J = 7.6 Hz), 1.6 - 1.3 (m, 8 H), 1.30 - 1.15 (m, 10 H), 1.15 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 178.0, 149.6, 108.6, 60.1, 42.1, 40.6, 35.8, 28.2, 25.1, 24.7, 14.2. HRMS (LSIMS, nba): Calcd. for $C_{22}H_{41}O_4$ (MH+): 369.3004, found 369.3009.

6.10 <u>7-Hydroxymethyl-2,2,12,12-tetramethyltridecanedioic acid diethyl ester</u>

Into a stirred solution of 2,2,12,12-tetramethyl-7-methylene-tridecanedioic acid diethyl ester (3.7 g, 10 mmol) in anhydrous THF (50 mL) was added borane-methyl sulfide complex (2.0 M in THF, 6 mL, 12 mmol) at room temperature and the solution was stirred for 6 h under argon atmosphere. Hydrogen peroxide (50 wt. % solution in water, 9 mL, 144 mmol) and an aqueous solution of sodium hydroxide (30 mL, 2.5 M, 75 mmol) were slowly introduced at 0 – 5 °C. The reaction mixture was stirred for an additional h at room temperature and then extracted with dichloromethane (3 x 100 mL). The combined organic layers were dried over sodium sulfate, filtered, evaporated, and purified by column chromatography on silica (hexanes : ethyl acetate = 95 : 5, then 90 : 10) to furnish the product (2.9 g, 77 %) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.11 (q, 4 H, J

= 7.0 Hz), 3.51 (d, 2 H, J = 5.4 Hz), 1.60 - 1.16 (m, 18 H), 1.25 (t, 6 H, J = 7.0 Hz), 1.15 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 178.0, 65.3, 60.1, 42.0, 40.6, 40.4, 30.7, 27.2, 25.4, 25.1, 14.2. HRMS (LSIMS, nba): Calcd. for $C_{22}H_{43}O_5$ (MH+): 387.3110, found 387.3108.

6.11 7-Hydroxymethyl-2,2,12,12-tetramethyltridecanedioic acid

To a homogeneous solution of potassium hydroxide (1.18 g, 21 mmol) in water (1.12 mL) and ethanol (3.8 mL) was added 7-hydroxymethyl-2,2,12,12-tetramethyltridecanedioic acid diethyl ester (2.9 g, 7.5 mmol) and the reaction mixture was heated at reflux for 4 h. The mixture was concentrated in vacuo, cooled to room temperature, and the residue was extracted with diethyl ether (2 x 50 mL). The pH of the aqueous layer was adjusted to 1 by addition of hydrochloric acid. The product was extracted with diethyl ether (3 x 50 mL). The combined organic layers were dried over sodium sulfate and concentrated in vacuo to afford the crude product which was purified by column chromatography on silica (hexanes : ethyl acetate = 60 : 40) to yield 7-hydroxymethyl-2,2,12,12-tetramethyltridecanedioic acid (2.0 g, 81 %) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.64 (br., 3 H), 3.50 (d, 2 H, J = 4.4 Hz), 1.60 - 1.20 (m, 17 H), 1.16 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 184.3, 65.2, 42.1, 40.5, 40.1, 30.6, 27.1, 25.2, 25.0. HRMS (LSIMS, nba): Calcd. for $C_{18}H_{35}O_5$ (MH+): 331.2484, found 331.2484.

6.12 7-(1-Hydroxy-1-methylethyl)-2,2,12,12-tetramethyltridecane-1,13-diol

A solution of 8-hydroxy-2-(6-hydroxy-5,5-dimethylhexyl)-7,7-dimethyloctanoic acid (1.0 g, 3.16 mmol) in THF (40 mL) was cooled in an ice-water bath and methyl lithium (1.4 M in diethyl ether, 27 mL, 37.8 mmol) was added in one portion. The reaction mixture was stirred for 2 h at 0 □C, then poured into dilute hydrochloric acid (5 mL concentrated hydrochloric acid/60 mL water). The organic layer was separated and the aqueous layer was extracted with diethyl ether (2 x 50 mL). The combined organic layers were dried over sodium sulfate and concentrated in vacuo to get the crude product (1.0 g). The crude product was purified by column chromatography on silica (hexanes : ethyl acetate = 80 : 20, then 50 : 50) to give 7-(1-hydroxy-1-methylethyl)-2,2,12,12-tetramethyltridecane-1,13-diol (0.40 g, 38 %) as a white solid (together with 7-acetyl-2,2,12,12-tetramethyltridecan-1,13-diol, 0.41 g, 41 %). M.p.: 72 - 74 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 3.24 (s, 4 H), 2.59 (br., 3 H), 1.55 - 0.95 (m, 23 H), 0.81 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 74.0, 71.5, 49.6, 38.4, 34.9, 31.2, 30.3,

27.1, 24.3, 23.9, 23.8. HRMS (LSIMS, gly): Calcd. for $C_{20}H_{43}O_3$ (MH+): 331.3212, found: 331.3205. HPLC: 96.4 % purity.

6.13 7-Bromo-2,2-dimethylheptanoic acid ethyl ester

Under argon atmosphere and cooling with an ice-bath, a solution of lithium diisopropylamide in THF (1.7 L, 2.0 M, 3.4 mol) was slowly dropped into a solution of 1,5-dibromopentane (950 g, 4.0 mol) and ethyl isobutyrate (396 g, 3.4 mol) in THF (5 L) while keeping the temperature below +5 □C. The reaction mixture was stirred at room temperature for 20 h and quenched by slow addition of saturated ammonium chloride solution (3 L). The resulting solution was divided into three 4-L portions. Each portion was diluted with saturated ammonium chloride solution (5 L) and extracted with ethyl acetate (2 ′ 2 L). Each 4-L portion of ethyl acetate was washed with saturated sodium chloride solution (2 L), 1 N hydrochloric acid (2 L), saturated sodium chloride solution (2 L), saturated sodium bicarbonate solution (2 L), and saturated sodium chloride solution (2 L). The three separate ethyl acetate layers were combined into a single 12-L portion, dried over magnesium sulfate, and concentrated in vacuo to give the crude material (1.7 L) which was purified by vacuum distillation. Two fractions were obtained: the first boiling at 88 – 104 °C / 0.6 torr (184.2 g), the second at 105 – 120 °C / 1.4 torr (409.6 g) for a total yield of 60 %. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.11 (q, 2 H, J = 7.2 Hz), 3.39 (t, 2 H, J = 6.8 Hz), 1.85 (m, 2 H), 1.56 - 1.35 (m, 4 H), 1.24 (t, 3 H, J = 7.2 Hz), 1.31 - 1.19 (m, 2 H), 1.16 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 177.9, 60.2, 42.1, 40.5, 33.8, 32.6, 28.6, 25.2, 24.2, 14.3. HRMS (EI, pos): Calcd. for $C_{11}H_{22}BrO_2$ (MH+): 265.0803, found: 265.0810.

6.14 7-Bromo-2,2-dimethylheptan-1-ol

Under Ar atmosphere, to a stirred suspension solution of LiBH4 (5.55 g, 95 %, 0.24 mol) in dichloromethane (80 mL) was added dropwise methanol (9.8 mL, 0.24 mol), keeping a gentle reflux while hydrogen gas was formed. The mixture was stirred for 30 min at 45 °C. To this solution was added dropwise a solution of 7-bromo-2,2-dimethylheptanoic acid ethyl ester (43 g, 0.15 mol) in dichloromethane (120 mL) at such a rate as to maintain a gentle reflux. The reaction mixture was heated at reflux for 20 h, cooled to room temperature and carefully hydrolyzed with 6 N hydrochloric acid (30 mL) and saturated ammonium chloride solution (360 mL). The aqueous layer was extracted with dichloromethane (3 x 50 mL). The combined organic layers were washed with water (2 □ 100 mL) and dried over anhydrous MgSO4. The reaction mixture was evaporated to yield crude 7-bromo-2,2-dimethylheptan-1-ol (36.2 g, 88 %) as a colorless, viscous oil. ^{1}H NMR

(300 MHz, $CDCl_3$/TMS): δ (ppm): 3.41 (t, 2 H, J = 6.9Hz), 3.30 (br. s, 2 H), 1.90 - 1.84 (m, 3 H), 1.42 - 1.22 (m, 6), 0.86 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 71.9, 38.6, 35.1, 34.1, 32.9, 29.2, 24.0, 23.2. HRMS (LSIMS, nba): Calcd. for $C_9H_{18}Br$ (MH+-H_2O): 205.0592, found: 205.0563.

6.15 2-(7-Bromo-2,2-dimethylheptyloxy)-tetrahydropyran

To a solution of 7-bromo-2,2-dimethylheptan-1-ol (36.0 g, 133.0 mmol) in dichloromethane (60 mL) was added p-toluenesulfonic acid (0.28 g, 1.3 mmol) and 3,4-dihydro-2H-pyran (18.54 g, 213 mmol) at 5 - 10 oC under cooling with an ice-water bath. The mixture was stirred and allowed to warm to room temperature overnight. The reaction solution was filtered through neutral alumina (200 g), which was rinsed with dichloromethane (500 mL). Concentration of the solvent gave the crude product as a brown oil, which was subjected to column chromatography on silica gel (240 g) using hexanes : ethyl acetate (50 : 1) as eluent to yield 2-(7-bromo-2,2-dimethylheptyloxy)-tetrahydropyran as a colorless oil (23.0 g, 48 %). ^1H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.54 (t, 1 H, J = 3.0 Hz), 3.84 (m, 1 H), 3.51 - 3.39 (m, 4 H), 2.98 (d, 1 H, J = 9.3 Hz), 1.89 - 1.80 (m, 3 H), 1.70 - 1.40 (m, 7 H), 1.29 - 1.22 (m, 4 H), 0.89 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 99.3, 76.6, 62.1, 39.3, 34.3, 34.2, 33.0, 30.8, 29.2, 25.7, 24.7, 23.2, 19.6. HRMS (LSIMS, nba): Calcd. for $C_{14}H_{27}BrO_2$: 307.1272, found: 307.1245.

6.16 8-Oxo-2,2,14,14-tetramethylpentadecane-1,15-diol

Under nitrogen atmosphere, to a solution of 2-(7-bromo-2,2-dimethylheptyloxy)-tetrahydropyran (26.0 g, 39.4 mmol), tetra-n-butylammonium iodide (3.0g, 8.1 mmol) and p-toluenesulfonyl methyl isocyanide (7.80g, 39.4 mmol) in anhydrous DMSO (200 mL) was added sodium hydride (3.80 g, 20.5 mmol, 60 % dispersion in mineral oil) in portions at 5 - 10 °C. The reaction mixture was stirred at room temperature for 20 h and quenched with ice-water (400 mL). The product was extracted with diethyl ether (3 □ 100 mL). The combined organic layers were washed with water (200 mL) and saturated sodium chloride solution (2 x 200 mL), dried over MgSO4, and concentrated in vacuo to get crude 2-[8-isocyano-2,2,14,14-tetramethyl-15-(tetrahydropyran-2-yloxy)-8-(toluene-4-sulfonyl)-pentadecyloxy]-tetrahydropyran (28.2 g) as an orange oil, which was used without purification. A solution of this crude product (28.0 g) and 48 % sulfuric acid (46 g, from 12 mL of concentrated sulfuric acid and 24 mL of water) in methanol (115 mL) was stirred for 80 min at room temperature. The solution was diluted with ice-water (120 mL). The aqueous layer was extracted with dichloromethane (3 x 100 mL). The combined organic layers were washed with saturated $Na2CO_3$ solution (2 x 150 mL) and saturated

NaCl solution (150 mL). The organic solution was dried over MgSO4 and concentrated in vacuo. The residue was purified by column chromatography (silica gel, hexanes : ethyl acetate = 2 : 1) to give 8-oxo-2,2,14,14-tetramethylpentadecane-1,15-diol (9.97 g, 80 % over two steps) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 3.30 (s, 4 H), 2.39 (t, 4 H, J = 7.2 Hz), 2.07 (br. s, 2 H), 1.60 - 1.55 (m, 4 H), 1.28 - 1.17 (m, 12 H), 0.85 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 212.0, 72.0, 43.0, 38.6, 35.2, 30.3, 24.0, 23.8. HRMS (LSIMS, gly): Calcd. for $C_{19}H_{39}O_3$ (MH+): 315.2899, found: 315.2886. HPLC: 94.7 % purity.

6.17 2,2,14,14-Tetramethylpentadecane-1,8,15-triol

Under nitrogen atmosphere, a solution of 8-oxo-2,2,14,14-tetramethylpentadecane-1,15-diol (0.9 g, 2.5 mmol) in iso-propanol (10 mL) was added dropwise to a stirred suspension of sodium borohydride (0.1 g, 2.7 mmol) in iso-propanol (10 mL) at room temperature. The reaction progress was monitored by thin layer chromatography (silica, hexanes : ethyl acetate = 1 : 1). Additional sodium borohydride was added after each hour (0.36 g, 10 mmol, six times). The reaction mixture was stirred for additional 20 h, hydrolyzed with water (10 mL), acidified with 1 N hydrochloric acid (25 mL) to pH 1, and extracted with dichloromethane (4 x 15 mL). The combined organic phases were washed with saturated sodium chloride solution (15 mL), dried over magnesium sulfate, and concentrated in vacuo to furnish the crude product (1.0 g) as a white solid in oil, which was purified by column chromatography (silica; hexanes, then hexanes : ethyl acetate = 2 : 1 to 1 : 2) to give the pure product (0.35 g, 43 %) as nice white crystals. M.p.: 71 – 75 °C. ^{1}H NMR (300 MHz, CD_3COCD_3/CD_3OD/TMS): δ (ppm): 4.32 - 4.03 (m, 3 H), 3.52 (s, 1 H), 3.22 (s, 4 H), 1.63 - 1.20 (m, 20 H), 0.83 (s, 12 H). ^{13}C NMR (75 MHz, CD_3COCD_3/CD_3OD/TMS): δ (ppm): 72.0, 71.7, 39.8, 38.4, 35.8, 31.8, 26.7, 24.8, 24.6. HRMS (LSIMS, gly): Calcd. for $C_{19}H_{41}O_3$ (MH+): 317.3056, found: 317.3026. HPLC: 97.1 % purity.

6.18 2,2,14,14-Tetramethyl-8-oxo-pentadecanedioic acid diethyl ester

Under Ar atmosphere, to a solution of 7-bromo-2,2-dimethylheptanoic acid ethyl ester (26.50 g, 100 mmol), tetra-n-butylammonium iodide (3.69 g, 10 mmol) and p-toluenesulfonyl methyl isocyanide (9.80 g, 50 mmol) in anhydrous DMSO (300 mL) was added sodium hydride (4.80 g, 20.5 mmol, 60 % dispersion in mineral oil) at 5 - 10 oC. The reaction mixture was stirred at room temperature for 20 h and quenched with ice-water (300 mL). The product was extracted with dichloromethane (3 □ 100 mL). The combined organic layers were washed with water (200 mL), half-saturated NaCl solution (2 ′ 200

mL), and saturated NaCl solution (200 mL), dried over MgSO4, and concentrated in vacuo to get the crude 8-isocyano-2,2,14,14-tetramethyl-8-(toluene-4-sulfonyl)-pentadecanedioic acid diethyl ester (36.8 g) as an orange oil, which was used in the next step without purification. To a solution of this crude product (36.8 g) in dichloromethane (450 mL) was added concentrated hydrochloric acid (110 mL) and the mixture was stirred at room temperature for 1 h. The solution was diluted with water (400 mL) and the aqueous layer was extracted with dichloromethane (200 mL). The combined organic layers were washed with saturated $NaHCO_3$ solution (2 x 150 mL) and saturated NaCl solution (150 mL). The organic solution was dried over Na2SO4 and concentrated in vacuo. The residue was subjected to column chromatography (silica gel, hexanes : ethyl acetate = 11 : 1) to give 2,2,14,14-tetramethyl-8-oxo-pentadecanedioic acid diethyl ester (12.20 g, 66 % over two steps) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.11 (q, 4 H, J = 6.9 Hz), 2.37 (t, 4 H, J = 7.5 Hz), 1.58 - 1.47 (m, 8 H), 1.35 - 1.10 (m, 8 H), 1.24 (t, 6 H, J = 7.2 Hz), 1.15 (s, 12 H). ^{13}C NMR (75 MHz, CDCl3/TMS): δ (ppm): 211.6, 178.3, 60.5, 43.1, 42.5, 40.9, 30.1, 25.5, 25.1, 24.1, 14.7. HRMS (LSIMS, nba): Calcd. for $C_{23}H_{43}O_5$ (MH+): 399.3110, found: 399.3129.

6.19 8-Oxo-2,2,14,14-tetramethylpentadecanedioic acid

A solution of KOH (25 g) in water (50 mL) was added to a solution of 2,2,14,14-tetramethyl-8-oxo-pentadecanedioic acid diethyl ester (10.69 g, 155 mmol) in ethanol (400 mL), then heated at reflux for 4 h. After cooling, the solution was evaporated to a volume of ca. 50 mL and diluted with water (800 mL). The organic impurities were removed by extracting with dichloromethane (2 x 200 mL). The aqueous layer was acidified to pH 2 with concentrated hydrochloric acid (50 mL) and extracted with methyl tert.-butyl ether (MTBE, 3 x 200 mL). The combined organic layers were dried over magnesium sulfate and concentrated in vacuo to give the crude product (9.51 g) as an oil. Crystallization from hexanes / MTBE (50 mL : 25 mL) afforded 8-oxo-2,2,14,14-tetramethylpentadecanedioic acid (6.92 g, 79 %) as waxy, white crystals. M.p.: 83 - 84 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 12.03 (s, 2 H), 2.37 (t, 4 H, J = 7.3 Hz), 1.52 – 1.34 (m, 8 H), 1.28 – 1.10 (m, 8 H), 1.06 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 210.5, 178.8, 41.7, 41.2, 29.1, 25.0, 24.4, 23.1. HRMS (LSIMS, gly): Calcd. for $C_{19}H_{35}O_5$ (MH+): 343.2484, found: 343.2485.

6.20 8-Hydroxy-2,2,14,14-tetramethylpentadecanedioic acid

Under nitrogen atmosphere, sodium borohydride (0.06 g, 1.6 mmol) was added to a stirred solution of 8-oxo-2,2,14,14-tetramethylpentadecanedioic acid (1.18 g, 3.4

mmol) in methanol (50 mL) at 0 °C. The reaction progress was monitored by thin layer chromatography (silica; hexanes : ethyl acetate = 50 : 50). Additional sodium borohydride was added after 1 h (0.48 g, 13 mmol). After 8 h, the reaction mixture was hydrolyzed with water (50 mL) and acidified with concentrated hydrochloric acid (3 mL) to pH 1. The solution was diluted with water (50 mL) and extracted with dichloromethane (4 x 25 mL). The combined organic layers were washed with saturated sodium chloride solution (2 x 30 mL), dried over magnesium sulfate, concentrated in vacuo, and dried in high vacuo to give 8-hydroxy-2,2,14,14-tetramethylpentadecanedioic acid (0.7 g, 60 %) as a very viscous oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.42 (br. s, 3 H), 3.59 (br. s, 1 H), 1.65 - 1.00 (m, 20 H), 1.18 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 184.5, 71.8, 42.1, 40.5, 37.0, 29.8, 25.2, 25.1, 24.9, 24.8. HRMS (FAB): Calcd. for $C_{19}H_{37}O_5$ (MH+): 345.2635, found: 345.2646. HPLC: 83.8 % purity.

6.21 <u>7-Isocyano-2,2-dimethyl-7-(toluene-4-sulfonyl)-heptanoic acid ethyl ester</u>

Under nitrogen atmosphere, to a solution of ethyl 6-bromo-2,2-dimethylhexanoate (Ackerley, N. J. Med. Chem. 1995, 38, 1608 - 1628) (36.60 g, 140 mmol), tetra-n-butylammonium iodide (4.23g, 11 mmol) and p-toluenesulfonyl methyl isocyanide (27.56 g, 140 mmol) in anhydrous DMSO (500 mL) was added sodium hydride (5.80 g, 146 mmol, 60 % dispersion in mineral oil) at 5 - 10 °C. The reaction mixture was stirred at room temperature for 20 h. The cooled solution was carefully quenched by addition of ice-water (1000 mL). The product was extracted with dichloromethane (3 x 150 mL). The combined organic layers were washed with water (200 mL) and saturated NaCl solution (2 x 200 mL), dried over MgSO4, and concentrated in vacuo to obtain the crude product mixture (40.9 g) as orange oil. The crude product (10.22 g) was subjected to column chromatography on silica gel eluting with hexanes/ethyl acetate (10 : 1) to give 7-isocyano-2,2-dimethyl-7-(toluene-4-sulfonyl)-heptanoic acid ethyl ester (2.05 g, 15 %) as a pale yellow oil and 7-isocyano-2,2,12,12-tetramethyl-7-(toluene-4-sulfonyl)-tridecanedioic acid diethyl ester (1.60 g, 8 %) as a colorless oil, together with a mixture of both (2.50 g, 7-isocyano-2,2-dimethyl-7-(toluene-4-sulfonyl)-heptanoic acid ethyl ester: 7-isocyano-2,2,12,12-tetramethyl-7-(toluene-4-sulfonyl)-tridecanedioic acid diethyl ester = 90 : 10). ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.86 (d, 2 H, J = 8.1 Hz), 7.43 (d, 2 H, J = 8.1 Hz), 4.48 (dd, 1 H, J = 7.2, 3.6 Hz), 4.11 (q, 2 H, J = 7.2 Hz), 2.49 (s, 3 H), 2.21 - 2.16 (m, 1 H), 1.90 - 1.78 (m, 1 H), 1.56 - 1.50 (m, 4 H), 1.25 (t, 5 H, J = 7.2 Hz), 1.16 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 177.8, 165.0, 146.7, 131.3, 130.3, 130.2, 72.9, 60.5, 42.2,

40.2, 28.3, 25.8, 25.3, 25.2, 24.2, 21.9, 14.4. HRMS (LSIMS, nba): Calcd. for $C_{19}H_{28}NO_4S$ (MH+): 366.1739, found: 366.1746.

6.22 Ethyl 12-hydroxy-2,2,11,11-tetramethyl-7-oxo-dodecanoate

Under nitrogen atmosphere, to a solution of 7-isocyano-2,2-dimethyl-7-(toluene-4-sulfonyl)-heptanoic acid ethyl ester (1.72 g, 4.71 mmol), tetra-n-butylammonium iodide (0.17g, 0.47 mmol) and 2-(5-bromo-2,2-dimethylpentyl)-tetrahydropyran (1.45 g, 4.95 mmol) in anhydrous DMSO (20 mL) was added sodium hydride (0.20 g, 4.75 mmol, 60 % dispersion in mineral oil) at 5 - 10 °C. The reaction mixture was stirred for 20 h at room temperature, and the cooled solution was carefully quenched by addition of ice-water (1000 mL). The product was extracted with dichloromethane (3 x 15 mL). The combined organic layers were washed with water (40 mL) and saturated sodium chloride solution (2 ′ 20 mL), dried over MgSO4, and concentrated in vacuo to obtain the crude intermediate (3.50 g) as a brown oil. This intermediate was dissolved in 48 % aqueous sulfuric acid (6 mL) and methanol (12 mL), stirred 100 min at room temperature, and diluted with water (50 mL). The product was extracted with dichloromethane (3 x 15 mL). The combined organic layers were washed with water (100 mL) and saturated NaCl solution (100 mL), dried over MgSO4, and concentrated in vacuo to obtain crude ethyl 12-hydroxy-2,2,11,11-tetramethyl-7-oxo-dodecanoate (2.70 g) as a yellow oil. The crude product (2.5 g) was subjected to column chromatography on silica gel eluting with hexanes/ethyl acetate (4 : 1, then 3 : 1) to give the pure product (0.82 g, 55 %) as a pale yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.14 - 4.03 (m, 2 H), 3.31 (br. s, 2 H), 2.42 (br. s, 1 H), 2.39 (m, 4 H), 1.54 - 1.48 (m, 6 H), 1.24 - 1.18 (m, 7 H), 1.14 (s, 6 H), 0.86 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 211.7, 178.0, 71.2, 60.3, 43.2, 42.7, 42.1, 40.4, 37.9, 35.1, 25.2, 24.6, 24.2, 24.1, 18.0, 14.3. HRMS (LSIMS, gly): Calcd. for $C_{18}H_{35}O_4$ (MH+): 315.2535, found: 315.2541.

6.23 2,2,11,11-Tetramethyl-7-oxo-dodecanedioic acid 1-ethyl ester

A mixture of ethyl 12-hydroxy-2,2,11,11-tetramethyl-7-oxo-dodecanoate (3.26 g, 10 mmol) and pyridinium dichromate (14.0 g, 36 mmol) in DMF (45 mL) was stirred at room temperature for 46 h. The solution was diluted with 48 % aqueous sulfuric acid (30 mL) and water (300 mL). The product was extracted with ethyl acetate (5 x 100 mL). The combined organic layers were washed with saturated NaCl solution (5 x 100 mL), dried over MgSO4, and concentrated to give the crude product (3.19 g) as a green oil. The crude product (3.1 g) was subjected to column chromatography on silica gel eluting with hexanes/ethyl acetate (3 : 1, then 2 : 1) to give pure 2,2,11,11-tetramethyl-7-oxo-

dodecanedioic acid 1-ethyl ester (2.69 g, 82 %) as a pale yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 11.30 (br. s, 1 H), 4.10 (q, 2 H, J = 7.2 Hz), 2.39 (t, 4 H, J = 7.2 Hz), 1.56 - 1.48 (m, 8 H), 1.24 (t, 5H, J = 7.2 Hz), 1.20 (s, 6 H), 1.15 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 210.9, 184.4, 178.1, 60.4, 43.1, 42.7, 42.2, 40.5, 39.8, 25.3, 25.0, 24.7, 24.3, 19.3, 14.4. HRMS (LSIMS, gly): Calcd. for $C_{18}H_{33}O_5$ (MH+): 329.2328, found: 329.2330.

6.24 2,2,11,11-Tetramethyl-6-oxo-dodecanedioc acid

A solution of 2,2,11,11-tetramethyl-7-oxo-dodecanedioic acid 1-ethyl ester (2.5 g, 7.2 mmol) and potassium hydroxide (1.8 g, 27.3 mmol) in water (3 mL) and ethanol (8 mL) was heated at reflux for 4 h. Ethanol was evaporated under reduced pressure and the residue was dissolved in water (10 mL). The solution was extracted with diethyl ether (50 mL) and then acidified with 6 N hydrochloric acid to pH 1. The product was extracted with diethyl ether (4 x 40 mL). The combined organic layers were washed with saturated NaCl solution (2 x 100 mL), dried over MgSO4, and concentrated in vacuo to give the crude product (2.17 g) as a white solid. The crude product (2.05 g) was recrystallized from diethyl ether/hexanes (30 mL/10 mL) to obtain pure 2,2,11,11-tetramethyl-6-oxo-dodecanedioc acid (1.94 g, 88 %) as white needles. M.p.: 72 – 73 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ ppm): 11.67 (br. s, 2 H), 2.41 (m, 4 H), 1.60 - 1.52 (m, 8 H), 1.29 - 1.24 (m, 2 H), 1.20 (s, 6 H), 1.18 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 211.2, 185.1, 184.9, 43.9, 42.7, 42.2, 40.3, 39.8, 25.1, 25.0, 24.7, 24.2, 19.3. HRMS (LSIMS, gly): Calcd. for $C_{16}H_{29}O_5$ (MH+): 301.2015, found: 301.2023. HPLC: 95.8 % purity.

6.25 2,2,11,11-Tetramethyl-6-hydroxy-dodecanedioc acid

To a solution of 2,2,11,11-tetramethyl-6-oxo-dodecanedioc acid (0.51 g, 1.5 mmol) in methanol (20 mL) was added sodium borohydride (0.60 g, 15.5 mmol) in portions at 0 □C. The mixture was stirred for 20 h, the methanol was evaporated, and the residue was carefully dissolved in 2 N hydrochloric acid (20 mL). The solution was extracted with dichloromethane (4 x 15 mL) and the aqueous layer acidified with 6 N hydrochloric acid to pH 1. The product was extracted with diethyl ether (4 x 40 mL). The combined organic layers were washed with saturated sodium chloride solution (2 x 100 mL), dried over magnesium sulfate, and concentrated to give the crude product (0.52 g) as a white solid. The crude product (0.51 g) was subjected to column chromatography on silica gel eluting with hexanes / ethyl acetate (2 : 1) to give pure 2,2,11,11-tetramethyl-6-hydroxy-dodecanedioc acid (0.42 g, 91 %) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 9.07 (br, s, 3 H), 3.53 (m, 1 H), 1.47 - 1.44 (m, 4 H), 1.35 (m, 6 H), 1.23 - 1.22 (m, 4 H), 1.11 (s, 6

H), 1.10 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 184.4, 184.3, 71.9, 42.2, 40.6, 40.5, 37.6, 37.1, 26.1, 25.1, 21.2. HRMS (LSIMS, gly): Calcd. for $C_{16}H_{31}O_5$ (MH+): 303.2171, found: 303.2157. HPLC: 86.3 % purity.

6.26 1-Ethyl 14-hydroxy-2,2,13,13-tetramethyl-7-oxo-tetradecanoate

Under nitrogen atmosphere, to a solution of crude 7-isocyano-2,2-dimethyl-7-(toluene-4-sulfonyl)-heptanoic acid ethyl ester (prepared as described above, but without chromatographic purification, 1.72 g, 4.71 mmol), tetra-n-butylammonium iodide (0.17g, .47 mmol) and 2-(7-bromo-2,2-dimethylheptyl)-tetrahydropyran (1.45 g, 4.95 mmol) in anhydrous DMSO (20 mL) was added sodium hydride (0.20 g, 4.75 mmol, 60 % dispersion in mineral oil) at 5 - 10 °C. The reaction mixture was stirred at room temperature for 20 h and the cooled solution was carefully quenched by addition of ice-water (1000 mL). The product was extracted with dichloromethane (3 x 15 mL). The combined organic layers were washed with water (40 mL) and saturated NaCl solution (2 x 20 mL), dried over MgSO4, and concentrated in vacuo to obtain the crude intermediate (3.50 g) as a brown oil. This intermediate was dissolved in 48 % aqueous sulfuric acid (6 mL) and methanol (12 mL). The mixture was stirred for 100 min and diluted with water (50 mL). The product was extracted with dichloromethane (3 x 15 mL). The combined organic layers were washed with water (100 mL) and saturated NaCl solution (100 mL), dried over MgSO4, and concentrated in vacuo to obtain the crude product (2.70 g) as a yellow oil. The crude product (2.5 g) was subjected to column chromatography on silica gel eluting with hexanes/ethyl acetate (4 : 1, then 3 : 1) to give pure 1-ethyl 14-hydroxy-2,2,13,13-tetramethyl-7-oxo-tetradecanoate (0.82 g, 55 %) as a pale yellow oil. ^1H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.10 (q, 2 H, J = 6.9 Hz), 3.30 (br. s, 2 H), 2.39 (t, 4 H, J = 6.9 Hz), 1.98 (br. s, 1 H), 1.56 - 1.48 (m, 6 H), 1.27 - 1.18 (m, 11 H), 1.14 (s, 6 H), 0.85 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 211.5, 178.0, 71.9, 60.3, 42.9, 42.7, 42.2, 40.5, 38.6, 35.1, 30.3, 25.2, 24.7, 24.3, 24.0, 23.8, 14.4. HRMS (LSIMS, gly): Calcd. for $C_{20}H_{39}O_4$ (MH+): 343.2848, found: 343.2846.

6.27 2,2,13,13-Tetramethyltetradecane-1,7,14-triol

Under Ar atmosphere, to a stirred suspension of lithium borohydride (0.30 g, 95 %, 13 mmol) in dichloromethane (80 mL) was added dropwise methanol (0.42 g, 13 mmol), keeping a gentle reflux while hydrogen gas was formed. The mixture was stirred for 10 min at 45 °C and a solution of 2,2,13,13-tetramethyl-7-oxo-tetradecanedioic acid 1-ethyl ester (1.57 g, 4.36 mol) in dichloromethane (10 mL) was added dropwise at such a rate as to maintain a gentle reflux. The reaction mixture was heated at reflux for 24 h, then cooled to

room temperature and carefully hydrolyzed with 2 N hydrochloric acid (50 mL) and saturated ammonium chloride solution (120 mL). The aqueous layer was extracted with dichloromethane (4 x 50 mL). The combined organic layers were washed with water (100 mL) and dried over anhydrous magnesium sulfate. The reaction mixture was concentrated to yield the crude product as a yellow oil (1.28 g). Purification by column chromatography on silica gel eluting with hexanes/ethyl acetate (4 : 1, then 3 : 1) followed by recrystallization from dichloromethane gave pure 2,2,13,13-tetramethyltetradecane-1,7,14-triol (0.86 g, 65 %) as white needles. M.p.: 79 – 80 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 3.57 (br. s, 1 H), 3.29 (s, 4 H), 2.17 (br. s, 3 H), 1.46 - 1.40 (m, 4 H), 1.33 - 1.24 (m, 12 H), 0.85 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 71.8, 71.7, 71.5, 38.7, 37.5, 37.3, 35.1, 30.7, 26.6, 25.7, 24.2, 24.0, 23.9, 23.8. HRMS (LSIMS, gly): Calcd. for $C_{18}H_{39}O_3$ (MH+): 303.2899, found: 303.2897. HPLC: 97 % purity.

6.28 <u>2,2,13,13-Tetramethyl-1,14-bis(tetrahydropyran-2-yloxy)tetradecan-6,9-diol</u>

A mixture of 2,5-dimethoxytetrahydrofuran (26.43 g, 0.2 mol) and 0.6 N hydrochloric acid (160 mL) was stirred at room temperature for 1.5 h. The pH was adjusted to 7 by addition of sodium hydrogen carbonate (8.4 g) and the solution was extracted with dichloromethane (3 ′ 50 mL). The aqueous phase was acidified with concentrated hydrochloric acid (10 mL) and stirred for another 1.5 h. Basification with sodium hydrogen carbonate (10.1 g) and extraction with dichloromethane was repeated. In total, the acidification - basification - extraction sequence was repeated four times. The combined organic extracts were dried over magnesium sulfate and the dichloromethane was distilled off under atmospheric pressure. The residue was distilled under reduced pressure (b.p.: 75 - 77 oC / 15 mm Hg) (House, H. O. *et al.*, J. Org. Chem. 1965, 30, 1061. B.p. = 55 - 60 °C / 12 mm Hg) to give succinaldehyde as a foul smelling, colorless liquid (5.71 g, 33 %), which was used immediately after distillation.

Under nitrogen atmosphere, to a stirred suspension of magnesium powder (3.65 g, 0.15 mol) in anhydrous THF (200 mL) was added 2-(5-bromo-2,2-dimethylpentyl)-tetrahydropyran (27.9 g, 0.1 mol) at such a rate as to maintain a gentle reflux. The reaction mixture was heated at reflux for additional 2 h, allowed to cool to room temperature, and then cooled in an ice-water bath. A solution of freshly distilled succinaldehyde (3.44 g, 0.04 mol) in THF (30 mL) was added dropwise. The reaction mixture was left to stir at room temperature overnight. The solution was decanted off the excess magnesium and poured into an aqueous saturated ammonium chloride solution (300 mL). The pH was carefully

adjusted to 1 - 2 with 2 N hydrochloric acid. The reaction mixture was extracted with diethyl ether and the organic extracts were washed with brine and dried over MgSO4. After solvent removal, a light-yellow oil (23.88 g) was obtained which was purified by flash column chromatography (SiO_2, ethyl acetate : hexanes = 1 : 3 to 1 :1) to afford the pure product as an almost colorless, very viscous oil (18.04 g, 92 %). ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.54 - 4.50 (m, 2 H), 3.89 - 3.82 (m, 2 H), 3.66 (br. s, 2 H), 3.48 (pseudo-t, 4 H, J = 9.6 Hz), 2.99 (dd, 2 H, J = 9.1, 3.5 Hz), 2.60 (br. s, 2 H), 1.90 - 1.20 (m, 28 H), 0.90 - 0.88 (m, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 99.4, 99.2, 76.4, 76.1, 72.1, 71.7, 71.3, 62.4, 62.0, 39.2, 38.8, 38.3, 38.2, 34.1, 33.4, 30.7, 30.6, 25.5, 24.9, 24.6, 24.5, 24.4, 20.0, 19.7, 19.5, 14.2. HRMS (LSIMS, nba): Calcd. for $C_{28}H_{55}O_6$ (MH+): 487.3998, found: 487.3995.

6.29 <u>Ethyl 8-bromo-2,2-dimethyloctanoate.</u>

Under N_2 atmosphere, a solution of LDA (2.0 M in heptane/tetrahydrofuran/ ethylbenzene, 2.94 L, 5.9 mol) was added dropwise to a stirred solution of ethyl isobutyrate (720 g, 6.2 mol) in anhydrous THF (4.7 L) at -45 °C. After 1 h, 1,6-dibromohexane (2400 g, 9.8 mol) was added dropwise, followed by the addition of DMPU (320 mL). The reaction mixture was stirred for 1 h and then allowed to warm to room temperature overnight. Saturated NH_4Cl solution (3 L) was added and the mixture was extracted with ethyl acetate (3 × 6 L). The combined organic layers were washed with brine (4.5 L), 1 M aqueous HCl (6 L), saturated $NaHCO_3$ solution (6 L), and brine (4.5 L). The solution was dried over $MgSO_4$ and concentrated in vacuo. The residue was distilled under high vacuo to furnish ethyl 8-bromo-2,2-dimethyloctanoate (856 g, 52 %) as a light yellowish oil. Bp 95 - 100 °C/0.2 mm. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.13 (q, *J* = 7.1, 2 H), 3.39 (t, *J* = 6.9, 2 H), 1.92 - 1.75 (m, 2 H), 1.58 - 1.25 (m, 8 H), 1.25 (t, *J* = 7.1, 3 H), 1.12 (s, 6 H).^{13}C NMR (75 MHz, $CDCl_3$ = 77.52 ppm): δ (ppm): 177.62, 60.01, 42.08, 40.50, 33.63, 32.68, 29.13, 27.93, 25.00, 24.66, 14.22. HRMS (LSIMS, nba): Calcd for $C_{12}H_{24}BrO_2$ (MH^+): 279.0960, found: 279.0957.

6.30 <u>9-Isocyano-2,2,16,16-tetramethyl-9-(toluene-4-sulfonyl)-heptadecanedioic acid diethyl ester.</u>

To a solution of ethyl 8-bromo-2,2-dimethyloctanoate (35.0 g, 125.4 mmol), tetrabutylammonium iodide (4.6 g, 12.5 mmol), and *p*-toluenesulphonylmethyl isocyanide (TosMIC, 12.2 g, 62.7 mmol) in anhydrous DMSO (450 mL) was added sodium hydride

(60% dispersion in mineral oil, 6.3 g, 158 mmol) under cooling with an ice-water bath and under N_2 atmosphere. The reaction mixture was stirred for 23 h at room temperature, then carefully hydrolyzed with ice-water (500 mL) and extracted with MTBE (3 × 200 mL). The organic layers were washed with water (300 mL) and brine (150 mL), dried over $MgSO_4$, and concentrated in vacuo to give crude 9-isocyano-2,2,16,16-tetramethyl-9-(toluene-4-sulfonyl)-heptadecanedioic acid diethyl ester (37.0 g, 100 %). ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.88 (d, J = 7.9 Hz, 2 H), 7.42 (d, J = 7.9 Hz, 2 H), 4.10 (q, J = 7.5 Hz, 4 H), 2.48 (s, 3H), 2.05-1.75 (m, 3H), 1.65-1.20 (m, 21H), 1.15 (t, J = 7.5 Hz, 6H), 1.10 (s, 12H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 177.89, 163.75, 146.23, 131.35, 130.28, 129.82, 81.79, 60.17, 42.09, 40.57, 33.09, 29.68, 25.17, 24.78, 23.66, 14.31. HRMS (LSIMS, gly): Calcd for $C_{37}H_{54}NO_6S$ (MH^+): 592.3672, found: 592.3667.

6.31 2,2,16,16-Tetramethyl-9-oxoheptadecanedioic acid diethyl ester

To a solution of 9-isocyano-2,2,16,16-tetramethyl-9-(toluene-4-sulfonyl)-heptadecanedioic acid diethyl ester (12.0 g, 20.3 mmol) in methylene chloride (200 mL) was added concd HCl (47 mL). The reaction mixture was stirred for 80 min at room temperature. The mixture was diluted with water (200 mL), the layers were separated, and the aqueous layer was extracted with methylene chloride (3 × 70 mL). The combined organic layers were washed with saturated $NaHCO_3$ solution (3 × 40 mL) and brine (50 mL). The solution was dried over $MgSO_4$, and concentrated in vacuo to yield the crude product (7.52 g). Purification by column chromatography (silica gel, ethyl acetate/hexanes = 1/9) gave 2,2,16,16-tetramethyl-9-oxoheptadecanedioic acid diethyl ester (3.5 g, 40 %) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.14 (q, J = 7.1 Hz, 4 H), 2.41 (t, J = 7.0 Hz, 4 H), 1.66-1.35 (m, 20 H), 1.25 (t, J = 7.1 Hz, 6 H), 1.17 (s, 12H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 211.24, 177.89, 60.01, 42.69, 42.07, 40.64, 29.86, 29.07, 25.13, 24.73, 23.74, 14.24. HRMS (LSIMS, gly): Calcd for $C_{25}H_{47}O_5$ (MH^+): 427.3423, found: 427.3430.

6.32 2,2,16,16-Tetramethylheptadecane-1,9,17-triol

Under N_2-atmosphere, methyl *tert*-butyl ether (MTBE, 80 mL) was added to lithium aluminum hydride (0.67 g, 17.60 mmol) and the suspension was stirred under cooling with an ice-water bath (0 °C). A solution of 2,2,16,16-tetramethyl-9-oxoheptadecanedioic acid diethyl ester (3.0 g, 7.04 mmol) in MTBE (20 mL) was added dropwise, followed by additional MTBE (40 mL). After 2 h at 0 °C, the reaction mixture

was carefully quenched by addition of ethyl acetate (8 mL, 80 mmol) and allowed to warm to room temperature overnight. The mixture was cooled with an ice-water bath and carefully hydrolyzed by addition of crushed ice (15 g) and water (15 mL). The pH was adjusted to 1 by addition of 2 *N* sulfuric acid (28 mL) and the solution was stirred at room temperature for 15 min. The layers were separated and the aqueous layer was extracted with MTBE (40 mL). The combined organic layers were washed with deionized water (50 mL), saturated $NaHCO_3$ solution (40 mL), brine (40 mL), dried over $MgSO_4$, concentrated in vacuo and dried in high vacuo to yield a crude product (2.65 g). The crude product was purified by recrystallization from hot CH_2Cl_2 (20 mL), which was cooled to room temperature and then kept at -5 °C. The crystals were filtered, washed with ice-cold CH_2Cl_2 (20 mL) and dried in high vacuo. This process was repeated to furnish 2,2,16,16-tetramethylheptadecane-1,9,17-triol (1.59 g, 65 %) as a white solid. Mp 75-77 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 3.57 (m, 1 H), 3.30 (s, 4 H), 1.72 (br, 2 H), 1.50-1.16 (m, 25 H), 0.85 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 72.09, 38.79, 37.61, 35.21, 30.70, 29.85, 25.78, 24.06, 23.92. HRMS (LSIMS, gly): Calcd for $C_{21}H_{45}O_3(MH^+)$: 345.3369, found: 345.3364. HPLC: 95 % pure.

6.33 <u>8-Hydroxy-2,2,12,12-tetramethylpentadecanedioic acid diethyl ester.</u>

To a solution of 2,2,12,12-tetramethyl-8-oxopentadecanedioic acid diethyl ester (33.6 g, 84.3 mmol) in 60 % aqueous isopropanol (337 mL) was added sodium borohydride (1.6 g, 41 mmol). The reaction mixture was heated to 45 °C for 2 h, diluted with water (400 mL), and extracted with MTBE (2 × 200 mL). The combined organic layers were washed with water (200 mL), dried over sodium sulfate, and concentrated in vacuo to give the crude product (33.0 g, 98 %). ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.11 (q, J = 7.2 Hz, 4 H), 3.55 - 3.45 (m, 1 H), 1.60-1.18 (m, 26 H), 1.15 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 178.1, 72.0, 60.3, 42.4, 40.9, 37.7, 30.4, 25.8, 25.4, 25.1, 14.5. HPLC: 87.5 % pure.

6.34 <u>2,2,14,14-Tetramethyl-8-(tetrahydropyran-2-yloxy)-pentadecanedioic acid diethyl ester.</u>

Under nitrogen atmosphere, 3,4-dihydro-2*H*-pyran (10.2 g, 121 mmol) was added dropwise to a stirred solution of 8-hydroxy-2,2,14,14-tetramethypentadecanedioic acid diethyl ester (16.1 g, 40 mmol) and *p*-toluenesulfonic acid monohydrate (catalytic amounts) in methylene chloride (100 mL) under cooling with an ice bath. The reaction

mixture was allowed to warm to room temperature and stirred overnight. After the reaction was completed (TLC), the solution was filtered through basic aluminum oxide (50 g), which was washed with methylene chloride (4 × 30 mL). The filtrate was concentrated in vacuo to give crude product (19.5 g), which was purified by chromatography (silica gel, 200 g, heptanes/ethyl acetate = 20:1, 10:1) yielding 2,2,14,14-tetramethyl-8-(tetrahydropyran-2-yloxy)-pentadecanedioic acid diethyl ester as a colorless oil (12.1 g, 62 %). ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.69 - 4.59 (m, 1 H), 4.11 (q, J = 7.3 Hz, 4 H), 3.98 - 3.82 (m, 1 H), 3.65 - 3.40 (m, 2 H), 2.00 - 1.18 (m, 26 H), 1.24 (t, J = 7.1 Hz, 6 H), 1.15 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 177.74, 97.36, 76.48, 62.61, 60.02, 42.05, 40.70, 40.63, 34.90, 33.38, 31.16, 30.32, 30.26, 25.48, 25.10, 24.86, 19.96, 14.23.

6.35 <u>2,2,14,14-Tetramethyl-8-(tetrahydropyran-2-yloxy)-pentadecane-1,15-diol.</u>

Under nitrogen atmosphere, $LiAlH_4$ (2.2 g, 58 mmol) was suspended in anhydrous MTBE (250 mL) and cooled with an ice/water bath. 2,2,14,14-Tetramethyl-8-(tetrahydropyran-2-yloxy)-pentadecanedioic acid diethyl ester (12.0 g, 24.7 mmol) in anhydrous MTBE (100 mL) was added dropwise over 1.5 h. This mixture was left overnight at ambient temperature. After the reaction was completed, deionized water (4 mL) was added followed by 20% aqueous NaOH solution (5 mL) and water (14 mL). The ether solution was decanted from the formed white residue. The residue was washed with MTBE (4 × 20 mL) and the combined ether solutions were dried over $MgSO_4$. The solvent was removed under reduced pressure to give crude 2,2,14,14-tetramethyl-8-(tetrahydropyran-2-yloxy)-pentadecane-1,15-diol as a colorless oil (8.9 g, 90 %), which was used without further purification. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.72 - 4.59 (m, 1 H), 4.03 - 3.84 (m, 1 H), 3.69 - 3.38 (m, 2 H), 3.31 (s, 4 H), 2.00 - 1.15 (m, 28 H), 0.87(s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 97.38, 76.57, 71.83, 62.65, 38.55, 34.96, 34.84, 33.33, 31.17, 30.75, 30.63, 26.92, 25.52, 24.95, 23.84, 23.70, 19.96. HRMS (EI, POS): Calcd for $C_{24}H_{48}O_4$ (M^+): 400.3553, found: 400.3564.

6.36 <u>Nicotinic acid 8-(tetrahydropyran-2-yloxy)-2,2,14,14-tetramethyl-15-nicotinoylpentadecyl ester.</u>

Anhydrous *tert*-butyl methyl ether (MTBE, 200 mL) and anhydrous pyridine (30 mL) were added to nicotinoyl chloride hydrochloride (12.3 g, 69 mmol). The mixture was stirred at room temperature under nitrogen atmosphere for 1 h, then cooled to 0 °C. A solution of 2,2,14,14-tetramethyl-8-(tetrahydropyran-2-yloxy)-pentadecane-1,15-diol (8.8 g,

21.9 mmol) in anhydrous MTBE (50 mL) was added and the mixture was stirred overnight at room temperature. The mixture was washed with deionized water (3 × 50 mL), saturated $NaHCO_3$ solution (2 × 50 mL) and brine (50 mL), and dried over magnesium sulfate. The solvent was removed under reduced pressure to give the crude product as a light yellow oil (11.1 g), which was purified by chromatography (silica gel, 75 g, heptanes:ethyl acetate = 10:1, 7:1, 5:1) to give nicotinic acid 8-(tetrahydropyran-2-yloxy)-2,2,14,14-tetramethyl-15-nicotinoylpentadecyl ester (9.2 g, 69 %) as a viscous, yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 9.37 - 9.15 (m, 2 H), 8.79 (dd, J = 4.8, 1.7 Hz, 2 H), 8.30 (dt, J = 7.9, 1.9 Hz, 2 H), 7.41 (dd, J = 4.8, 7.9 Hz, 2 H), 4.71 - 4.55 (m, 1 H), 4.07 (s, 4 H), 3.99 - 3.80 (m, 1 H), 3.69 - 3.52 (m, 1 H), 3.52 - 3.35 (m, 1 H), 1.92 - 1.08 (m, 26 H), 1.00 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 165.23, 153.34, 150.85, 136.99, 126.40, 123.36, 97.69, 76.77, 73.45, 62.91, 39.54, 39.49, 35.19, 34.23, 33.70, 31.42, 30.97, 30.88, 25.84, 25.74, 25.26, 24.61, 24.07, 20.25. HRMS (EI, POS): Calcd for $C_{36}H_{54}N_2O_6$ (M^+): 610.3982, found: 610.3977. Elemental analysis ($C_{36}H_{54}N_2O_6$): Calcd for C, 70.79; H, 8.91; N, 4.59. Found: C, 70.71; H, 9.06; N, 4.48.

6.37 <u>Nicotinic acid 8-hydroxy-2,2,14,14-tetramethyl-15-nicotinoylpentadecyl ester</u>

Nicotinic acid 8-(tetrahydropyran-2-yloxy)-2,2,14,14-tetramethyl-15-nicotinoylpentadecyl ester (9.0 g, 14.7 mmol) was heated in a mixture of glacial acetic acid, THF, and water (160 mL / 80 mL / 40 mL) to 45 °C for 6 h, then stirred overnight at ambient temperature. After the reaction was completed (TLC), the reaction mixture was poured onto ice (220 g), stirred for 30 - 45 min and extracted with methylene chloride (4 × 100 mL). The combined organic layers were washed with saturated $NaHCO_3$ solution (4 × 100 mL) and brine (100 mL), dried over $MgSO_4$, and concentrated to give a crude oil (7.9 g). Purification by chromatography (silica gel, 75 g, heptanes:ethyl acetate = 1:1) afforded nicotinic acid 8-hydroxy-2,2,14,14-tetramethyl-15-nicotinoylpentadecyl ester (4.5 g, 58 %) as a white solid. Mp 65 - 67 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 9.24 (s, 2 H), 8.78 (d, J = 3.8 Hz, 2 H), 8.31 (d, J = 8.0 Hz, 2 H), 7.42 (dd, J = 8.0, 4.9 Hz, 2 H), 4.08 (s, 4 H), 3.58 (br s, 1 H), 2.02 (br s, 1 H, OH), 1.62 - 1.08 (m, 20 H), 1.00 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 164.96, 153.03, 150.53, 136.81, 126.17, 123.16, 73.18, 71.58, 39.17, 37.41, 33.96, 30.44, 25.61, 24.37, 23.78. HRMS (EI, nba): Calcd for $C_{31}H_{47}N_2O_5$ (MH^+): 527.3485, found: 527.3482. HPLC: 99.7 % pure. Elemental analysis ($C_{31}H_{46}N_2O_5$): Calcd for C, 70.69; H, 8.80; N, 5.32. Found: C, 70.63; H, 8.83; N, 5.41.

6.38 Bis-(4-bromomethylphenyl)-methanone.

Under irradiation with a 100-W white lamp, a mixture of 4,4'-dimethylbenzophenone (40.0 g, 190.2 mmol), NBS (71.10 g, 399.5 mmol), and dichloromethane (700 mL) was heated to reflux for 8 h and stirred at room temperature for 12 h. The white precipitate was removed by filtration and the filtrate was concentrated. The residue (70 g) was purified by column chromatography on silica using hexanes/ethyl acetate (8:1, 6:1, then 4:1) as eluent to afford bis-(4-bromomethylphenyl)-methanone (52.3 g, 75 %) as a colorless solid. Mp 118 - 119 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.83 (d, 4 H, J = 7.8 Hz), 7.53 (d, 4 H, J = 7.8 Hz), 4.56 (s, 4 H). ^{13}C NMR (75 MHz, $CDCl_3$ =77.00 ppm): δ (ppm): 195.3, 142.4, 137.3, 130.6, 129.2, 32.4.

6.39 3-{4-[4-(2-Ethoxycarbonyl-2-methylpropyl)-benzoyl]-phenyl}-2,2-dimethylpropionic acid ethyl ester.

Under Ar atmosphere, to a solution of ethyl isobutyrate (18.2 g, 156.6 mmol) and DMPU (1 mL) in THF (30 mL) was added LDA (80 mL, 2 M in heptanes, 160 mmol) at -78 °C. The mixture was stirred for 30 min. A solution of bis-(4-bromomethylphenyl)-methanone (21.1 g, 57.3 mmol) in THF (100 mL) was added dropwise. The reaction mixture was allowed to stir overnight, gradually warming to room temperature. Most of the THF (120 mL) was removed under reduced presure. The mixture was hydrolyzed with 6 N aqueous HCl (30 mL), water (170 g), and saturated NH_4Cl solution(200 mL). The solution was extracted with ethyl acetate (200 mL, 2 × 100 mL). The organic layers were washed with half-saturated NaCl solution (100 mL), dried over $MgSO_4$, and concentrated under vacuum to give a crude oil (35.8 g). Purification by column chromatography on silica (800 g) using hexanes/ethyl acetate (10:1) as eluent afforded 3-{4-[4-(2-ethoxycarbonyl-2-methylpropyl)-benzoyl]-phenyl}-2,2-dimethylpropionic acid ethyl ester (8.50 g, 34 %) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.73 (d, 4 H, J = 8.1 Hz), 7.26 (d, 4 H, J = 8.1 Hz), 4.19 - 4.11 (m, 4 H), 2.97 (s, 4 H), 1.29 - 1.15 (m, 18 H). ^{13}C NMR (75 MHz, $CDCl_3$ = 77.00 ppm): δ (ppm): 195.8, 176.8, 142.9, 135.8, 129.9, 129.7, 60.4, 46.0, 43.4, 24.8, 14.1. HRMS (LSIMS, nba): Calcd for $C_{27}H_{35}O_5$ (M+H): 439.2484, found: 439.2487.

6.40 3-(4-{Hydroxy-[4-(3-hydroxy-2,2-dimethylpropyl)-phenyl]-methyl}-phenyl)-2,2-dimethylpropan-1-ol.

Under Ar atmosphere, to a suspension solution of $LiBH_4$ (1.55 g, 71.2 mmol) in CH_2Cl_2 (100 mL) was added methanol (2.28 g, 71.2 mmol) at room temperature. The mixture was stirred under reflux for 30 min. A solution of 3-{4-[4-(2-ethoxycarbonyl-2-methylpropyl)-benzoyl]-phenyl}-2,2-dimethylpropionic acid ethyl ester (4.0 g, 9.1 mmol) in CH_2Cl_2 (50 mL) was added dropwise. The reaction mixture was heated to reflux for 100 h. The mixture was hydrolyzed with 6 N HCl (10 mL), water (125 mL), and saturated NH_4Cl solution (125 mL). The solution was extracted with CH_2Cl_2 (2 × 50 mL). The combined organic layers were washed with saturated $NaHCO_3$ solution (150 mL), dried over $MgSO_4$, and concentrated under vacuum to give a mixture of 3-(4-{hydroxy-[4-(3-hydroxy-2,2-dimethyl-propyl)phenyl]-methyl}-phenyl)-2,2-dimethylpropan-1-ol and 3-(4-{hydroxy-[4-(3-hydroxy-2,2-dimethyl-propyl)-phenyl]-methyl}-phenyl)-2,2-dimethyl-propionic acid ethyl ester (2.7 g, ratio 40/60) as a colorless oil. Under Ar atmosphere, to a suspension solution of $LiBH_4$ (2.52 g, 116 mmol) in CH_2Cl_2 (80 mL) was added methanol (3.7 g, 116 mmol) at room temperature. The mixture was stirred at 45 °C for 30 min. A solution of the above mixture (2.70 g) in CH_2Cl_2 (20 mL) was added dropwise. The reaction mixture was heated to reflux for 76 h. The mixture was hydrolyzed with 6 N HCl (10 mL), water (150 g), and saturated NH_4Cl (150 mL), and the solution was extracted with CH_2Cl_2 (2 × 80 mL). The organic layers were washed with saturated NaCl (140 mL), dried over $MgSO_4$, and concentrated under vacuum. The residue was subjected to column chromatography on silica gel using hexanes/ethyl acetate (2:1, 1:1) as eluent to afford 3-(4-{hydroxy-[4-(3-hydroxy-2,2-dimethylpropyl)-phenyl]-methyl}-phenyl)-2,2-dimethylpropan-1-ol (0.45 g, 14 %) as a white solid. Mp 169 - 170 °C. ^1H NMR (300 MHz, CD_3OD/TMS): δ (ppm): 7.15 (d, 4 H, J = 7.8 Hz), 7.01 (d, 4 H, J = 7.8 Hz), 5.62 (s, 1 H), 3.11 (s, 4 H), 2.42 (s, 4 H), 0.71(s, 12 H). ^{13}C NMR (75 MHz, CD_3OD = 49.15ppm): δ (ppm): 143.6, 139.2, 131.6, 127.3, 76.8, 71.4, 45.2, 37.3, 24.5. HRMS (LSIMS, gly): Calcd for $C_{23}H_{31}O_2$ (M+H-H_2O): 339.2324, found: 339.2323. HPLC: 98.1 % pure.

6.41 3-(4-{[4-(2-Ethoxycarbonyl-2-methylpropyl)-phenyl]-hydroxymethyl}-phenyl)-2,2-dimethylpropionic acid ethyl ester.

A solution of 3-{4-[4-(2-ethoxycarbonyl-2-methylpropyl)-benzoyl]-phenyl}-2,2-dimethyl-propionic acid ethyl ester (4.40 g, 10.0 mmol) in methanol (80 mL) was cooled in an ice-water bath. Sodium borohydride (0.45 g, 13.7 mmol) was added and the mixture was stirred for 5 h. Water (150 mL) and dichloromethane (65 mL) were added and

the layers were separated. The aqueous layer was washed with dichloromethane (2 × 65 mL). The combined organic layers were washed with saturated NaCl solution (100 mL), dried over $MgSO_4$, and concentrated under vacuum. The residue was subjected to column chromatography on silica using hexanes/ethyl acetate (9:1 and 6:1) as eluent to afford 3-(4-{[4-(2-ethoxycarbonyl-2-methylpropyl)-phenyl]-hydroxymethyl}-phenyl)-2,2-dimethylpropionic acid ethyl ester (3.63 g, 82 %) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.24 (d, 4 H, J = 8.0 Hz), 7.07 (d, 4 H, J = 8.0 Hz), 5.77 (s, 1 H), 4.08 (q, 4 H, J = 7.1 Hz), 2.83 (s, 4 H), 2.62 (s, 1 H), 1.21 (t, 6 H, J = 7.1 Hz), 1.16 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$ = 77.23 ppm): δ (ppm): 177.6, 142.2, 137.3, 130.3, 126.3, 75.9, 60.5, 46.0, 43.4, 25.1, 14.3. HRMS (LSIMS, nba): Calcd for $C_{27}H_{35}O_4$ (M+H-H_2O): 423.2535, found: 423.2520.

6.42 3-{4-[4-(2-Carboxy-2-methylpropyl)-phenyl]-hydroxymethyl]-phenyl}-2,2-dimethylpropionic acid.

A solution of 3-(4-{[4-(2-ethoxycarbonyl-2-methylpropyl)-phenyl]-hydroxymethyl}-phenyl)-2,2-dimethylpropionic acid ethyl ester (3.6 g, 8.2 mmol) and potassium hydroxide (85 %, 2.16 g, 33.0 mmol) in ethanol (9 mL) and water (2.5 mL) was heated to reflux for 5 h. Diethyl ether (20 mL) was added and the mixture was stirred for 1 h, then diluted with water (50 mL). The mixture was extracted with diethyl ether (2 × 20 mL). The aqueous solution was acidified with 6 N HCl (ca. 8 mL) to pH 1 and extracted with dichloromethane (4 × 35 mL). The organic extracts were washed with saturated NaCl solution (50mL), dried over $MgSO_4$, and concentrated in vacuum to give 3-{4-[4-(2-carboxy-2-methylpropyl)-phenyl]-hydroxymethyl]-phenyl}-2,2-dimethylpropionic acid (3.18 g, 100 %) as colorless needles. Mp 114 - 116 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 10.0 - 8.0 (br, 2 H), 7.18 (d, 4 H, J = 8.0 Hz), 7.17 (d, 4 H, J = 8.0 Hz), 5.67 (s, 1 H), 2.81 (s, 4 H), 1.15 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$ = 77.23 ppm): δ (ppm): 184.3, 142.0, 136.9, 130.3, 126.5, 75.8, 45.8, 43.6, 24.9, 24.8. HRMS (LSIMS, nba): Calcd for $C_{23}H_{27}O_4$ (M+H): 367.1909, found: 367.1906. HPLC: 99.3 % pure.

6.43 Di-*m*-tolyl-methanone.

An oven-dried, three-necked 1-L flask equipped with magnetic stirring bar, gas inlet, dropping funnel, and condenser was flushed with nitrogen and loaded with *m*-tolunitrile (49.1 g, 419 mmol) and THF (30 mL). A solution of *m*-tolyl magnesium chloride in THF (1 M, 440 mL) was added dropwise at such a rate that the internal temperature was

kept below 50 °C. The mixture was heated to reflux for 18 h, then cooled to -15 °C, and hydrolyzed with ice-water (210 mL) and aqueous HCl (36.5 %, 300 mL). The mixture was stirred at room temperature for 30 min and heated to 80 °C for 18 h. Most of the THF (400 mL) was removed by distillation. The solution was extracted with MTBE (250 mL, 3 × 200 mL). The combined organic layers were washed with saturated $NaHCO_3$ solution (200 mL) and saturated NaCl solution (200 mL), dried over $MgSO_4$, and concentrated under vacuum to give di-*m*-tolyl-methanone (99.5 g, quantitative) as a red oil, which was used without further purification for the next step. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.62 (s, 2 H), 7.54 (d, 2 H, J = 7.0 Hz), 7.36 - 7.31 (m, 4 H), 2.37 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$ = 77.23 ppm): δ (ppm): 197.1, 138.1, 133.2, 130.5, 128.3, 127.4, 21.4 [lit. ref.: Coops, J.; Nauta, W. Th.; Ernsting, M. J. E.; Faber, M. A. C. *Recueil* **1940**, 57, 1109].

6.44 <u>Bis-(3-bromomethylphenyl)-methanone.</u>

Under irradiation with a 100-W white lamp, a mixture of di-*m*-tolyl-methanone (99.5 g, 473 mmol), NBS (195 g, 1096 mmol), and dichloromethane (1.4 L) was heated to reflux for 20 h. The precipitate was removed by filtration. The filtrate was washed with aqueous sodium hydroxide solution (8 %, 3 × 550 mL) and concentrated in vacuo to give the crude product as a pale yellow solid (130 g), which was recrystalized from methylene chloride/hexanes (800 mL/200 mL) affording bis-(3-bromomethylphenyl)-methanone (66.20 g, 38 %) as white crystals. Mp 147 - 148 °C (lit. mp 149 - 151 °C; Atzmuller, M.; Vogtle, F. *Chem. Ber.* **1978**, *111*, 2547-2556). ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.84 (s, 2 H), 7.75 - 7.64 (m, 4 H), 7.49 (t, 2 H, J = 7.7 Hz), 4.54 (s, 4 H). ^{13}C NMR (75 MHz, $CDCl_3$ = 77.00 ppm): δ (ppm): 195.6, 138.5, 138.0, 133.3, 130.6, 130.2, 129.1, 32.4.

6.45 <u>3-{3-[3-(2-Ethoxycarbonyl-2-methylpropyl)-benzoyl]-phenyl}-2,2-dimethylpropionic acid ethyl ester.</u>

Under Ar atmosphere, to a solution of ethyl isobutyrate (59 g, 513 mmol) in THF (100 mL) was added LDA (256 mL, 2 M in heptanes, 512 mmol) at -78 °C. The mixture was stirred for 30 min and a solution of bis-(3-bromomethylphenyl)-methanone (66.0 g, 179 mmol) in THF (100 mL) was added dropwise. The reaction mixture was allowed to stir overnight, gradually warming to room temperature. The mixture was hydrolyzed with ice (500 g) and water (800 g). The solution was extracted with MTBE (5 × 200 mL). The organic layers were washed with saturated $NaHCO_3$ solution (100 mL) and

saturated NaCl solution (100 mL), dried over $MgSO_4$, and concentrated under vacuum. The residual oil (95 g) was subjected to column chromatography on silica (800 g) using hexanes/ethyl acetate (10:1) as eluent to afford 3-{3-[3-(2-ethoxycarbonyl-2-methylpropyl)-benzoyl]-phenyl}-2,2-dimethylpropionic acid ethyl ester (49.4 g, 63 %) as a pale yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.67 (m, 2 H), 7.59 (s, 2 H), 7.40 - 7.38 (m, 4 H), 4.11 (q, 4 H, J = 7.2 Hz), 2.96 (s, 4 H), 1.23 (s, 12 H), 1.22 (t, 6 H, J = 7.2 Hz). ^{13}C NMR (75 MHz, $CDCl_3$ = 77.00 ppm): δ (ppm): 196.6, 176.9, 138.2, 137.4, 134.1, 131.5, 128.3, 127.9, 60.4, 45.9, 43.5, 25.0, 14.1. HRMS (LSIMS, gly): Calcd for $C_{27}H_{35}O_5$ (M+H): 439.2484, found: 439.2484.

6.46 <u>3-(3-{Hydroxy-[3-(3-hydroxy-2,2-dimethylpropyl)-phenyl]-methyl}-phenyl)-2,2-dimethylpropan-1-ol.</u>

Under Ar atmosphere, to a suspension of $LiAlH_4$ (7.90 g, 208 mmol) in MTBE (200 mL) was added dropwise a solution of 3-{3-[3-(2-ethoxycarbonyl-2-methylpropyl)-benzoyl]-phenyl}-2,2-dimethylpropionic acid ethyl ester (25.9 g, 59 mmol) in MTBE (150 mL). The reaction mixture was stirred at room temperature for 16 h and heated to reflux for 3 h. Ethyl acetate (100 mL) was added and the reaction mixture was heated to reflux for 1 h and cooled to room temperature. The reaction mixture was poured into ice (500 g) and acidified with hydrochloric acid solution (2 N, 800 mL). The aqueous solution was extracted with MTBE (4 × 200 mL). The combined organic layers were washed with saturated $NaHCO_3$ solution (200 mL) and saturated NaCl solution (200 mL), dried over $MgSO_4$, and concentrated under vacuum. The residue (22.6 g) was subjected to column chromatography on silica gel using hexanes/ethyl acetate (3:2) as eluent to afford 3-(3-{hydroxy-[3-(3-hydroxy-2,2-dimethylpropyl)-phenyl]-methyl}-phenyl)-2,2-dimethylpropan-1-ol (19.0 g, 90 %) as a white solid. Mp 98 - 99 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.26 - 7.19 (m, 6 H), 7.06 - 7.03 (m, 2 H), 5.80 (d, 1 H, J = 3.4 Hz), 3.23 (s, 4 H), 3.05 (d, 1 H, J = 3.4 Hz), 2.56 (s, 4 H), 2.07 (br d, 2 H, J = 4.4 Hz), 0.85 (s, 12 H). ^{13}C NMR (75 MHz, CD_3OD = 49.15 ppm): δ (ppm): 145.5, 140.2, 130.5, 130.1, 128.7, 125.4, 77.1, 71.5, 45.6, 37.4, 24.6, 24.5. HRMS (FAB, gly): Calcd for $C_{23}H_{33}O_3$ (M+H): 357.2430, found: 357.2388. HPLC: 99.8 % pure.

6.47 <u>3-(3-{[3-(2-Ethoxycarbonyl-2-methylpropyl)-phenyl]-hydroxymethyl}-phenyl)-2,2-dimethylpropionic acid ethyl ester.</u>

Under Ar atmosphere, to a solution of 3-{3-[3-(2-ethoxycarbonyl-2-methyl-propyl)-benzoyl]-phenyl}-2,2-dimethylpropionic acid ethyl ester (12.37 g, 28.2 mmol) in methanol (240 mL) was added sodium borohydride (0.45 g, 13.7 mmol) under cooling with

an ice water bath. The mixture was stirred for 5 h and water (480 mL) and dichloromethane (200 mL) were added. The aqueous layer was extracted with dichloromethane (2 × 200 mL). The combined organic layers were washed with saturated $NaHCO_3$ solution (150 mL and saturated NaCl solution (150 mL), dried over $MgSO_4$, and concentrated under vacuum to give 3-(3-{[3-(2-ethoxycarbonyl-2-methylpropyl)-phenyl]-hydroxymethyl}-phenyl)-2,2-dimethylpropionic acid ethyl ester (12.4 g, 100 %) as a colorless oil, which was used for the next step without further purification. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.20 - 7.18 (m, 4 H), 7.10 (s, 2 H), 7.00 - 6.98 (m, 2 H), 5.69 (d, 1 H, J = 3.2 Hz), 4.02 (q, 4 H, J = 7.1 Hz), 2.97 (d, 1 H, J = 3.2 Hz), 2.81 (s, 4 H), 1.19 (t, 6 H, J = 7.1 Hz), 1.13 (s, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$ = 77.23 ppm): δ (ppm): 177.6, 143.8, 138.2, 129.3, 128.5, 128.1, 124.8, 76.1, 60.5, 46.3, 43.6, 25.1, 25.0, 14.3. HRMS (LSIMS, gly): Calcd for $C_{27}H_{35}O_4$ (M+H-H_2O): 423.2535, found: 423.2542.

6.48 3-{3-[3-(2-Carboxy-2-methylpropyl)-phenyl]-hydroxymethyl]-phenyl}-2,2-dimethylpropionic acid.

A solution of 3-(3-{[3-(2-Ethoxycarbonyl-2-methylpropyl)-phenyl]-hydroxymethyl}-phenyl)-2,2-dimethylpropionic acid ethyl ester (12.8 g, 29.1 mmol) and potassium hydroxide (85 %, 7.4 g, 112.0 mmol) in ethanol (21 mL) and water (9 mL) was heated to reflux for 4 h. MTBE (100 mL) was added and the mixture was stirred for 72 h, then diluted with water (50 mL). The aqueous layer was extracted with MTBE (2 × 50 mL). The aqueous solution was acidified with 6 N HCl (ca. 20 mL) to pH 1 and extracted with dichloromethane (4 × 100 mL). The organic extracts were washed with saturated NaCl solution (50mL), dried over $MgSO_4$, and concentrated in vacuum to give a colorless solid (10.5 g, 94 %). Recrystallization from dichloromethane (50 mL) and ethanol (10 mL) yielded 3-{3-[3-(2-carboxy-2-methylpropyl)-phenyl]-hydroxymethyl]-phenyl}-2,2-dimethylpropionic acid (6.7 g, 60 %) in form of colorless crystals. Mp 116 - 117 °C. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.44 - 7.41 (m, 2 H), 7.26 - 7.22 (m, 4 H) 7.06 - 7.03 (m, 2 H), 5.73 (s, 1 H), 2.83 (m, 4 H), 1.27 (s, 6 H), 1.25 (s, 6 H). ^{13}C NMR (75 MHz, DMSO-d_6/TMS): δ (ppm): 178.9, 145.6, 138.2, 128.8, 128.5, 128.1, 124.7, 74.8, 45.9, 43.0, 25.2, 25.1. HRMS (LSIMS, EI): Calcd for $C_{23}H_{26}O_4$ $[M-H_2O]^+$: 366.1831, found: 366.1821. HLPC: 99.3 % pure.

6.49 2,2-Dimethyl-8-oxododecanoic acid ethyl ester

An aqueous solution of NaOH (30 %, 240 mL) was added dropwise to a stirred solution of 4-iodobutane (110.5 g, 0.6 mol), *p*-toluenesulfonyl methyl isocyanide

(58.6 g, 0.3 mol), and tetrabutylammonium iodide (8.0 g, 21.6 mmol) in CH_2Cl_2 (300 mL) at room temperature. The reaction mixture was stirred overnight and diluted with water (200 mL). The organic layer was separated and the aqueous layer was extracted with CH_2Cl_2 (3 × 100 mL). The organic layers were combined, washed with saturated NaCl solution (100 mL), dried over $MgSO_4$, and concentrated in vacuo. The residue was taken up in diethyl ether (3 × 200 mL) and filtered. The filtrate was concentrated and purified by column chromatography (silica gel, ethyl acetate/hexanes = 1:3) to give 1-(1-isocyanopentane-1-sulfonyl)-4-methylbenzene (65.7 g, 87 %) as an oil. Under N_2-atmosphere, sodium hydride (60 % dispersion in mineral oil, 11.0 g, 0.275 mol) was added in portions to a solution of ethyl 7-bromo-2,2-dimethylheptanoate (72.8 g, 0.27 mol) and 1-(1-isocyanopentane-1-sulfonyl)-4-methylbenzene (69.0 g, 0.27 mol) in DMSO (500 mL) and diethyl ether (500 mL) at room temperature. After 30 min, tetrabutylammonium iodide (8.0 g, 21.7 mmol) was added and the mixture was stirred for 5 h. A precipitate formed and additional DMSO (500 mL) was added. After stirring overnight at room temperature, the mixture was heated to reflux for 3 h. Water (500 mL) and diethyl ether (500 mL) were added and the layers were separated. The aqueous layer was extracted with diethyl ether (4 × 200 mL). The combined organic layers were washed with water (500 mL) and saturated NaCl solution (300 mL), dried over $MgSO_4$, and concentrated in vacuo to give crude 8-isocyano-2,2-dimethyl-8-(toluene-4-sulfonyl)-dodecanoic acid ethyl ester (126.2 g) as a dark oil, which was used without further purification. Concentrated, hydrochloric acid (200 mL) was added slowly to a solution of crude 8-isocyano-2,2-dimethyl-8-(toluene-4-sulfonyl)-dodecanoic acid ethyl ester (126.2 g, 0.29 mol) in methylene chloride (300 mL). The reaction mixture was stirred at room temperature for 4 h. Water (500 mL) was added. The aqueous layer was separated and extracted with methylene chloride (3 × 100 mL). The organic solutions were combined, washed with water (300 mL) and saturated, aqueous $NaHCO_3$ solution (200 mL) and dried over $MgSO_4$. The solvent was evaporated and the residue was purified by column chromatography (silica gel, ethyl acetate/hexanes = 1:10) to yield 2,2-dimethyl-8-oxododecanoic acid ethyl ester (69.6 g, 89 %) as an oil. ^1H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 4.1 (q, J = 7.3 Hz, 2 H), 2.40 - 2.31 (m, 4 H), 1.58 - 1.45 (m, 6 H), 1.31 - 1.19 (m, 6H), 1.22 (t, 3 H, J = 7.3 Hz), 1.12 (s, 6 H), 0.88 (t, J = 7.3 Hz, 3 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 210.5, 178.0, 60.5, 42.5, 42.0, 30.0, 27.0, 26.0, 25.5, 24.0, 23.0, 14.5, 14.0. HRMS (LSIMS, gly): Calcd for $C_{16}H_{31}O_3$ (MH^+): 271.2273, found: 271.2275. HPLC: 84 % pure.

6.50 2,2-Dimethyldodecane-1,8-diol

A solution of 2,2-dimethyl-8-oxododecanoic acid ethyl ester (14.33 g, 5.3 mmol) in Et_2O (30 mL) was added to a suspension of $LiAlH_4$ (4.6 g, 12 mmol) in Et_2O (200 mL). The reaction mixture was heated to reflux for 2 h. Water (100 mL) and aqueous HCl (10 %, 200 mL) were added. The aqueous solution was separated and extracted with Et_2O (2 × 100 mL). The combined organic solutions were washed with saturated, aqueous $NaHCO_3$ solution (100 mL) and brine (50 mL) and dried over $MgSO_4$. The solvent was evaporated and the residue was purified by column chromatography (silica gel, ethyl acetate/hexanes = 1:10, 200 mL, then 1:3, 150 mL) to yield 2,2-dimethyldodecan-1,8-diol (9.9 g, 81 %) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 3.55 (br s, 1 H), 3.29 (s, 2 H), 1.7 (br. s, 2 H), 1.42 - 1.20 (m, 16 H), 0.89 (t, J = 7.2 Hz, 3 H), 0.84 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 72.1, 72.0, 38.7, 37.6, 37.3, 35.2, 30.8, 28.0, 25.8, 24.0, 23.9, 22.9, 14.3. HRMS (LSIMS, gly): Calcd for $C_{14}H_{31}O_2$ (MH^+): 231.2324, found: 231.2324. HPLC: 99.8 % pure. Elemental analysis ($C_{14}H_{30}O_2$): Calcd for C, 72.99; H, 13.12. Found: C, 72.75; H, 13.23.

6.51 8-Hydroxy-2,2-dimethyldodecanoic acid

Sodium borohydride (8.0 g, 0.21 mol) was added in portions to 2,2-dimethyl-8-oxododecanoic acid (27.02 g, 0.11 mol) in ethanol (200 mL), followed by addition of Na_2CO_3 (5 g) while the reaction mixture was gently refluxed. The reaction mixture was stirred at 40 - 50 °C for 3.5 h and at 60 °C for 1 h. Water (100 mL) and aqueous HCl (10 %, 100 mL) were added. The mixture was extracted with ethyl acetate (3 × 80 mL). The organic solutions were combined, washed with water (100 mL) and brine (2 × 50 mL), and dried over $MgSO_4$. The solvent was evaporated and the residue was purified twice by column chromatography (silica gel, ethyl acetate/heptane = 1:3). Coevaporation with toluene and drying in high vacuo at 70 °C for 1 h gave 8-hydroxy-2,2-dimethyldodecanoic acid (9. 6 g, 35 %) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 7.5 - 6.5 (br , 1 H), 3.60 (m, 1 H), 1.53 - 1.29 (m, 17 H), 1.21 (s, 6 H), 0.91 (t, J = 6.6 Hz, 3 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 185.0, 73.0, 43.1, 41.5, 38.2, 38.0, 31.2, 28.8, 26.5, 26.0, 25.9, 23.8, 15.1. HRMS (LSIMS, gly): Calcd for $C_{14}H_{29}O_3$ (MH^+): 245.2116, found: 245.2107. HPLC: 97.1 % pure. Elemental analysis ($C_{14}H_{28}O_3$): Calcd for C, 68.81; H, 68.67. Found: C, 68.67; H, 11.64.

6.52 2,2,13,13-Tetramethyl-1,14-*bis*(tetrahydropyran-2-yloxy)tetradecan-6,9-diol

A mixture of 2,5-dimethoxytetrahydrofuran (26.43 g, 0.2 mol) and 0.6 *N* hydrochloric acid (160 mL) was stirred at room temperature for 1.5 h. The pH was adjusted

to 7 by addition of sodium hydrogen carbonate (8.4 g) and the solution was extracted with dichloromethane (3 × 50 mL). The aqueous phase was acidified with concentrated hydrochloric acid (10 mL) and stirred for another 1.5 h. Basification with sodium hydrogen carbonate (10.1 g) and extraction with dichloromethane was repeated. In total, the acidification - basification - extraction sequence was repeated four times. The combined organic extracts were dried over magnesium sulfate and the dichloromethane was distilled off under atmospheric pressure. The residue was distilled under reduced pressure (b.p.: 75 - 77 °C / 15 mm Hg) (House, H. O. et al., *J. Org. Chem.* **1965**, *30*, 1061. B.p. = 55 - 60 °C / 12 mm Hg) to give succinaldehyde as a foul smelling, colorless liquid (5.71 g, 33 %), which was used immediately after distillation.

Under nitrogen atmosphere, to a stirred suspension of magnesium powder (3.65 g, 0.15 mol) in anhydrous THF (200 mL) was added 2-(5-bromo-2,2-dimethylpentyl)-tetrahydropyran (27.9 g, 0.1 mol) at such a rate as to maintain a gentle reflux. The reaction mixture was heated at reflux for additional 2 h, allowed to cool to room temperature, and then cooled in an ice-water bath. A solution of freshly distilled succinaldehyde (3.44 g, 0.04 mol) in THF (30 mL) was added dropwise. The reaction mixture was left to stir at room temperature overnight. The solution was decanted off the excess magnesium and poured into an aqueous saturated ammonium chloride solution (300 mL). The pH was carefully adjusted to 1 - 2 with 2 *N* hydrochloric acid. The reaction mixture was extracted with diethyl ether and the organic extracts were washed with brine and dried over $MgSO_4$. After solvent removal, a light-yellow oil (23.88 g) was obtained which was purified by flash column chromatography (SiO_2, ethyl acetate : hexanes = 1 : 3 to 1 :1) to afford the pure product as an almost colorless, very viscous oil (18.04 g, 92 %). ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ(ppm): 4.54 - 4.50 (m, 2 H), 3.89 - 3.82 (m, 2 H), 3.66 (br. s, 2 H), 3.48 (pseudo-t, 4 H, J = 9.6 Hz), 2.99 (dd, 2 H, J = 9.1, 3.5 Hz), 2.60 (br. s, 2 H), 1.90 - 1.20 (m, 28 H), 0.90 - 0.88 (m, 12 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 99.4, 99.2, 76.4, 76.1, 72.1, 71.7, 71.3, 62.4, 62.0, 39.2, 38.8, 38.3, 38.2, 34.1, 33.4, 30.7, 30.6, 25.5, 24.9, 24.6, 24.5, 24.4, 20.0, 19.7, 19.5, 14.2. HRMS (LSIMS, nba): Calcd. for $C_{28}H_{55}O_6$ (MH^+): 487.3998, found: 487.3995.

6.53 <u>2,2,13,13-Tetramethyltetradecan-1,6,9,14-tetraol</u>

A solution of 2,2,13,13-tetramethyl-1,14-*bis*(tetrahydropyran-2-yloxy)tetradecane-6,9-diol (5.07 g, 0.01 mol) in methanol (100 mL) was treated with dilute aqueous sulfuric acid (5 mL of concentrated sulfuric acid in 15 mL of water), and stirred at room temperature overnight. The methanol was removed under reduced pressure and the

residue was extracted with ethyl acetate (100 mL). The aqueous phase was saturated with solid sodium chloride and extracted again with ethyl acetate (75 mL). The combined organic extracts were washed with a saturated sodium chloride solution (50 mL) and dried over magnesium sulfate. The solid obtained after solvent removal was washed with diethyl ether (10 mL) to give 2,2,13,13-tetramethyltetradecan-1,6,9,14-tetraol (1.85 g, 58 %) as a white powder. M.p.: 96 – 97 °C. ^{1}H NMR (300 MHz, DMSO-d_6/TMS): δ (ppm): 4.42 (pseudo-t, 2 H, J = 5.0 Hz), 4.28 (pseudo-t, 2 H, J = 5.0 Hz), 3.37 - 3.34 (m, 2 H), 3.06 (d, 4 H, J = 5.0 Hz), 1.47 – 1.08 (m, 16 H), 0.77 (s, 12 H). ^{13}C NMR (75 MHz, DMSO-d_6/TMS): δ (ppm): 70.1, 69.9, 38.8, 38.4, 34.9, 33.7, 24.2, 19.7. HRMS (LSIMS, nba): Calcd. for $C_{18}H_{39}O_4$ (MH^+): 319.2843, found: 319.2853.

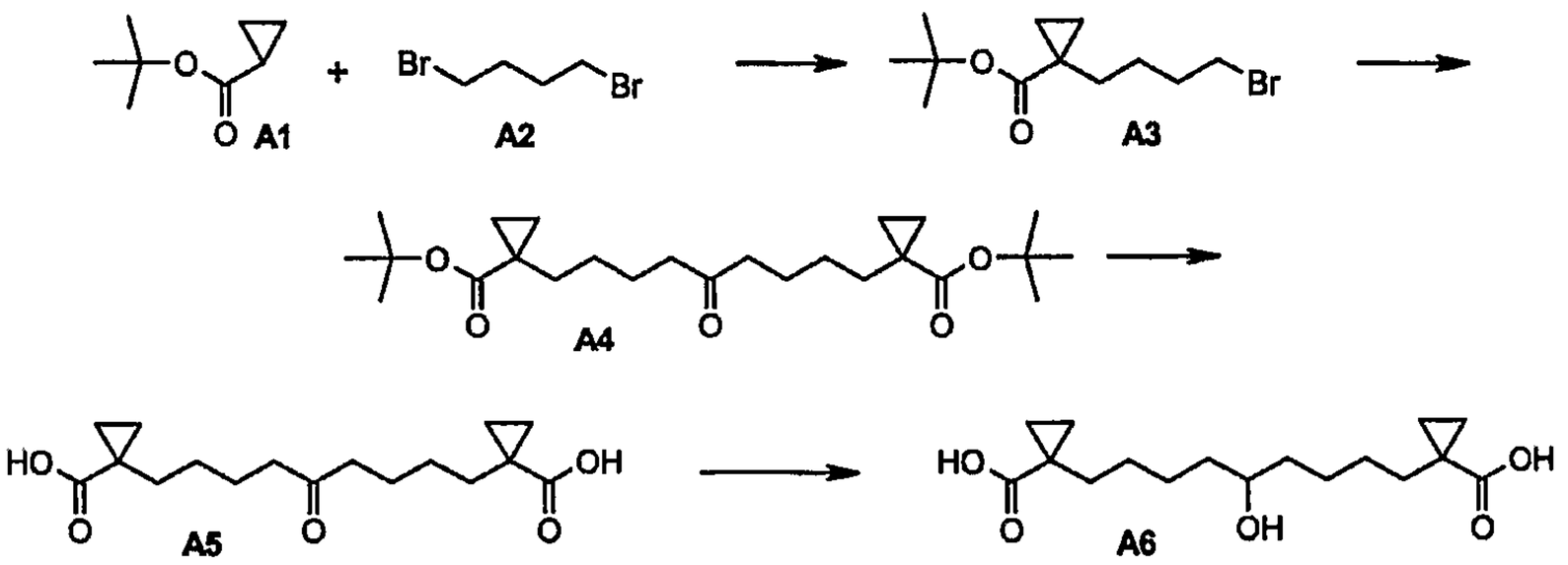
6.54 2,2,14,14-Tetramethyl-1,15-*bis*(tetrahydropyran-2-yloxy)pentadecan-6,10-diol

A solution of glutaric aldehyde (50 % wt. aqueous, 25 mL) was extracted with dichloromethane (4 × 50 mL). The organic extracts were dried over $MgSO_4$ and the dichloromethane was removed by distillation under atmospheric pressure. The residue was distilled under reduced pressure (B.p.: 65 - 66 °C / 5 mm Hg) (House, H. O. et al., *J. Org. Chem.* **1965**, *30*, 1061. B.p. = 68 - 69 °C / 25 mm Hg) to give glutaric aldehyde as a foul smelling, colorless liquid (7.97 g, 64 %), which was used immediately after distillation. Under nitrogen atmosphere, to a stirred suspension of magnesium powder (4.8 g, 0.2 mol) in anhydrous THF (200 mL) was added 2-(5-bromo-2,2-dimethylpentyl)-tetrahydropyran (36.9 g, 0.132 mol) at such a rate as to maintain a gentle reflux. The reaction mixture was heated at reflux for additional 2 h, allowed to cool to room temperature, and cooled in an ice-water bath. A solution of freshly distilled glutaric aldehyde (6.0 g, 0.06 mol) in anhydrous THF (30 mL) was added dropwise. The reaction mixture was left to stir at room temperature overnight. The solution was decanted off the excess magnesium and poured into aqueous saturated ammonium chloride solution (500 mL). The pH was carefully adjusted to 1 - 2 with 2 *N* hydrochloric acid and the reaction mixture was extracted with diethyl ether. The organic extracts were washed with brine and dried over $MgSO_4$. After solvent removal, a colorless oil (34.10 g) was obtained which was purified by flash column chromatography (SiO_2, ethyl acetate : hexanes = 1 : 5 to 1 : 1) to afford the pure product as an almost colorless, very viscous oil (16.67 g, 56 %). ^{1}H NMR (300 MHz, $CDCl_3$/TMS): δ (ppm): 0.89, 0.90 (2 × s, 12 H), 1.20 - 1.90 (m, 32 H), 2.99 (dd, J = 9.1, 3.2 Hz, 2 H), 3.48 (pseudo-t, J = 8.6 Hz, 4 H), 3.63 (br. s, 2 H), 3.80 - 3.88 (m, 2 H), 4.51 - 4.54 (m, 2 H). ^{13}C NMR (75 MHz, $CDCl_3$/TMS): δ (ppm): 19.5, 19.7, 19.8, 20.0, 21.7, 24.4, 24.6, 24.8, 25.5,

30.7, 34.2, 37.4, 38.2, 38.9, 39.2, 62.0, 62.3, 71.5, 71.8, 76.3, 99.2, 99.3. HRMS (LSIMS, nba): Calcd. for $C_{29}H_{57}O_6$ (MH^+): 501.4155, found 501.4152.

6.55 2,2,14,14-Tetramethylpentadecane-1,6,10,15-tetraol.

To a solution of 2,2,14,14-tetramethyl-1,15-*bis*(tetrahydropyranyloxy)-pentadecane-6,10-diol (5.75 g, 11.5 mmol) in methanol (100 mL) was added dilute aqueous sulfuric acid (1 mL of concentrated sulfuric acid in 9 mL of water) at room temperature. The reaction mixture was stirred at room temperature for 5 h, diluted with water (20 mL), and the methanol was removed under reduced pressure. The residue was extracted with ethyl acetate. The organic extract was separated and washed with water (30 mL) and saturated sodium chloride solution (30 mL). The combined aqueous extracts were saturated with solid sodium chloride and re-extracted with ethyl acetate (50 mL). The combined organic extracts were dried over magnesium sulfate and concentrated in vacuo to give a colorless oil (4 g) which was dissolved in the minimum amount of dichloromethane and treated with hexanes for 15 min. After 2 h at room temperature, the product crystallized as a white solid. Filtration and additional washing with hexanes (10 mL) gave 2,2,14,14-tetramethylpentadecane-1,6,10,15-tetraol (3.06 g, 80 %) as a white solid. M.p.: 85 – 86 °C. ^{1}H NMR (300 MHz, DMSO-d_6/TMS): δ (ppm): 4.40 (t, 2 H, J = 5.3 Hz), 4.20 (d, 2 H, J = 5.5 Hz), 3.40 - 3.30 (m, 2 H), 3.06 (d, 4 H, J = 5.3 Hz), 1.50 - 1.05 (m, 18 H), 0.77 (s, 12 H). ^{13}C NMR (75 MHz, DMSO-d_6/TMS): δ (ppm): 69.9, 69.7, 38.4, 37.5, 34.8, 24.1, 21.7, 19.7. HRMS (LSIMS, nba): Calcd. for $C_{19}H_{41}O_4$ (MH^+): 333.3005, found 333.2997.



6.56 *Tert*-Butyl 1-(4-bromo-butyl)-cyclopropanecarboxylate.

Under a N_2 atmosphere at -60°C, a solution of *tert*-butyl cyclopropanecarboxylate (80.05 g, 0.507 mol) and 1,4-dibromobutane (219.3 g, 1.01 mol) in dry THF (800 mL) was added drop wise to a solution of LDA (2 M in

THF/heptane/ethylbenzene, 380 mL, 0.76 mol) in 1.5 h. Stirring was continued for 5 h, during which the reaction mixture was allowed to slowly reach rt. After that, the reaction mixture was poured into saturated aqueous NH_4Cl (1 L). The organic layer was separated and concentrated *in vacuo* to a smaller volume. The aqueous layer was extracted with Et_2O (3 x 200 mL). The combined organic layers were washed with saturated aqueous NH_4Cl (2 x 400 mL) and brine (400 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was purified by fractional distillation under reduced pressure to give *tert*-Butyl 1-(4-bromo-butyl)-cyclopropanecarboxylate (51.4 g, 94% pure by GC, 34%) as a slightly yellow oil. bp: T = 93-96 °C (p = 0.075-0.087 Torr). ^{1}H NMR ($CDCl_3$): δ = 3.40 (t, J = 6.8 Hz, 2H), 1.85 (quintet, J = 7.1 Hz, 2H), 1.65-1.46 (m, 4H), 1.43 (s, 9H), 1.12 (q, J = 3.5 Hz, 2H), 0.60 (q, J = 3.5 Hz, 2H). ^{13}C NMR ($CDCl_3$): δ = 174.0, 79.8, 33.6, 33.2, 32.8, 27.9 (3x), 26.3, 23.9, 15.1 (2x). HRMS calcd for $C_{12}H_{21}BrO_2$ (MH^+): 277.0803, found: 277.0807.

6.57 <u>*Tert*-butyl 1-[9-[1-(*tert*-butoxycarbonyl)cyclopropyl]-5-oxononyl]-1-cyclopropanecarboxylate.</u>

Under a N_2 atmosphere, NaH (60%($^w/_w$) in mineral oil, 2.91 g, 72.8 mmol) was added portion wise to a solution of TosMIC (5.85 g, 30.0 mmol) and Bu_4NI (1.10 g, 2.98 mmol) in dry DMSO (100 mL) while stirring vigorously and cooling with a water bath. After 10 min, *tert*-Butyl 1-(4-bromo-butyl)-cyclopropanecarboxylate (16.56 g, 94% pure by GC, 56.2 mmol) was added drop wise in 20 min and stirring was continued for 1 h and 50 min. Then, H_2O (100 mL) was added drop wise and the resulting mixture was extracted with Et_2O (3 x 100 mL). The combined organic layers were washed with brine (2 x 100 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining oil was purified by column chromatography (silica, heptane:EtOAc = 6:1) to give *t*ert-butyl 1-{9-[1-(*t*ert-butoxycarbonyl)cyclopropyl]-5-isocyano-5-[(4-methylphenyl)sulfonyl]nonyl}-1-cyclopropanecarboxylate (10.00 g) as a slightly yellow oil. The above mentioned oil (10.00 g) was dissolved in CH_2Cl_2 (200 mL) and conc aqueous HCl (4 mL) was added. After stirring vigorously for 1 h, H_2O (100 mL) was added and the layers were separated. The aqueous phase was extracted with CH_2Cl_2 (100 mL) and the combined organic layers were washed with saturated aqueous $NaHCO_3$ (3 x 100 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was purified by column chromatography (silica, heptane:EtOAc = 10:1) to give *tert*-butyl 1-[9-[1-(*tert*-butoxycarbonyl)cyclopropyl]-5-oxononyl]-1-cyclopropanecarboxylate (5.80 g, 49%) as a colorless oil. ^{1}H NMR ($CDCl_3$): δ = 2.39 (t, J = 7.3 Hz, 4H), 1.63-1.38 (m, 30H), 1.10 (dd, J = 6.6, 3.9 Hz, 4H), 0.59 (dd, J = 6.7, 3.9 Hz, 4H). ^{13}C NMR ($CDCl_3$): δ = 211.1, 174.4 (2x), 79.9 (2x), 42.7 (2x), 33.9 (2x),

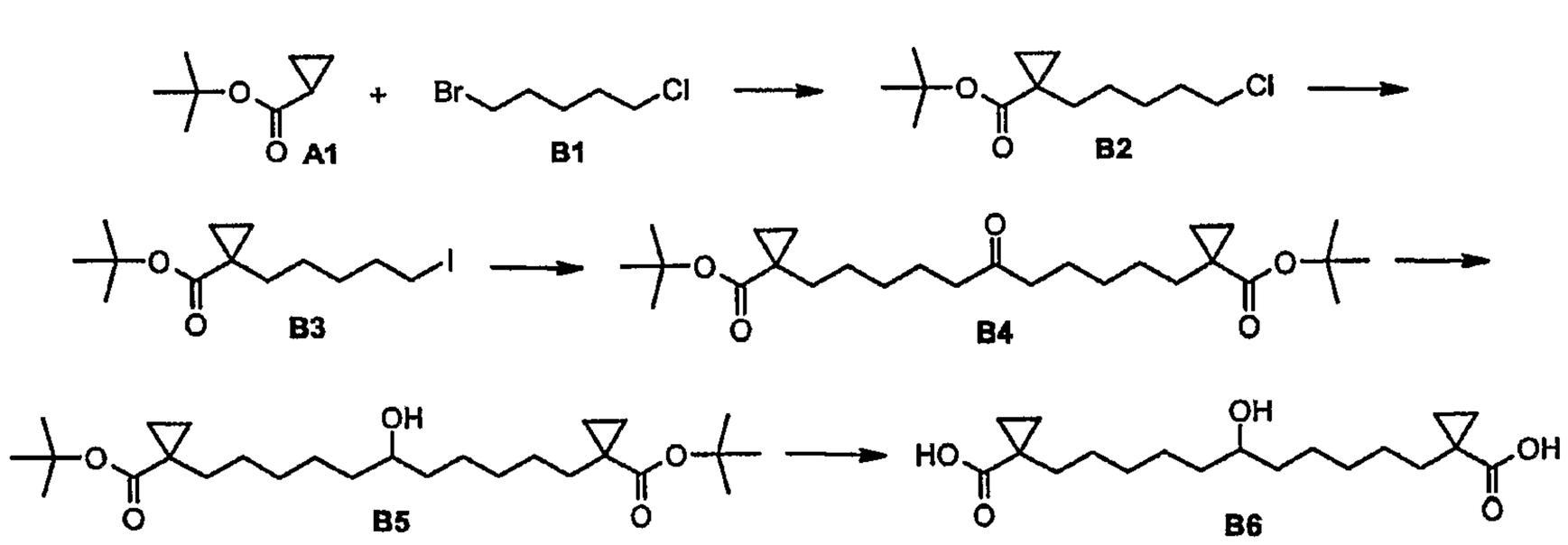
28.0 (6x), 27.4 (2x), 24.1 (2x), 24.0 (2x), 15.2 (4x). HRMS calcd for $C_{25}H_{43}O_5$ (MH^+): 423.3111, found: 423.3111.

6.58 <u>1-[9-(1-Carboxycyclopropyl)-5-oxononyl]-1-cyclopropanecarboxylic acid.</u>

A solution of *tert*-butyl 1-[9-[1-(*tert*-butoxycarbonyl)cyclopropyl]-5-oxononyl]-1-cyclopropanecarboxylate (5.31 g, 12.6 mmol) in HCO_2H (50 mL) was stirred for 3 h, evaporated *in vacuo* and coevaporated from toluene (3 x 25 mL) to give 1-[9-(1-carboxycyclopropyl)-5-oxononyl]-1-cyclopropanecarboxylic acid (3.89 g, 99%) as a white solid. An analytical sample was obtained after recrystallization from iPr_2O/heptane. mp: 132-134 °C. ^1H NMR (CD_3OD): δ = 2.45 (t, *J* = 6.9 Hz, 4H), 1.58-1.39 (m, 12H), 1.14 (dd, *J* = 6.6, 3.7 Hz, 4H), 0.70 (dd, *J* = 6.8, 3.9 Hz, 4H). ^{13}C NMR (CD_3OD): δ = 214.4, 179.4 (2x), 43.5 (2x), 34.9 (2x), 28.5 (2x), 25.1 (2x), 24.2 (2x), 16.2 (4x). Anal. calcd for $C_{17}H_{26}O_5$: C, 65.78; H, 8.44, found: C, 65.40; H, 8.37.

6.59 <u>1-[9-(1-Carboxycyclopropyl)-5-hydroxynonyl]-1-cyclopropanecarboxylic acid.</u>

To a suspension of 1-[9-(1-carboxycyclopropyl)-5-oxononyl]-1-cyclopropanecarboxylic acid (6.95 g, 22.4 mmol) in *i*PrOH (40 mL) and H_2O (40 mL) was added NaOH (1.80 g, 45.0 mmol). After 30 min of stirring, $NaBH_4$ (0.45 g, 11.8 mmol) was added to the resulting clear solution. After 3 h and 15 min, the mixture was acidified to pH~1 with aqueous HCl (1M) and extracted with Et_2O (3 x 100 mL). The combined organic phases were dried (Na_2SO_4) and evaporated in *vacuo* to give 1-[9-(1-carboxycyclopropyl)-5-hydroxynonyl]-1-cyclopropanecarboxylic acid (6.02 g, 86%) as a slightly yellow oil. ^1H NMR (CD_3OD): δ = 3.49 (br s, 1H), 1.57-1.25 (m, 16H), 1.14 (dd, *J* = 3.6, 6.3, 4H), 0.70 (dd, *J* = 3.3, 6.3, 4H). ^{13}C NMR (CD_3OD): δ = 178.9 (2x), 72.2, 38.4 (2x), 35.1 (2x), 28.9 (2x), 27.0 (2x), 24.3 (2x), 16.3 (2x), 16.2 (2x).



6.60 *Tert*-butyl 1-(5-chloropentyl)-1-cyclopropanecarboxylate.

Under an Ar atmosphere at 0 °C, BuLi (2.5M in hexanes, 80 mL, 0.20 mol) was added dropwise to a solution of iPr$_2$NH (27.2 mL, 194 mmol, distilled from NaOH) in dry THF (200 mL) in 30 min. The reaction mixture was stirred for 30 min, cooled to -70 °C and then, *tert*-butyl cyclopropanecarboxylate (prepared according to Kohlrausch, K. W. F.; Skrabal, R., *Z. Elektrochem. Angew. Phys. Chem*, **1937**, *43*, 282-285, 25.0 g, 176 mmol) was added dropwise in 30 min. The resultant mixture was allowed to warm up to -35 °C, cooled again to -70 °C and then 1-bromo-5-chloropentane (36 mL, 50.7 g, 273 mmol) was added dropwise in 15 min. The reaction mixture was allowed to reach -5 °C, stirred for 3 h, poured into a mixture of ice (100 mL), H_2O (100 mL), brine (200 mL) and aqueous HCl (2M, 200 mL) and extracted with Et_2O (2 x 300 mL). The combined organic layers were washed with a mixture of brine and saturated aqueous $NaHCO_3$ (10:1, 300 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining oil was purified by fractional distillation under reduced pressure to give *tert*-butyl 1-(5-chloropentyl)-1-cyclopropanecarboxylate (31.5 g 73%) as a colorless liquid. bp: T = 67-74°C (p = 0.001 mbar). ^{1}H NMR ($CDCl_3$): δ = 3.52 (t, J = 6.6 Hz, 2H), 1.77 (quintet, J = 6.8 Hz, 2H), 1.48-1.38 (m, 6H), 1.42 (s, 9H), 1.10 (dd, J = 6.5 Hz, 3.8 Hz, 2H), 0.59 (dd, J = 6.6, 3.9 Hz, 2H). ^{13}C NMR ($CDCl_3$): δ = 174.1, 79.9, 45.2, 34.2, 32.7, 28.2 (3x), 27.20, 27.17, 24.3, 15.4 (2x). HRMS calcd for $C_{13}H_{24}ClO_2$ (MH^+): 247.1465, found: 247.1465.

6.61 *Tert*-butyl 1-(5-iodopentyl)-1-cyclopropanecarboxylate.

To a solution of *tert*-butyl 1-(5-chloropentyl)-1-cyclopropanecarboxylate (31.5 g, 128 mmol) in 2- butanone (150 mL) was added NaI (24.9 g, 166 mmol). The reaction mixture was stirred under reflux for 24 h, diluted with heptane (220 mL) and filtered through a layer of silica (~ 2 cm) in a glassfilter. The residue was eluted with a mixture of heptane and EtOAc (3:1, 5 x 100 mL). The combined filtrate and elutes were evaporated in *vacuo* to give *tert*-butyl 1-(5-iodopentyl)-1-cyclopropanecarboxylate (42.3 g, 99%) as a slightly yellow liquid. ^{1}H NMR ($CDCl_3$): δ = 3.18 (t, J = 7.1 Hz, 2H), 1.82 (quintet, J = 7.1 Hz, 2H), 1.48-1.33 (m, 6H), 1.42 (s, 9H), 1.10 (dd, J = 6.8 Hz, Hz, 2H), 0.58 (dd, J = 6.6, 3.9 Hz, 2H). ^{13}C NMR ($CDCl_3$): δ = 174.0, 79.9, 34.1, 33.6, 30.8, 28.2 (3x), 26.8, 24.3, 15.4 (2x), 7.4. HRMS calcd for $C_{13}H_{23}IO_2$ (M^+): 338.0743, found: 338.0743.

6.62 *Tert*-butyl 1-11-[1-(*tert*-butoxycarbonyl)cyclopropyl]-6-oxoundecyl-1-cyclopropanecarboxylate.

Under a N_2 atmosphere at 0 °C, KO*t*Bu (8.35 g, 74.6 mmol) was added to a solution of TosMIC (13.84 g, 70.9 mmol) in DMAc (100 mL). Then *tert*-butyl 1-(5-iodopentyl)-1-cyclopropanecarboxylate (24.0 g, 71.0 mmol) was added dropwise in 15 min and the reaction mixture was allowed to warm to rt, stirred for 0.5 h and cooled again to 0 °C. Another portion of KO*t*Bu (8.35 g, 74.6 mmol) and *tert*-butyl 1-(5-iodopentyl)-1-cyclopropanecarboxylate (24 g, 71 mmol, in 15 min) were added and the resultant mixture was allowed to warm to rt. After 2 h, the reaction mixture was poured into an ice/H_2O (300 mL) mixture and extracted with Et_2O (3 x 150 mL). To the combined organic layers was added EtOAc (100 mL) and the resultant solution was washed with a mixture of brine (100 mL), H_2O (100 mL) and aqueous Na_2SO_3 (10%, 50 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was taken up in EtOAc (100 mL) and filtered through a layer of silica in a glassfilter (elute: heptane:EtOAc = 1:1, 5 x 80 mL). The combined filtrate and washings were evaporated in *vacuo*. The remaining oil was dissolved in CH_2Cl_2 (400 mL) and conc aqueous HCl (11.4 mL) was added. After 0.5 h, the reaction mixture was treated with saturated aqueous $NaHCO_3$ (250 mL) and stirred for 0.5 h. The layers were separated and the aqueous phase was extracted with CH_2Cl_2 (200 mL). The combined organic layers were dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was dissolved in heptane and set aside for 3 d upon which precipitation occurred. The residue was separated by decantation and washed with heptane (3 x 75 mL). The combined heptane layers were evaporated in *vacuo* and the resultant oil was purified by column chromatography (silica, heptane:EtOAc = 12:1) to give *tert*-butyl 1-11-[1-(*tert*-butoxycarbonyl)cyclopropyl]-6-oxoundecyl-1-cyclopropanecarboxylate (16.3 g, >90% pure by ^1H NMR, 46%) as a colorless oil. ^1H NMR ($CDCl_3$): $\delta = 2.37$ (t, $J = 7.4$ Hz, 4H), 1.62-1.49 (quintet, $J = 7.4$ Hz, 4H), 1.48-1.36 (m, 8H), 1.41 (s, 18H), 1.33-1.20 (m, 4H) 1.09 (dd, $J = 6.5$, 3.8 Hz, 4H), 0.58 (dd, $J = 6.6$, 3.9 Hz, 4H). ^{13}C NMR ($CDCl_3$): $\delta = 210.9$, 174.1 (2x), 79.8 (2x), 42.9 (2x), 34.1 (2x), 29.6 (2x), 28.2 (6x), 27.7 (2x), 24.4 (2x), 24.0 (2x), 15.4 (4x). HRMS calcd for $C_{27}H_{46}O_5Na$ (MNa^+): 473.3243, found 473.3233.

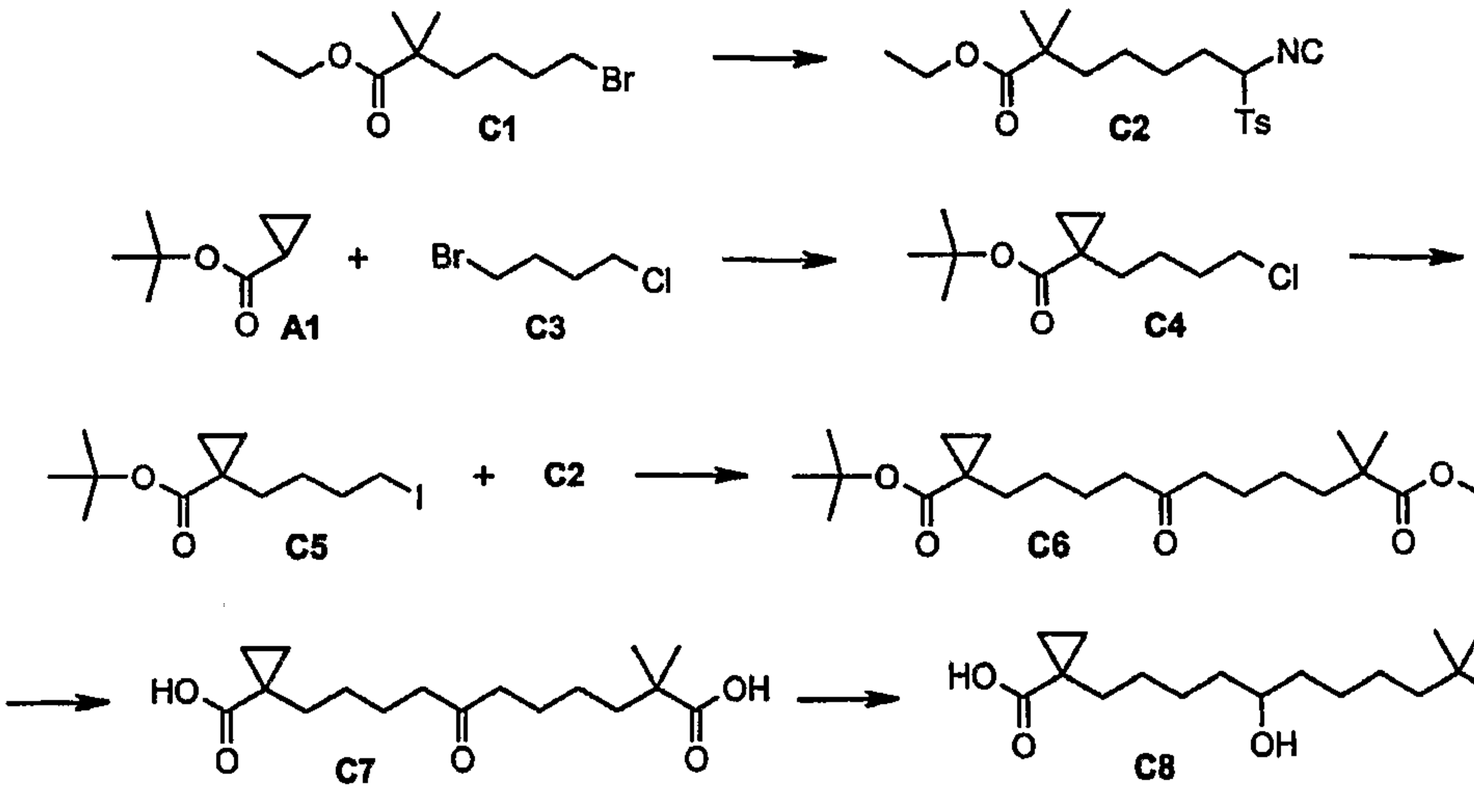
6.63 *Tert*-butyl 1-11-[1-(*tert*-butoxycarbonyl)cyclopropyl]-6-hydroxyundecyl-1-cyclopropanecarboxylate.

A solution of *tert*-butyl 1-11-[1-(*tert*-butoxycarbonyl)cyclopropyl]-6-oxoundecyl-1-cyclopropanecarboxylate (7.87 g, 17.4 mmol) in EtOH (40 mL) was treated portion wise with $NaBH_4$ (0.726 g, 19.2 mmol) in ~ 2 min at 0 °C. The reaction mixture was

stirred at rt for 1.5 h, and then poured into a mixture of H_2O and ice (200 mL). The resultant mixture was extracted with Et_2O (2 x 200 mL), and the combined organic layers were dried (Na_2SO_4) and concentrated in *vacuo*. The remaining residue was purified by column chromatography (silica, heptane:EtOAc = 8:1) to give *tert*-butyl 1-11-[1-(*tert*-butoxycarbonyl)cyclopropyl]-6-hydroxyundecyl-1-cyclopropanecarboxylate (7.00 g, 89%) as a colorless oil. ^{1}H NMR ($CDCl_3$) δ = 3.61-3.51 (m, 1H), 1.49-1.21 (m, 39H) 1.09 (dd, *J* = 6.5, 3.8 Hz, 4H), 0.58 (dd, *J* = 6.5, 3.8 Hz, 4H). ^{13}C NMR ($CDCl_3$) δ = 174.2 (2x), 79.7 (2x), 71.9, 37.6 (2x), 34.2 (2x), 30.0 (2x), 28.2 (6x), 27.9 (2x), 25.8 (2x), 24.4 (2x), 15.4 (2x), 15.3 (2x). HRMS calcd for $C_{27}H_{49}O_5$ $(M+H)^+$: 453.3580, found 453.3550.

6.64 <u>1-[11-(1-Carboxycyclopropyl)-6-hydroxyundecyl]-1-cyclopropanecarboxylic acid.</u>

A solution of *tert*-butyl 1-11-[1-(*tert*-butoxycarbonyl)cyclopropyl]-6-hydroxyundecyl-1-cyclopropanecarboxylate (6.49 g, 14.4 mmol) in 1,4-dioxane (70 mL) was treated with conc HCl (70 mL) and stirred overnight. Then the mixture was treated with a mixture of ice and H_2O (1:1, 300 mL), and extracted with EtOAc (3 x 100 mL). The combined organic layers were washed with brine (3 x 100 mL), dried (Na_2SO_4), and concentrated in *vacuo*. The remaining oil was coevaporated in *vacuo* from toluene (2 x 50 mL), CH_2Cl_2 (50 mL) and Et_2O (3 x 50 mL), and finally further concentrated in *vacuo* at 65 °C for 3 h, to give 1-[11-(1-carboxycyclopropyl)-6-hydroxyundecyl]-1-cyclopropanecarboxylic acid (5.08 g, 100%) as a slightly yellow oil, contaminated with Et_2O (4 %($^w/_w$)) and toluene (0.5 %($^w/_w$)). The thick oil started to crystallize spontaneously after 10 d, after which H_2O (100 mL) was added. The resulting mixture was left standing for 3 d, and the so obtained crystalline material was filtered and air dried to give 1-[11-(1-carboxycyclopropyl)-6-hydroxyundecyl]-1-cyclopropanecarboxylic acid (4.64 g, 95%) as colorless crystals. mp: 87-91 °C. ^{1}H NMR ($CDCl_3$) δ = 5.50 (br s, 3H), 3.58, (br s, 1H), 1.53-1.22 (m, 20H) 1.25 (dd, *J* = 6.6, 3.9 Hz, 4H), 0.74 (dd, *J* = 6.9, 3.9 Hz, 4H). ^{13}C NMR ($CDCl_3$) δ = 181.6 (2x), 72.0, 37.3 (2x), 33.7 (2x), 29.9 (2x), 27.6 (2x), 25.6 (2x), 23.5 (2x), 16.7 (2x), 16.6 (2x). Anal. calcd for $C_{19}H_{32}O_5$: C, 67.03; H, 9.47. Found: C, 66.83; H, 9.24.



6.65 {7-Ethoxy-6,6-dimethyl-1-[(4-methylphenyl)sulfonyl]-7-oxoheptyl}(methylidyne)ammonium.

To a mixture of K_2CO_3 (13.18 g, 95.6 mmol) and Bu_4NI (2.35 g, 6.36 mmol) in dry DMF (50 mL) was added a solution of ethyl 2,2-dimethyl-6-bromohexanoate (prepared according to Ackerley, N.; Brewster, A. G.; Brown, G. R.; Clarke, D. S.; Foubister, A. J., Griffin, S. J.; Hudson, J. A.; Smithers, M. J.; Whittamore, P. R. O., *J. Med. Chem.*, **1995**, *38*, 1608-1628, 24.00 g, 95.6 mmol) and TosMIC (12.41 g, 63.7 mmol) in dry DMF (50 mL) in 20 min under a N_2 atmosphere while stirring vigorously. After 4 d, H_2O (100 mL) was added drop wise while keeping the temperature below 25 °C by cooling with an ice-bath. The resulting mixture was extracted with Et_2O (3 x 200 mL). The combined organic layers were washed with saturated aqueous $NaHCO_3$ (2 x 200 mL), dried (Na_2SO_4), and evaporated in *vacuo*. The remaining residue was purified by column chromatography (silica; heptane:EtOAc = 6:1; a layer of $NaHCO_3$ was put on the base of the column) to give {7-ethoxy-6,6-dimethyl-1-[(4-methylphenyl)sulfonyl]-7-oxoheptyl}(methylidyne)ammonium (15.68 g, 42.8 mmol, 67%) as a slightly yellow oil which slowly solidified on standing. An analytical sample was obtained after recrystallization (0.43 g) from iPr_2O/heptane at ~4 °C to give {7-ethoxy-6,6-dimethyl-1-[(4-methylphenyl)sulfonyl]-7-oxoheptyl}(methylidyne)ammonium (0.30 g) as a white solid. mp: 38-39 °C. ^{1}H NMR ($CDCl_3$): δ = 7.84 (d, J = 8.4 Hz, 2H), 7.40 (d, J = 7.8 Hz, 2H), 4.43 (dd, J = 3.3, 10.8 Hz, 1H), 4.10 (q, J = 7.1 Hz, 2H), 2.48 (s, 3H), 2.23-2.12 (m, 1H), 1.90-1.77 (m, 1H), 1.66-40 (m, 4H), 1.38-1.22 (m, 2H), 1.24 (t, J = 7.1 Hz, 3H), 1.15 (s, 6H). ^{13}C NMR ($CDCl_3$): δ = 177.3, 164.6, 146.3, 131.0, 129.93 (2x), 129.87 (2x), 72.8, 60.4, 42.2, 40.2, 28.4, 26.0, 25.35, 25.30, 24.2, 22.0, 14.5. Anal. calcd for $C_{19}H_{27}NO_4S$: C, 62.44; H, 7.45; N, 3.83, found: C, 62.57; H, 7.57; N, 3.96.

6.66 *Tert*-butyl 1-(4-chlorobutyl)-1-cyclopropanecarboxylate.

Under an Ar atmosphere at 0 °C, BuLi (2.5M in hexanes, 37 mL, 92.5 mmol) was added drop wise to a solution of iPr$_2$NH (12.3 mL, 88 mmol, distilled from NaOH) in dry THF (150 mL) in 10 min. The reaction mixture was stirred for 20 min, cooled to -70 °C and then, *tert*-butyl cyclopropanecarboxylate (prepared according to Kohlrausch, K. W. F.; Skrabal, R., *Z. Elektrochem. Angew. Phys. Chem*, **1937**, *43*, 282-285, 12.5 g, 88 mmol) was added drop wise in 20 min. After 3 min, 1-bromo-4-chlorobutane (13.7 mL, 20.1 g, 117 mmol) was added drop wise in 15 min. The reaction mixture was allowed to reach rt, poured into a mixture of aqueous saturated NH_4Cl (200 mL) and ice (50 mL) and extracted with Et_2O (1 x 200 mL, 1 x 100 mL). The combined organic layers were washed with brine, dried (Na_2SO_4) and evaporated in *vacuo*. The remaining oil, was purified by fractional distillation to give *tert*-butyl 1-(4-chlorobutyl)-1-cyclopropanecarboxylate (10.73 g, 52%) as a colorless oil. bp: T = 57-61°C (p = 0.001 mbar). ^{1}H NMR ($CDCl_3$): δ = 3.52 (t, J = 6.6 Hz, 2H), 1.76 (quintet, J = 6.8 Hz, 2H), 1.64-1.54 (m, 2H), 1.51-1.46 (m, 2H), 1.42 (s, 9H), 1.12 (dd, J = 6.6, 3.9 Hz, 2H), 0.60 (dd, J = 6.6, 3.9 Hz, 2H). ^{13}C NMR ($CDCl_3$): δ = 173.9, 80.0, 45.1, 33.6, 32.9, 28.2 (3x), 25.3, 24.2, 15.4 (2x). HRMS calcd for $C_{12}H_{22}ClO_2$ (MH^+): 233.1308, found: 233.1308.

6.67 *Tert*-butyl 1-(4-iodobutyl)-1-cyclopropanecarboxylate.

To a solution of *tert*-butyl 1-(4-chlorobutyl)-1-cyclopropanecarboxylate (10.6 g, 45.7 mmol) in 2- butanone (50 mL) was added NaI (8.23 g, 54.5 mmol). The reaction mixture was stirred under reflux overnight, diluted with Et_2O (100 mL), washed with a mixture of H_2O (100 mL) and aqueous $Na_2S_2O_4$ (0.5 M, 10 mL) and brine (50 mL). The organic phase was dried (Na_2SO_4) and evaporate in *vacuo* to give *tert*-butyl 1-(4-iodobutyl)-1-cyclopropanecarboxylate (14.8 g, 94% pure by GC, 94%) as a slightly yellow liquid. ^{1}H NMR ($CDCl_3$): δ = 3.18 (t, J = 6.9 Hz, 2H), 1.76 (quintet, J = 7.1 Hz, 2H), 1.62-1.45 (m, 4H), 1.43 (s, 9H), 1.12 (dd, J = 6.7 Hz, 3.8 Hz, 2H), 0.60 (dd, J = 6.6 Hz, 3.9 Hz, 2H). ^{13}C NMR ($CDCl_3$): δ = 173.9, 80.0, 33.8, 33.3, 28.9, 28.2 (3x), 24.2, 15.5 (2x), 7.2. HRMS calcd for $C_{12}H_{21}IO_2$ (M^+): 324.0587, found: 324.0587.

6.68 Ethyl 11-[1-(*t*-butoxycarbonyl)cyclopropyl]-2,2-dimethyl-7-oxoundecanoate.

Under a N_2 atmosphere at 0 °C, a solution of {7-ethoxy-6,6-dimethyl-1-[(4-methylphenyl)sulfonyl]-7-oxoheptyl}(methylidyne)ammonium (20.5 g, 55.9 mmol) in *N*,*N*-

dimethylacetamide (DMAc, 125 mL) followed by a solution of *tert*-butyl 1-(4-iodobutyl)-1-cyclopropanecarboxylate (18.11 g, 55.9 mmol) in DMAc (125 mL) were added drop wise in 30 and 20 min, respectively to a solution of KO*t*Bu (6.57 g, 58.7 mmol) in DMAc (250 mL). The mixture was allowed to reach rt and stirring was continued for 100 min. Then, the reaction mixture was quenched by the drop wise addition of H_2O (250 mL) while cooling with an ice-bath. The resulting mixture was extracted with Et_2O (3 x 250 mL) and the combined organic layers were washed with brine (2 x 250 mL), dried (Na_2SO_4) and evaporated in *vacuo* to give a yellow oil (31.79 g). Part of this oil (30.63 g) was dissolved in CH_2Cl_2 (300 mL) and conc aqueous HCl (23 mL) was added. After 2 h of vigorous stirring, H_2O (250 mL) was added. The layers were separated and the aqueous phase was extracted with CH_2Cl_2 (3 x 250 mL). The combined organic phases were washed with saturated aqueous $NaHCO_3$ (250 mL), dried (Na_2SO_4) and evaporated in *vacuo*. To the remaining suspension of a yellow oil with a white solid was added heptane (~50 mL) and the white solid was filtered off and washed with heptane (~50 mL). The filtrate was stored at rt for 2 d and more white solid was formed, which was filtered off through a layer of silica (~1 cm) and washed with heptane (~50 mL). The combined filtrates were evaporated in *vacuo* to give impure ethyl 11-[1-(*t*-butoxycarbonyl)cyclopropyl]-2,2-dimethyl-7-oxoundecanoate (17.90 g) as a colorless oil. This batch was further purified by column chromatography (silica, heptane:EtOAc = 40:1) to give ethyl 11-[1-(*t*-butoxycarbonyl)cyclopropyl]-2,2-dimethyl-7-oxoundecanoate (9.83 g, >90% pure by NMR, 43%) as a colorless oil. ^{1}H NMR ($CDCl_3$): δ = 4.09 (q, J = 7.2 Hz, 2H), 2.38 (t, J = 7.2 Hz, 4H), 1.62-1.35 (m, 10H), 1.41 (s, 9H), 1.26-1.17 (m, 2H), 1.24 (t, J = 7.2 Hz, 3H), 1.14 (s, 6H), 1.09 (dd, J = 6.9, 4.2 Hz, 2H), 0.59 (dd, J = 6.3, 3.6 Hz, 2H). ^{13}C NMR: δ 210.5, 177.4, 174.0, 79.8, 60.2, 42.8, 42.6, 42.1, 40.5, 34.0, 28.2 (3x), 27.5, 25.2 (2x), 24.7, 24.3, 24.2, 24.1, 15.3 (2x), 14.4. HRMS calcd for $C_{23}H_{41}O_5$ (MH^+): 397.2954, found: 397.2956.

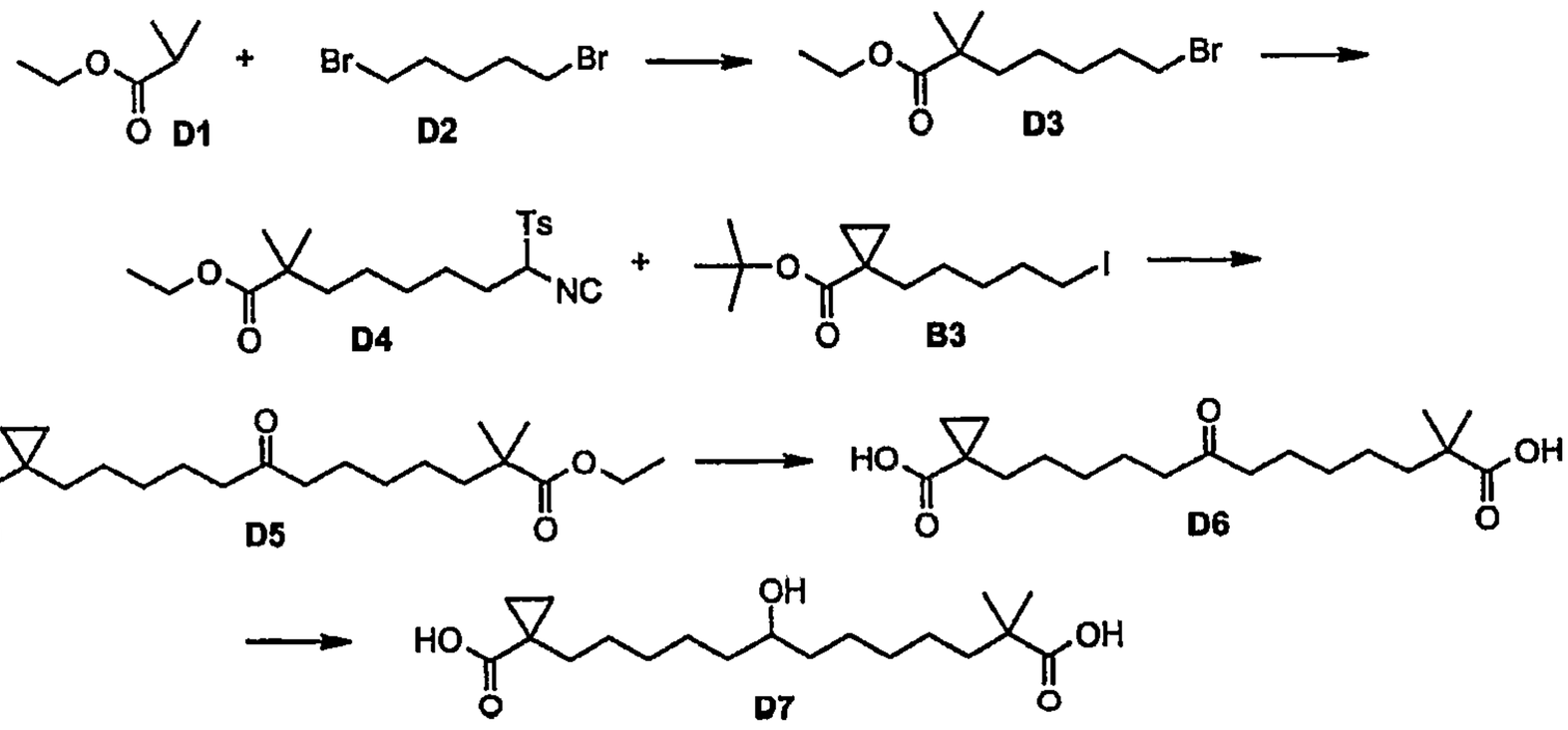
6.69 <u>11-(1-Carboxycyclopropyl)-2,2-dimethyl-7-oxoundecanoic acid.</u>

A solution of ethyl 11-[1-(*t*-butoxycarbonyl)cyclopropyl]-2,2-dimethyl-7-oxoundecanoate (9.27 g, >90% pure by NMR, 21.0 mmol) in HCO_2H (50 mL) was stirred for 1.5 h, evaporated in *vacuo* and coevaporated from toluene (10 mL). The remaining residue was dissolved in a mixture of EtOH and H_2O (2:1, 100 mL) and NaOH (5.33 g, 132 mmol) was added. The resulting clear solution was warmed to 80 °C and after 5 h EtOH was evaporated in *vacuo*. The remaining solution was diluted with H_2O to ~100 mL, extracted with Et_2O (3 x 100 mL), acidified to pH ~1 with conc aqueous HCl (~9 mL) and extracted with Et_2O (3 x 100 mL). The latter organic layers were combined, dried (Na_2SO_4)

and evaporated in *vacuo*. The remaining residue was purified by column chromatography (silica, heptane:EtOAc = 2:1 (containing 1%($^{v}/_{v}$) HOAc)) to give 11-(1-carboxycyclopropyl)-2,2-dimethyl-7-oxoundecanoic acid (5.83 g, >90% pure by ^{1}H NMR, 80%) as a slightly yellow oil which turns solid when stored at -18°C for several days. mp: 49-52 °C. ^{1}H NMR (CD_3OD): δ = 2.44 (t, *J* = 7.2 Hz, 4H), 1.57-1.42 (m, 10H), 1.30-1.19 (m, 2H), 1.17-1.07 (m, 2H), 1.14 (s, 6H), 0.59 (dd, *J* = 6.6, 3.9 Hz, 2H). ^{13}C NMR (CD_3OD): δ = 213.5, 181.4, 178.9, 43.5, 43.4, 43.0, 41.7, 34.9, 28.5, 25.9 (3x), 25.5, 25.2, 24.3, 16.4 (2x). Anal. calcd for $C_{17}H_{28}O_5$: C, 65.36; H, 9.03, found: C, 65.06; H, 9.02.

6.70 <u>11-(1-Carboxycyclopropyl)-7-hydroxy-2,2-dimethylundecanoic acid.</u>

To a mixture of 11-(1-carboxycyclopropyl)-2,2-dimethyl-7-oxoundecanoic acid (3.63 g, >90% pure by NMR, 10.4 mmol) in *i*PrOH (20 mL) and H_2O (20 mL) was added NaOH (0.94 g, 23.5 mmol). After 5 min of stirring, $NaBH_4$ (0.24 g, 6.3 mmol) was added to the resulting clear solution. After 19 h, the mixture was acidified to pH~1 with aqueous HCl (2M) and extracted with Et_2O (3 x 50 mL). The combined organic phases were washed with brine (1 x 50 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was coevaporated in *vacuo* from EtOAc to give 11-(1-carboxycyclopropyl)-7-hydroxy-2,2-dimethylundecanoic acid (3.43 g, 93%, contains 8%($^{w}/_{w}$) EtOAc and 3%($^{w}/_{w}$) *i*PrOH) as a viscous colorless oil. ^{1}H NMR (CD_3OD): δ = 3.5 (br s, 1H), 1.56-1.27 (m, 16H), 1.16 (s, 6H), 1.16-1.14 (m, 2H), 0.72 (dd, *J* = 3.4, 6.6 Hz, 2H). ^{13}C NMR (CD_3OD): δ = 181.6, 179.1, 72.3, 43.1, 42.0, 38.5, 38.4, 35.2, 29.0, 27.5, 27.1, 26.4, 26.0, 25.9, 24.4, 16.43, 16.38. HRMS calcd for $C_{17}H_{31}O_5$ ($M+H^+$): 315.2171, found 315.2175.



6.71 Ethyl 7-bromo-2,2-dimethylheptanoate.

Under Ar atmosphere at -78 °C, to a solution of ethyl isobutyrate (124.0 g, 1.06 mol) and DMPU (5 mL) in THF (160 mL) was added LDA (750 mL, 2M). After 30 min, 1,5-dibromopentane (313 g, 1.32 mol) was added in a single portion. The reaction mixture was allowed to stir overnight, gradually warming to rt. The mixture was hydrolyzed with ice (500 g), saturated NH_4Cl (400 mL) and aqueous HCl (6M, 400 mL), and the solution was extracted with Et_2O (3 x 300 mL). The organic layers were washed with half saturated NaCl (2 x 300 mL), dried ($MgSO_4$) and evaporated in *vacuo*. The remaining residue was purified by distillation under reduced pressure to give ethyl 7-bromo-2,2-dimethylheptanoate (97.4 g, 32%) as a colorless oil. bp: T = 109-110 °C (p = 1.5-2 Torr). ^1H NMR ($CDCl_3$): δ = 4.15 (q, J = 7.2 Hz, 2H), 3.40 (t, J = 6.9 Hz, 2H), 1.90-1.83 (m, 2H), 1.55-1.37 (m, 4H), 1.25 (t, J = 6.9 Hz, 3H), 1.30-1.22 (m, 2H), 1.16 (s, 6H). ^{13}C NMR ($CDCl_3$): δ = 177.9, 60.3, 42.2, 40.5, 33.7, 32.7, 28.6, 25.2, 24.2, 14.3. HRMS calcd for $C_{11}H_{22}BrO_2$ (MH^+): 265.0803, found: 265.0816.

6.72 {8-Ethoxy-7,7-dimethyl-1-[(4-methylphenyl)sulfonyl]-8-oxooctyl}(methylidyne)ammonium.

Under a N_2 atmosphere, TosMIC (10.01 g, 51.3 mmol) and ethyl 7-bromo-2,2-dimethylheptanoate (20.41 g, 77.0 mmol) were dissolved in dry DMF (100 mL) and Bu_4NI (1.89 g, 5.12 mmol) and K_2CO_3 (10.62 g, 76.8 mmol) were added while stirring vigorously. After 5 d, the reaction mixture was poured in an ice/H_2O mixture (500 mL), extracted with Et_2O (1 x 200 mL, 2 x 100 mL) The combined organic layers were washed with brine (2 x 50 mL), dried (Na_2SO_4), and evaporated in *vacuo*. The remaining residue was purified by column chromatography (silica, heptane:EtOAc = 3:1) to give in order of elution ethyl 7-bromo-2,2-dimethylheptanoate (5.67 g, 90% pure by GC), an impure batch of {8-ethoxy-7,7-dimethyl-1-[(4-methylphenyl)sulfonyl]-8-oxooctyl}(methylidyne)ammonium (0.94 g), and pure {8-ethoxy-7,7-dimethyl-1-[(4-methylphenyl)sulfonyl]-8-oxooctyl}(methylidyne)ammonium (11.83 g, 61%) as a colorless oil. ^1H NMR ($CDCl_3$): δ = 7.86 (d, J = 8.1 Hz, 2H), 7.43 (d, J = 8.1 Hz, 2H), 4.45 (dd, J = 10.9, 3.5 Hz, 1H), 4.11 (q, J = 7.2 Hz, 2H), 2.49 (s, 3H), 2.22-2.11 (m, 1H), 1.90-1.77 (m, 1H), 1.67-1.57 (m, 1H), 1.53-1.42 (m, 3H), 1.24 (t, J = 7.2 Hz, 3H), 1.39-1.20 (m, 4H), 1.15 (s, 6H). ^{13}C NMR ($CDCl_3$): δ = 177.8, 164.8, 146.5, 131.1, 130.1 (2x), 130.0 (2x), 72.8, 60.2, 42.0, 40.3, 29.0, 28.3, 25.12, 25.06 (2x), 24.5, 21.7, 14.2. HRMS calcd for $C_{20}H_{29}NNaO_4S$ (MNa^+): 402.1715, found: 402.1736.

6.73 Ethyl 13-[1-(*t*-butoxycarbonyl)cyclopropyl]-2,2-dimethyl-8-oxotridecanoate.

Under a N_2 atmosphere at 0 °C, a solution of {8-ethoxy-7,7-dimethyl-1-[(4-methylphenyl)sulfonyl]-8-oxooctyl}(methylidyne)ammonium (28.4 g, 75.0 mmol) in *N,N*-dimethylacetamide (DMAc, 125 mL) followed by a solution of *tert*-butyl 1-(5-iodopentyl)-1-cyclopropanecarboxylate (**B3**, 25.4 g, 75.0 mmol) in DMAc (125 mL) were added dropwise in 60 and 30 min, respectively to a solution of KO*t*Bu (8.83 g, 79.0 mmol) in DMAc (250 mL). The mixture was allowed to reach rt and stirring was continued for 2 h. Then, the reaction mixture was quenched by the dropwise addition of H_2O (250 mL) while cooling with an ice-bath. The resulting mixture was extracted with Et_2O (3 x 250 mL) and the combined organic layers were washed with brine (2 x 250 mL), dried (Na_2SO_4) and evaporated in *vacuo* to give a yellow oil (43.02 g). Part of this oil (42.50 g) was dissolved in CH_2Cl_2 (250 mL) and conc aqueous HCl (34 mL) was added. After 1.5 h of vigorous stirring, H_2O (250 mL) was added. The layers were separated and the aqueous phase was extracted with CH_2Cl_2 (3 x 250 mL). The combined organic phases were washed with saturated aqueous $NaHCO_3$ (250 mL), dried (Na_2SO_4) and evaporated in *vacuo*. To the remaining residue was purified by column chromatography (silica, heptane:EtOAc = 8:1) to give ethyl 13-[1-(*t*-butoxycarbonyl)cyclopropyl]-2,2-dimethyl-8-oxotridecanoate (19.0 g, 95% pure by ^1H NMR, 57%) as a slightly yellow oil. ^1H NMR ($CDCl_3$): δ = 4.09 (q, J = 7.2 Hz, 2H), 2.37 (t, J = 7.2 Hz, 2H), 2.36 (t, J = 7.2 Hz, 2H), 1.62-1.35 (m, 10H), 1.41 (s, 9H), 1.30-1.21 (m, 6H), 1.24 (t, J = 7.2 Hz, 3H), 1.14 (s, 6H), 1.09 (dd, J = 6.6, 3.9 Hz, 2H), 0.58 (dd, J = 6.3, 3.6 Hz, 2H). ^{13}C NMR ($CDCl_3$): δ = 210.8, 177.6, 174.1, 79.8, 60.2, 42.9. 42.8, 42.2, 40.6, 34.1, 29.8, 29.6, 28.2 (3x), 27.6, 25.3 (2x), 24.9, 24.3, 23.9, 23.8, 15.3 (2x), 14.4. HRMS calcd for $C_{25}H_{45}O_5$ (MH^+): 425.3267, found: 425.3267.

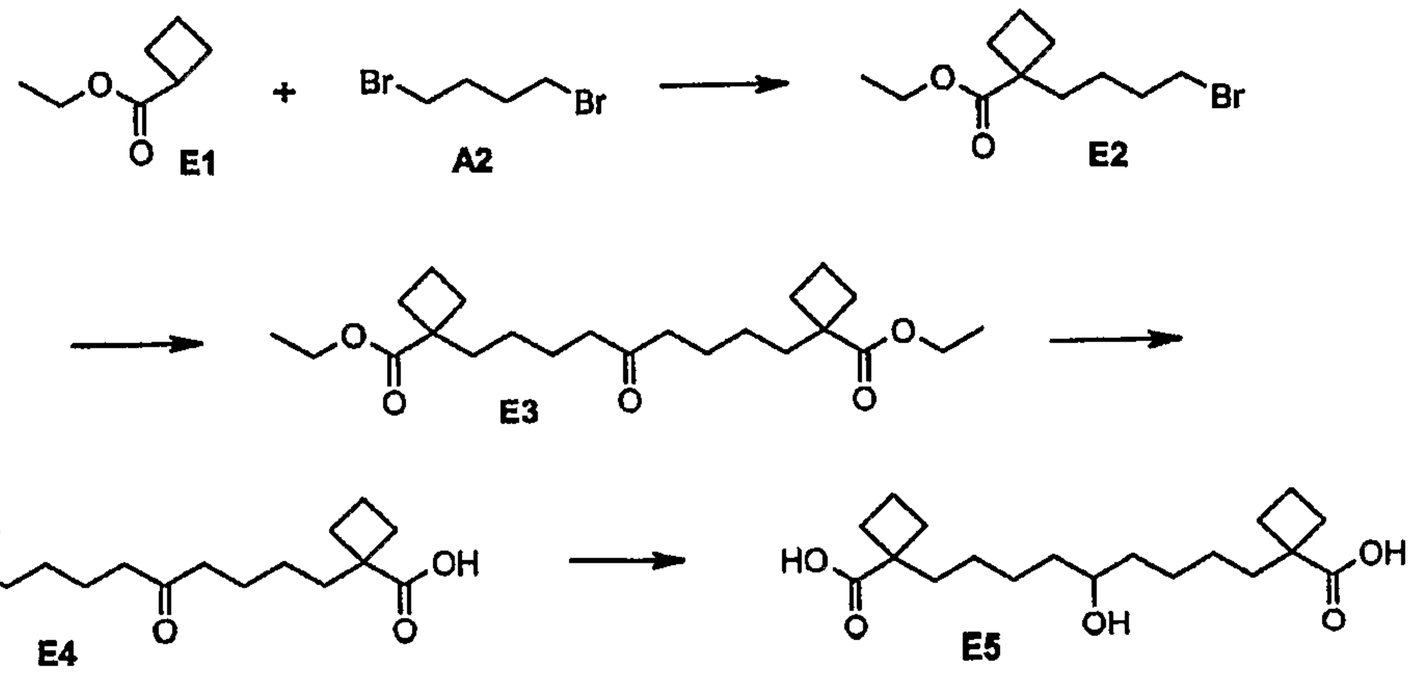
6.74 13-(1-Carboxycyclopropyl)-2,2-dimethyl-8-oxotridecanoic acid.

A solution of ethyl 13-[1-(*t*-butoxycarbonyl)cyclopropyl]-2,2-dimethyl-8-oxotridecanoate (18.34 g, 43.3 mmol) in HCO_2H (50 mL) was stirred for 1.5 h, evaporated in *vacuo* and coevaporated in *vacuo* from toluene (10 mL). The remaining residue was dissolved in a mixture of EtOH and H_2O (2:1, 250 mL) and NaOH (9.68 g, 241 mmol) was added. The resulting clear solution was warmed to 80 °C and after 5 h EtOH was evaporated in *vacuo*. The remaining solution was diluted with H_2O to ~250 mL, extracted with Et_2O (3 x 250 mL), acidified to pH ~1 with conc aqueous HCl (~18 mL) and extracted with Et_2O (3 x 250 mL). The latter organic layers were combined, dried (Na_2SO_4) and evaporated in *vacuo* to give a yellow oil which solidified overnight. The remaining residue was recrystallized from *i*Pr_2O/heptane to give 13-(1-carboxycyclopropyl)-2,2-dimethyl-8-

oxotridecanoic acid (9.47 g, 57%) as a white solid. The mother liquor was evaporated in *vacuo* and the remaining residue was purified by column chromatography (heptane:EtOAc = 2:1 (containing 1%($^{v}/_{v}$) HOAc)) and recrystallization from iPr$_2$O/heptane to give a second batch 13-(1-carboxycyclopropyl)-2,2-dimethyl-8-oxotridecanoic acid (2.23 g, 14%) as a white solid. mp = 65-66 °C. ^{1}H NMR: (CD_3OD): δ = 2.43 (t, J = 7.2 Hz, 4H), 1.58-1.42 (m, 10H), 1.35-1.20 (m, 6H), 1.14 (s, 6H), 1.15-1.06 (m, 2H), 0.70 (dd, J = 6.6, 3.9 Hz, 2H). ^{13}C NMR: (CD_3OD): δ = 213.8, 181.6, 179.0, 43.6, 43.5, 43.1, 41.9, 35.1, 31.0, 30.6, 28.7, 26.2, 25.9 (2x), 25.02, 24.96, 24.4, 16.4 (2x). Anal. calcd for $C_{19}H_{32}O_5$: C, 67.03; H, 9.47, found: C, 66.86; H, 9.50.

6.75 <u>13-(1-Carboxycyclopropyl)-8-hydroxy-2,2-dimethyltridecanoic acid.</u>

To a mixture of 13-(1-carboxycyclopropyl)-2,2-dimethyl-8-oxotridecanoic acid (3.67 g, 10.8 mmol) in iPrOH (20 mL) and H_2O (20 mL) was added NaOH (0.90 g, 22.5 mmol). After 5 min of stirring, $NaBH_4$ (0.20 g, 5.3 mmol) was added to the resulting clear solution. Additional $NaBH_4$ (0.10 g) was added after 100 min of stirring. After 16 h, the mixture was acidified to pH~1 with aqueous HCl (1M) and extracted with Et_2O (3 x 50 mL). The combined organic phases were washed with brine (2 x 50 mL), dried (Na_2SO_4), evaporated in *vacuo* and coevaporated in *vacuo* from EtOAc (2 x 15 mL) to give 13-(1-carboxycyclopropyl)-8-hydroxy-2,2-dimethyltridecanoic acid (3.99 g, 97%, contains 10 %($^{w}/_{w}$) EtOAc) as a viscous colorless oil. ^{1}H NMR (CD_3OD): δ = 3.48 (m, 1H), 1.50-1.21 (m, 20H), 1.14 (s, 6H), 1.14-1.12 (m, 2H), 0.70 (dd, J = 3.9, 6.3 Hz, 2H). ^{13}C NMR (CD_3OD): δ = 181.6, 179.0, 72.4, 43.2, 42.0, 38.6, 38.5, 35.2, 31.5, 31.2, 28.9, 26.94, 26.87, 26.3, 25.94, 25.92, 24.4, 13.67, 16.36. HRMS calcd for $C_{19}H_{35}O_5$ $(M+H)^+$: 343.2484, found 343.2487.



6.76 Ethyl 1-(4-chlorobutyl)-1-cyclobutanecarboxylate.

Under an N_2 atmosphere at ~7 °C, BuLi (2.5M in hexanes, 52.8 mL, 132 mmol) was added drop wise to a solution of iPr$_2$NH (18.52 mL, 132 mmol, distilled from NaOH) in dry THF (70 mL) in 10 min. The reaction mixture was allowed to warm to rt, stirred for 0.5 h, cooled to -60 °C and then, ethyl 1-cyclobutanecarboxylate (prepared according to Török, B.; Molnár, Á., *J. Chem. Soc. Perkin Trans. 1*, **1993**, *7*, 801-804, 14.05 g, 110 mmol) in dry THF (30 mL) was added dropwise in 20 min. The resulting mixture was allowed to warm to 0 °C in 20 min., cooled again to -60 °C and then, a solution of 1-bromo-4-chlorobutane (19.1 mL, 165 mmol) in dry THF (30 mL) was added dropwise in 20 min, after which the temperature was raised to -20 °C in 15 min. After 1.5 h, the temperature was raised to -10 °C and stirring was continued for 1 h. The reaction mixture was allowed to reach rt, poured into a mixture of aqueous saturated NH_4Cl (200 mL) and ice (50 mL) and extracted with Et_2O (500 mL). The organic layer was washed with brine (250 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining oil was purified by fractional distillation under reduced pressure to give ethyl 1-(4-chlorobutyl)-1-cyclobutanecarboxylate (20.53 g, 86%) as a thin, colorless oil. ^{1}H NMR ($CDCl_3$): δ = 4.13 (q, J = 7.1 Hz, 2H), 3.51 (t, J = 6.8 Hz, 2H), 2.50-2.32 (m, 2H), 1.96-1.70 (m, 8H), 1.40-1.20 (m, 2H), 1.26 (t, J = 7.2 Hz, 3H). ^{13}C NMR ($CDCl_3$): δ = 176.6, 60.3, 47.6, 44.8, 37.3, 32.8, 30.1 (2x), 22.4, 15.8, 14.4. HRMS calcd for $C_{11}H_{20}(^{37}Cl)O_2$ (MH^+): 221.1122, found: 221.1116.

6.77 Ethyl 1-(4-iodobutyl)-1-cyclobutanecarboxylate.

To a solution of ethyl 1-(4-chlorobutyl)-1-cyclobutanecarboxylate (21.21 g, 97.0 mmol) in 2-butanone (125 mL) was added NaI (19.07 g, 127 mmol). The reaction mixture was stirred under reflux for 20 h and diluted with Et_2O (500 mL). The resulting mixture was washed with aqueous $Na_2S_2O_3$ (10%($^w/_w$), 250 mL), brine (250 mL), dried (Na_2SO_4) and evaporated in *vacuo* to give ethyl 1-(4-iodobutyl)-1-cyclobutanecarboxylate (29.91 g, 99%) as a slightly yellow oil. ^{1}H NMR ($CDCl_3$): δ = 4.14 (q, J = 7.1 Hz, 2H), 3.17 (t, J = 6.9 Hz, 2H), 2.49-2.32 (m, 2H), 1.98-1.69 (m, 8H), 1.37-1.19 (m, 2H), 1.27 (t, J = 7.1 Hz, 3H). ^{13}C NMR ($CDCl_3$): δ = 176.5, 60.3, 47.5, 36.9, 33.7, 30.1 (2x), 26.0, 15.7, 14.5, 6.8. HRMS calcd for $C_{11}H_{20}IO_2$ (MH^+): 311.0508, found: 311.0511.

6.78 Ethyl 1-9-[1-(ethoxycarbonyl)cyclobutyl]-5-oxononyl-1-cyclobutanecarboxylate.

Under a N_2 atmosphere at 0 °C, KOtBu (8.61 g, 76.7 mmol) was added portion wise to a solution of ethyl 1-(4-iodobutyl)-1-cyclobutanecarboxylate (24.83 g, 80.1

mmol) and TosMIC (7.26 g, 36.4 mmol) in DMAc (150 mL). After 30 min, the reaction mixture was allowed to warm to rt, stirred for 1.5 h and diluted with DMAc (10 mL). Then, ethyl 1-(4-iodobutyl)-1-cyclobutanecarboxylate (2.01 g, 6.5 mmol) and KO*t*Bu (0.81 g, 7.2 mmol) were added followed by another portion of ethyl 1-(4-iodobutyl)-1-cyclobutanecarboxylate (1.00 g, 3.2 mmol) and KO*t*Bu (0.86 g, 7.7 mmol) after 1 h. After 1 h, the reaction mixture was poured into a mixture of Et_2O (700 mL) and aqueous NaCl (10%, 500 mL) and the layers were separated. The organic layer was washed with brine (1 x 500 mL, 1 x 300 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was purified by column chromatography (silica, heptane:EtOAc = 6:1) to give ethyl 1-9-[1-(ethoxycarbonyl)cyclobutyl]-5-isocyano-5-[(4-methylphenyl)sulfonyl]nonyl-1-cyclobutanecarboxylate (18.35 g) as a slightly yellow oil. Part of this oil (15.62 g, 27.9 mmol) was dissolved in CH_2Cl_2 (200 mL) and conc aqueous HCl (75 mL) was added. After stirring vigorously for 2 h, H_2O (300 mL) was added and the layers were separated. The aqueous layer was extracted with CH_2Cl_2 (2 x 100 mL) and the combined CH_2Cl_2 layers were washed with saturated aqueous $NaHCO_3$ (2 x 250 mL) and brine (250 mL). All aqueous layers were combined and extracted with Et_2O (2 x 200 mL). The combined Et_2O layers were washed with saturated aqueous $NaHCO_3$ (200 mL) and brine (200 mL). The CH_2Cl_2 layers and Et_2O layers were combined, dried (Na_2SO_4) and evaporated in *vacuo*. To the remaining residue heptane (150 mL) was added, and the mixture was filtered through two stacked folded filter papers. The hazy filtrate was filtered again to give a clear filtrate, which was evaporated in *vacuo*. The remaining residue was purified by column chromatography (silica, heptane:EtOAc = 6:1) to give ethyl 1-9-[1-(ethoxycarbonyl)cyclobutyl]-5-oxononyl-1-cyclobutanecarboxylate (9.99 g, 82%) as a slightly yellow liquid, after evaporation from CH_2Cl_2 (100 mL). ^1H NMR ($CDCl_3$): δ = 4.12 (q, J = 7.1 Hz, 4H), 2.44-2.32 (m, 8H), 1.93-1.79 (m, 8H), 1.77-1.72 (m, 4H), 1.55 (quintet, J = 7.5 Hz, 4H), 1.25 (t, J = 7.1 Hz, 6H), 1.21-1.10 (m, 4H). ^{13}C NMR ($CDCl_3$): δ = 210.2, 176.7 (2x), 60.2 (2x), 47.6 (2x), 42.6 (2x), 37.9 (2x), 30.1 (4x), 24.7 (2x), 24.1 (2x), 15.7 (2x), 14.4 (2x). HRMS calcd for $C_{23}H_{38}O_5$ (M^+): 394.2719, found: 394.2703.

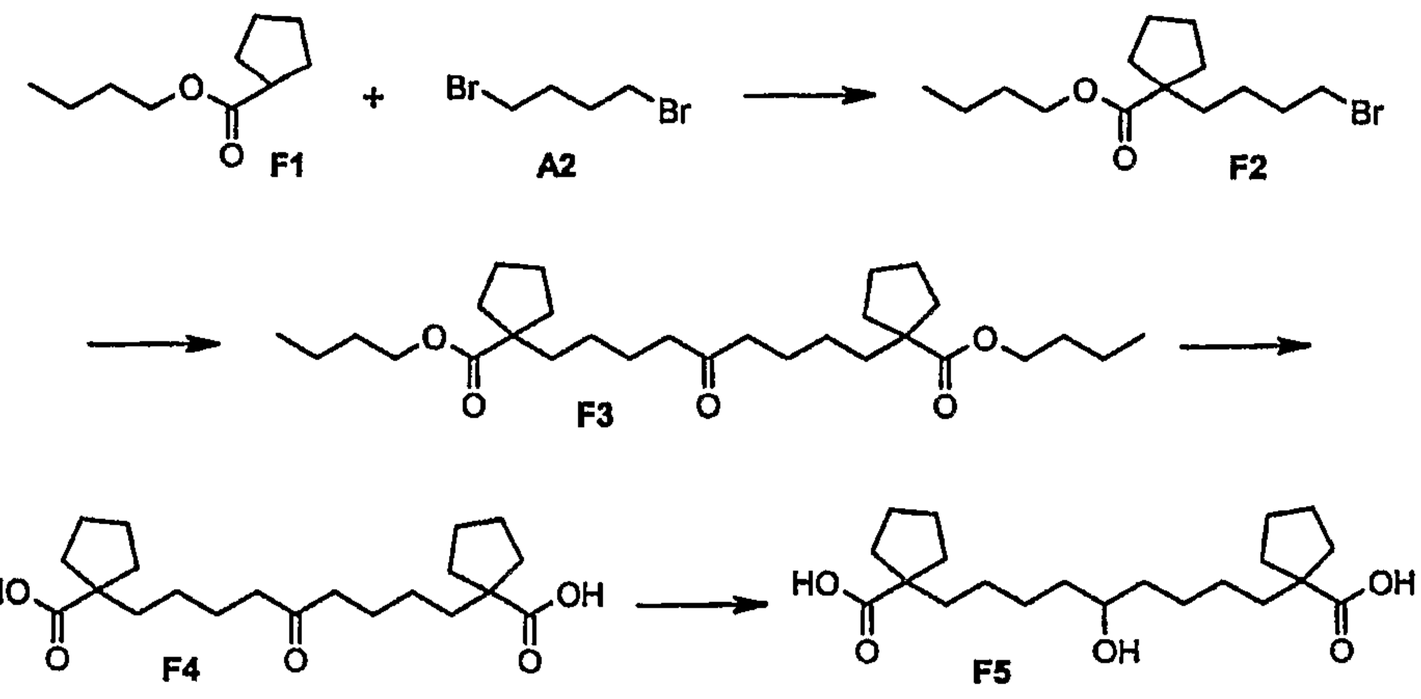
6.79 **<u>1-[9-(1-Carboxycyclobutyl)-5-oxononyl]-1-cyclo-butanecarboxylic acid.</u>**

$LiOH \cdot H_2O$ (3.94 g, 93.9 mmol) and H_2O (30 mL) were added to a solution of ethyl 1-9-[1-(ethoxycarbonyl)cyclobutyl]-5-oxononyl-1-cyclobutanecarboxylate (9.20 g, 23.3 mmol) in EtOH (90 mL) and the resulting mixture was stirred at reflux temperature for 17 h, allowed to cool to rt and concentrated in *vacuo* to a smaller volume. H_2O (150 mL) was added and the resulting mixture was extracted with Et_2O (50 mL), acidified with

aqueous HCl (6 M, 25 mL) and extracted with Et_2O (1 x 100 mL, 2 x 50 mL). The latter organic layers were combined, washed with brine (50 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was recrystallized from a mixture of iPr_2O and heptane to give 1-[9-(1-carboxycyclobutyl)-5-oxononyl]-1-cyclo-butanecarboxylic acid (4.41 g, 56%) as small, white granules. mp 69-70 °C. ^1H NMR ($CDCl_3$): δ = 11.2 (br s, 2H), 2.50-2.37 (m, 4H), 2.39 (t, J = 7.2 Hz, 4H), 1.96-1.84 (m, 8H), 1.81-1.75 (m, 4H), 1.57 (quintet, J = 7.4 Hz, 4H), 1.26-1.12 (m, 4H). ^{13}C NMR ($CDCl_3$): δ = 210.6, 183.4 (2x), 47.6 (2x), 42.7 (2x), 37.8 (2x), 30.1 (4x). 24.7 (2x), 24.1 (2x), 15.7 (2x). Anal. calcd for $C_{19}H_{30}O_5$: C, 67.43; H, 8.93, found: C, 67.19; H, 8.97.

6.80 <u>1-[9-(1-Carboxycyclobutyl)-5-hydroxynonyl]-1-cyclobutanecarboxylic acid.</u>

To a solution of 1-[9-(1-carboxycyclobutyl)-5-oxononyl]-1-cyclo-butanecarboxylic acid (7.83 g, 23.1 mmol) in aqueous NaOH (1M, 70 mL) and *i*-PrOH (70 mL) was added $NaBH_4$ (0.659 g, 17.3 mmol). After stirring for 3.5 h, the reaction mixture was acidified to pH~1 with conc HCl and extracted with Et_2O (1 x 250 mL, 2 x 150 mL). The combined organic layers were washed with brine (250 mL), dried (Na_2SO_4) and concentrated in *vacuo*. The remaining residue was dried under high vacuum to give 1-[9-(1-carboxycyclobutyl)-5-hydroxynonyl]-1-cyclobutanecarboxylic acid (8.17 g, 97%, contains 7 %($^w/_w$) Et_2O) as a thick, colorless oil. ^1H NMR ($CDCl_3$): δ = 8.56 (br s, 3H), 3.58 (br s, 1H), 2.55-2.30 (m, 4H), 2.00-1.80 (m, 8H), 1.78 (t, J = 7.7 Hz, 4H), 1.52-1.15 (m, 12H). ^{13}C NMR ($CDCl_3$): δ = 183.0 (2x), 71.7, 47.7 (2x), 38.0 (2x), 37.1 (2x), 30.2 (2x), 30.1 (2x), 25.9 (2x), 25.0 (2x), 15.7 (2x).



6.81 Butyl 1-(4-bromo-butyl)-cyclopentanecarboxylate.

Under a N_2 atmosphere at -60°C, a solution of butyl cyclopentanecarboxylate (prepared according to Payne, G. B.; Smith, C. W., *J. Org. Chem.*, **1957**, *22*, 1680-1682, 80.0 g, 0.42 mol) and 1,4-dibromobutane (183.3 g, 0.84 mol) in dry THF (700 mL) was added drop wise to a mixture of LDA (2M in THF/heptane/ethylbenzene, 250 mL, 0.50 mol) and dry THF (250 mL) in 1.5 h. After that, the reaction mixture was allowed to slowly reach rt during 3.5 h. Then, the reaction mixture was poured into ice-cold saturated aqueous NH_4Cl (1 L). The organic layer was decanted and concentrated in *vacuo* to a smaller volume. The aqueous layer was extracted with Et_2O (3 x 250 mL). The combined organic layers were washed with saturated aqueous NH_4Cl (250 mL) and brine (2 x 250 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was purified by fractional distillation to give butyl 1-(4-bromo-butyl)-cyclopentanecarboxylate (62.8 g, 49%) as a light yellow liquid. bp: T = 116-117°C (p = 0.040-0.051 Torr). ^{1}H NMR ($CDCl_3$): δ = 4.07 (t, J = 6.6 Hz, 2H), 3.38 (t, J = 6.8 Hz, 2H), 2.16-2.10 (m, 2H), 1.83 (quintet, J = 7.1 Hz, 2H), 1.65-1.59 (m, 8H), 1.50-1.31 (m, 6H), 0.94 (t, J = 7.2 Hz, 3H). ^{13}C NMR ($CDCl_3$): δ = 177.6, 64.1, 53.9, 38.2, 36.0 (2x), 33.3, 33.0, 30.6, 24.8 (2x), 24.6, 19.1, 13.6. HRMS calcd for $C_{14}H_{25}BrO_2$ (M^+): 304.1038, found: 304.1042.

6.82 Butyl 1-9-[1-(butoxycarbonyl)cyclopentyl]-5-oxononyl-1-cyclopentanecarboxylate.

Under a N_2 atmosphere, NaH (60%($^w/_w$) in mineral oil, 3.20 g, 80.0 mmol) was added portion wise to a solution of TosMIC (6.58 g, 33.0 mmol) and Bu_4NI (1.31 g, 3.55 mmol) in dry DMSO (100 mL) while stirring vigorously and cooling with a water bath. After 30 min, butyl 1-(4-bromo-butyl)-cyclopentanecarboxylate (21.59 g, 67.2 mmol) was added drop wise to the mixture in 20 min and after 1 h of stirring, another portion of NaH (60%($^w/_w$) in mineral oil, 0.56 g, 14 mmol) was added. After 20 min, H_2O (250 mL, ice-cold) was added drop wise while cooling with a water bath and the resulting mixture was extracted with Et_2O (3 x 100 mL). The combined organic layers were washed with brine (2 x 100 mL), dried (Na_2SO_4) and filtered through a layer of silica. The residue was washed with Et_2O (200 mL) and the combined filtrate and washings were evaporated in *vacuo*. The remaining oil was purified by column chromatography (silica, heptane/EtOAc = 8:1) to give butyl 1-{9-[1-(butoxycarbonyl)cyclopentyl]-5-isocyano-5-[(4-methylphenyl)sulfonyl]nonyl}-1-cyclopentanecarboxylate as a yellow oil (13.38 g). This oil (13.38 g) was dissolved in CH_2Cl_2 (250 mL), and conc aqueous HCl (75 mL) was added. After stirring vigorously for 18 h, H_2O (300 mL) was added and the layers were separated.

The aqueous phase was extracted with CH_2Cl_2 (2 x 100 mL) and the combined organic layers were washed with saturated aqueous $NaHCO_3$ (2 x 250 mL) and brine (250 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was suspended in heptane (100 mL) and filtered. The filtrate was evaporated in *vacuo*. The remaining residue was purified by column chromatography (silica, heptane/EtOAc = 6:1) to give butyl 1-9-[1-(butoxycarbonyl)cyclopentyl]-5-oxononyl-1-cyclopentanecarboxylate (9.05 g, 56%) as a slightly yellow liquid. ^{1}H NMR ($CDCl_3$): δ = 4.05 (t, *J* = 6.5 Hz, 4H), 2.36 (t, *J* = 7.5 Hz, 4H), 2.14-2.05 (m, 4H), 1.65-1.32 (m, 28H), 1.24-1.16 (m, 4H), 0.96 (t, *J* = 7.2 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ = 210.8, 177.8 (2x), 64.1 (2x), 54.0 (2x), 42.6 (2x), 39.0 (2x), 36.0 (4x), 30.7 (2x), 25.6 (2x), 24.9 (4x), 24.1 (2x), 19.1 (2x), 13.6 (2x). HRMS calcd for $C_{29}H_{50}O_5$ (M^+): 478.3658, found 478.3663.

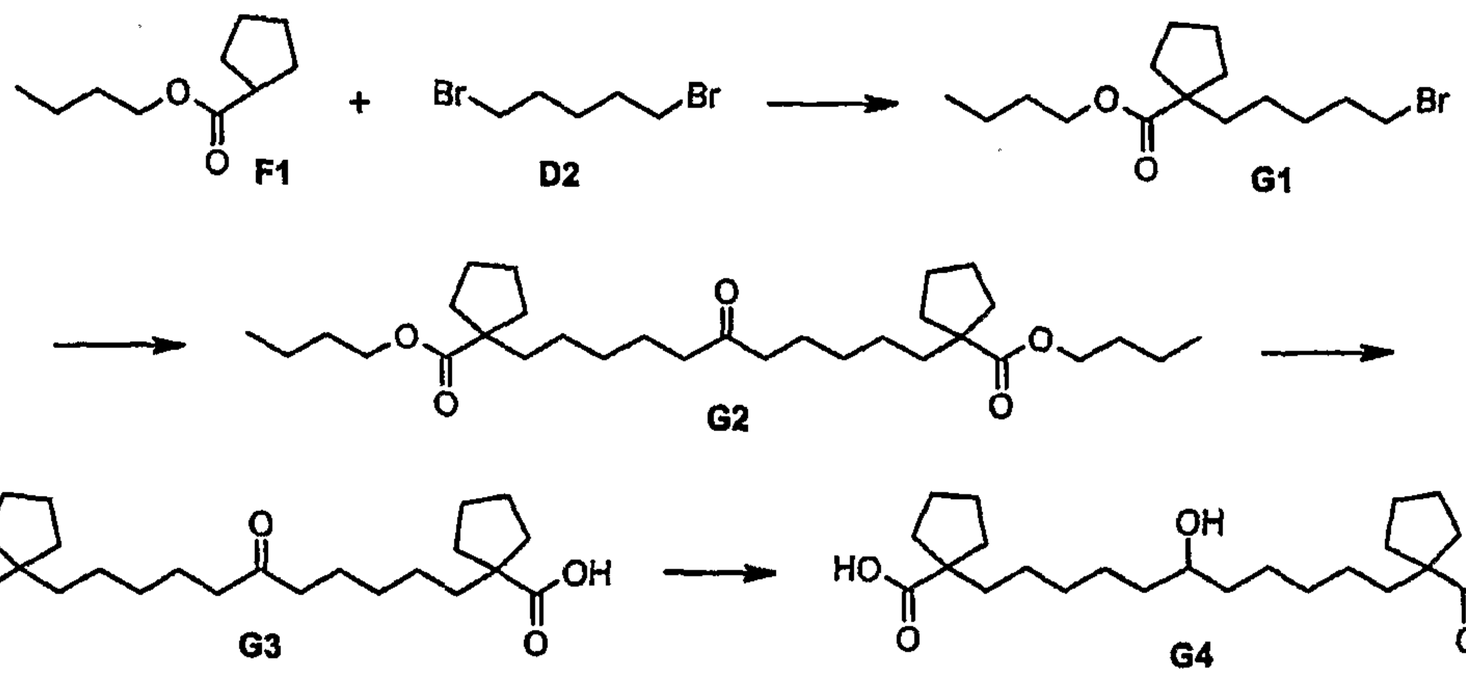
6.83 <u>1-[9-(1-Carboxycyclopentyl)-5-oxononyl]-1-cyclopentanecarboxylic acid.</u>

$LiOH \cdot H_2O$ (3.21 g, 76.4 mmol) and H_2O (40 mL) were added to a solution of butyl 1-9-[1-(butoxycarbonyl)cyclopentyl]-5-oxononyl-1-cyclopentanecarboxylate (7.25 g, 15.0 mmol) in EtOH (120 mL) and the resulting mixture was stirred at reflux temperature for 25 h, allowed to cool to rt and concentrated in *vacuo* to a smaller volume. H_2O (100 mL) was added and the resulting mixture was extracted with Et_2O (25 mL), acidified with aqueous HCl (6 M, 15 mL) and extracted with Et_2O (3 x 50 mL). The latter organic layers were combined, dried (Na_2SO_4, to avoid loss of material, a minimal amount of Na_2SO_4 was used, with the desiccant becoming a white, oily paste. The organic layer was decanted from the desiccant.) and evaporated in *vacuo* to give 1-[9-(1-carboxycyclopentyl)-5-oxononyl]-1-cyclopentanecarboxylic acid (5.46 g, 95% pure by ^{1}H NMR, 94%, mp = 99-103 °C) as a white solid. An analytical sample was obtained after recrystallization from *i*Pr_2O/heptane. mp = 104-106 °C. ^{1}H NMR ($CDCl_3$): δ = 2.39 (t, *J* = 6.9 Hz, 4H), 2.18-2.10 (m, 4H), 1.69-141 (m, 20H), 1.27-1.14 (m, 4H). ^{13}C NMR ($CDCl_3$): δ = 211.1, 184.6 (2x), 53.9 (2x), 42.5 (2x), 39.0 (2x), 35.9 (4x), 25.7 (2x), 24.9 (4x), 24.0 (2x). Anal. calcd for $C_{21}H_{34}O_5$: C, 68.82; H, 9.35, found: C, 68.78; H, 9.47.

6.84 <u>1-[9-(1-Carboxycyclopentyl)-5-hydroxynonyl]-1-cyclo-pentanecarboxylic acid.</u>

To a mixture of 1-[9-(1-carboxycyclopentyl)-5-oxononyl]-1-cyclopentanecarboxylic acid (4.70 g, 11.5 mmol) in *i*PrOH (30 mL) and H_2O (30 mL) was added NaOH (1.10 g, 27 mmol). To the resulting clear solution, $NaBH_4$ (0.242 g, 6.4 mmol) was added. After 23 h, TLC analysis revealed the reaction to be incomplete, and an

additional portion of $NaBH_4$ (0.036 g, 0.95 mmol) was added. Stirring was continued for 17 h and then, the reaction mixture was concentrated in *vacuo*. The remaining residue was dissolved in H_2O (80 mL) and washed with Et_2O (20 mL). The aqueous layer was acidified with aqueous HCl (6M, 15 mL) and then extracted with Et_2O (3 x 50 mL). The combined organic layers were washed with brine (2 x 50 mL), dried (Na_2SO_4) and concentrated in *vacuo* to give 1-[9-(1-carboxycyclopentyl)-5-hydroxynonyl]-1-cyclo-pentanecarboxylic acid (4.45 g, 98%, contains 7%($^w/_w$) Et_2O) as a thick, slightly hazy, light yellow oil. ^1H NMR ($CDCl_3$): δ = 3.56 (br s, 1H), 2.16-2.10 (m, 4H), 1.65-1.60 (m, 12H), 1.51-1.18 (m, 16H). ^{13}C NMR ($CDCl_3$): δ = 184.1 (2x), 71.1, 54.2 (2x), 39.4 (2x), 37.1 (2x), 36.1 (2x), 35.7 (2x), 26.0 (2x), 25.8 (2x), 25.03 (2x), 25.00 (2x).



6.85 <u>Butyl 1-(5-bromo-pentyl)-cyclopentanecarboxylate.</u>

Under a N_2 atmosphere at -60°C, a solution of butyl cyclopentanecarboxylate (prepared according to Payne, G. B.; Smith, C. W., *J. Org. Chem.*, **1957**, *22*, 1680-1682, 40.2 g, 0.236 mol) and 1,5-dibromopentane (64 mL, 0.45 mol) in dry THF (400 mL) was added drop wise to a solution of LDA (2M in THF/heptane/ethylbenzene, 200 mL, 0.40 mol) in 30 min. After 3 h, the reaction mixture was allowed to reach rt in 30 min. Then the reaction mixture was poured out into ice-cold saturated aqueous NH_4Cl (1 L). The organic layer was decanted and concentrated in *vacuo* to a smaller volume. The aqueous layer was extracted with Et_2O (3 x 150 mL). The combined organic layers were washed with saturated aqueous NH_4Cl (3 x 150 mL), brine (150 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was purified by fractional distillation to give butyl 1-(5-bromo-pentyl)-cyclopentanecarboxylate (49.1 g, >90% pure by GC, 59%) as a bright yellow liquid. bp: T = 123°C (p = 0.001 Torr). ^1H NMR ($CDCl_3$): δ = 4.06 (t, J = 6.6 Hz, 2H), 3.38 (t, J = 6.9 Hz, 2H), 2.15-2.07 (m, 2H), 1.89-1.79 (quintet, J = 7.1 Hz, 2H), 1.69-1.56 (m, 8H),

1.49-1.32 (m, 6H), 1.28-1.17 (m, 2H), 0.94 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$): δ = 177.7, 64.0, 54.0, 39.0, 36.0 (2x), 33.6, 32.5, 30.7, 28.5, 25.1, 24.8 (2x), 19.1, 13.6. HRMS calcd for $C_{15}H_{27}BrO_2$ (M^+): 318.1195, found: 318.1192.

6.86 Butyl 1-{11-[1-(butoxycarbonyl)cyclopentyl]-6-oxoundecyl}-1-cyclopentanecarboxylate.

Under a N_2 atmosphere, NaH (60%($^w/_w$) in mineral oil, 7.55 g, 189 mmol) was added portion wise to a solution of TosMIC (12.48 g, 62.6 mmol) and Bu_4NI (2.56 g, 6.93 mmol) in dry DMSO (200 mL) while stirring vigorously and cooling with a water bath. After 30 min, butyl 1-(5-bromo-pentyl)-cyclopentanecarboxylate (44.46 g, >90% pure by GC, 125 mmol) was added drop wise to the mixture in 20 min and after 1 h of stirring, another portion of NaH (60%($^w/_w$) in mineral oil, 1.20 g, 30.0 mmol) was added. After 1 h, the reaction mixture was slowly poured into ice-cold H_2O (500 mL) and the resulting mixture was extracted with Et_2O (3 x 250 mL). The combined organic layers were washed with aqueous NaCl (10%, 250 mL) and brine (2 x 200 mL), dried (Na_2SO_4) and filtered through a layer of silica (150 g). The residue was washed with Et_2O (250 mL) and the combined filtrate and washings were evaporated in *vacuo*. The remaining oil was purified by column chromatography (silica, heptane:EtOAc = 8:1) to give butyl 1-{11-[1-(butoxycarbonyl)cyclopentyl]-6-isocyano-6-[(4-methylphenyl)sulfonyl]undecyl}-1-cyclopentanecarboxylate as a yellow oil (32.79 g). This oil (32.79 g) was dissolved in CH_2Cl_2 (400 mL), and conc aqueous HCl (150 mL) was added. After stirring vigorously for 4.5 h, H_2O (500 mL) was added and the layers were separated. The aqueous phase was extracted with CH_2Cl_2 (2 x 100 mL) and the combined organic layers were washed with saturated H_2O (200 mL), saturated aqueous $NaHCO_3$ (500 mL) and brine (500 mL), dried (Na_2SO_4) and evaporated in *vacuo*. The remaining residue was purified by column chromatography (silica, heptane:EtOAc = 6:1) to give butyl 1-{11-[1-(butoxycarbonyl)cyclopentyl]-6-oxoundecyl}-1-cyclopentanecarboxylate (24.11 g, 90% pure by ^{1}H NMR, 69%) as a slightly yellow liquid. ^{1}H NMR ($CDCl_3$): δ = 4.06 (t, J = 6.6 Hz, 4H), 2.36 (t, J = 7.4 Hz, 4H), 2.15-2.06 (m, 4H), 1.65-1.52 (m, 20H), 1.49-1.32 (m, 8H), 1.27-1.19 (m, 8H), 0.94 (t, J = 7.4 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ = 210.9, 177.6 (2x), 63.8 (2x), 54.0 (2x), 42.5 (2x), 38.9 (2x), 35.8 (4x), 30.6 (2x), 29.5 (2x), 25.6 (2x), 24.7 (4x), 23.4 (2x), 19.0 (2x), 13.5 (2x). HRMS calcd for $C_{31}H_{54}O_5$ (M^+): 506.3971, found: 506.3981.

6.87 1-[11-(1-Carboxycyclopentyl)-6-oxoundecyl]-1-cyclopentanecarboxylic acid.

$LiOH \cdot H_2O$ (7.83 g, 187 mmol) and H_2O (100 mL) were added to a solution of butyl 1-{11-[1-(butoxycarbonyl)cyclopentyl]-6-oxoundecyl}-1-cyclopentanecarboxylate (21.03 g, 90% pure by ^1H NMR, 37.3 mmol) in EtOH (300 mL) and the resulting mixture was stirred at reflux temperature for 2 d, allowed to cool to rt and concentrated in *vacuo* to a smaller volume. H_2O (100 mL) was added and the resulting mixture was extracted with Et_2O (100 mL), acidified with conc aqueous HCl (25 mL) and extracted with Et_2O (3 x 150 mL). The latter organic layers were combined, dried (Na_2SO_4; To avoid loss of material, a minimal amount of Na_2SO_4 was used, with the desiccant becoming a white, oily paste. The organic layer was decanted from the desiccant.) and evaporated in *vacuo*. The remaining residue was purified by recrystallization from a mixture of iPr_2O and heptane to give 1-[11-(1-carboxycyclopentyl)-6-oxoundecyl]-1-cyclopentanecarboxylic acid (12.15 g, 83%) as white granules. mp = 78-85 °C. ^1H NMR ($CDCl_3$): $\delta = 2.37$ (t, $J = 7.4$ Hz, 4H), 2.18-2.10 (m, 4H), 1.65-1.45 (m, 20H), 1.29-1.25 (m, 8H). ^{13}C NMR ($CDCl_3$): $\delta = 211.5$, 184.8 (2x), 54.0 (2x), 42.4 (2x), 38.9 (2x), 35.9 (4x), 29.2 (2x), 25.5 (2x), 24.9 (4x), 23.5 (2x). Anal. calcd for $C_{23}H_{38}O_5$: C, 70.02; H, 9.71, found: C, 70.37; H, 9.72.

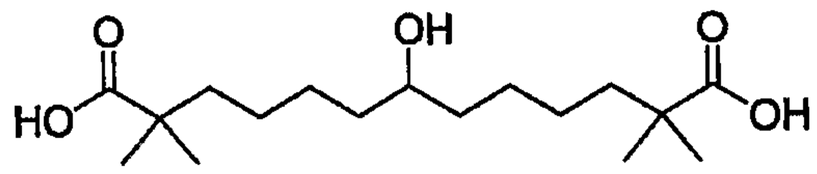
6.88 1-[11-(1-Carboxycyclopentyl)-6-hydroxyundecyl]-1-cyclopentanecarboxylic acid.

To a mixture of 1-[11-(1-carboxycyclopentyl)-6-oxoundecyl]-1-cyclopentanecarboxylic acid (5.00 g, 12.7 mmol) in *i*PrOH (30 mL) and H_2O (30 mL) was added NaOH (1.07 g, 26.3 mmol). To the resulting clear solution, $NaBH_4$ (0.38 g, 10.0 mmol) was added. After 19 h, the reaction mixture was concentrated in *vacuo*. The remaining residue was dissolved in H_2O (50 mL) and acidified with aqueous HCl (6M, 15 mL). The resulting mixture was extracted with Et_2O (100 mL, 2 x 50 mL), and the combined organic layers were washed with brine (2 x 50 mL), dried (Na_2SO_4) and concentrated in *vacuo* to give 1-[11-(1-carboxycyclopentyl)-6-hydroxyundecyl]-1-cyclopentanecarboxylic acid (5.18 g, 99%, contains 4%($^w/_w$) Et_2O) as a thick, light yellow oil that slowly crystallized on standing. mp =: 76-77 °C. ^1H NMR ($CDCl_3$); $\delta = 3.56$ (br s, 1H), 2.16-2.11 (m, 4H), 1.64-1.61 (m, 12H), 1.51-1.18 (m, 20H). ^{13}C NMR ($CDCl_3$): $\delta =$ 184.3 (2x), 71.4, 54.2 (2x), 39.2 (2x), 36.9 (2x), 36.2 (2x), 35.7 (2x), 29.5 (2x), 25.9 (2x), 25.2 (2x), 25.1 (2x), 25.0 (2x).

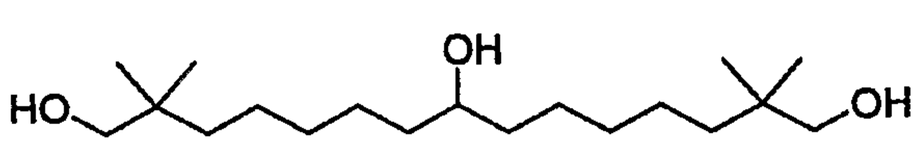
7. BIOLOGICAL ASSAYS

7.1 Effects of Illustrative Compounds of the Invention on NonHDL Cholesterol, HDL Cholesterol, Triglyceride Levels, Glycemic Control indicators and Body Weight Control in Obese Female Zucker Rats

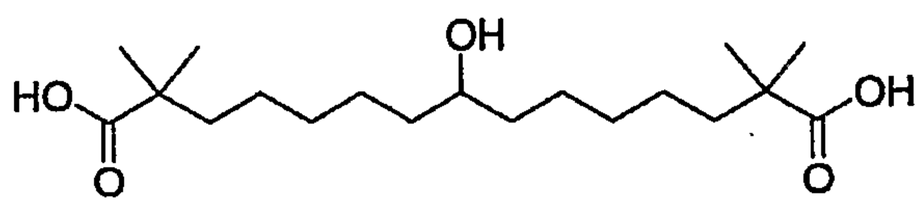
In a number of different experiments, illustrative compounds of the invention are administered daily at a dose of up to 100 mg/kg to chow fed obese female Zucker rats for fourteen days in the morning by oral gavage in 1.5% carboxymethylcellulose/0.2% Tween 20 or 20% ethanol/80% polyethylene glycol (dosing vehicles). Animals are weighed daily. Animals are allowed free access to rodent chow and water throughout the study except on days of blood sampling where food is restricted for six hours prior to blood sampling. Blood glucose is determined after the 6 hour fast in the afternoon without anesthesia from a tail vein. Serum is also prepared from pretreatment blood samples subsequently obtained from the orbital venous plexus (with O_2/CO_2 anesthesia) and following the fourteenth dose at sacrifice from the heart following O_2/CO_2 anesthesia. Serums are assayed for lipoprotein cholesterol profiles, triglycerides, total cholesterol, Non-HDL cholesterol, HDL cholesterol, the ratio of HDL cholesterol to that of Non-HDL cholesterol, insulin, non-esterified fatty acids, and beta-hydroxy butyric acid. The percent body weight gain and the ratio of liver to body weight is also determined. These are shown as absolute values or as a percent change of the pretreatment values in Table 1 for compounds **A-K** and in Table 2 for compounds **L-M**.



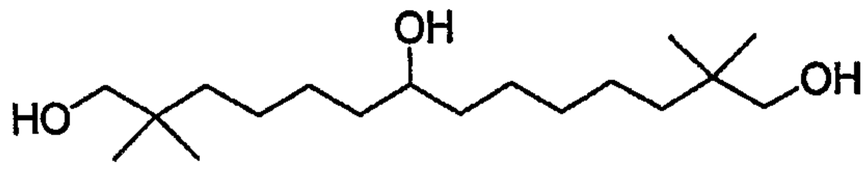
Compound A



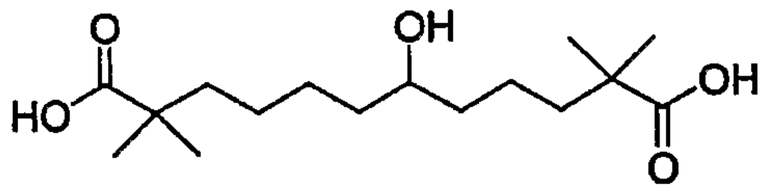
Compound B



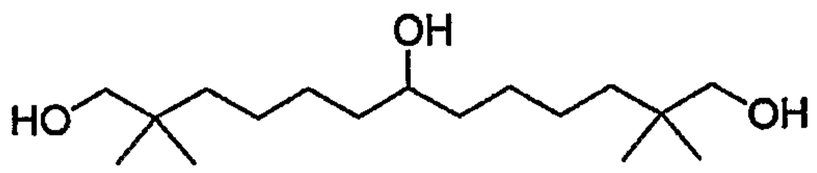
Compound C



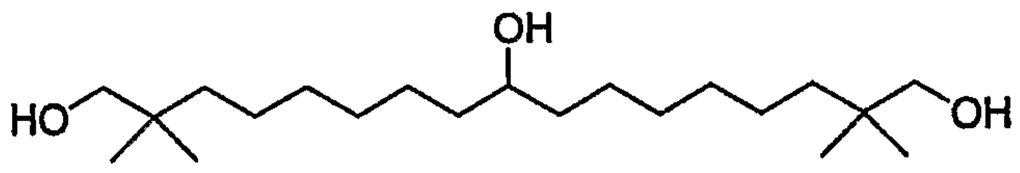
Compound D



Compound E

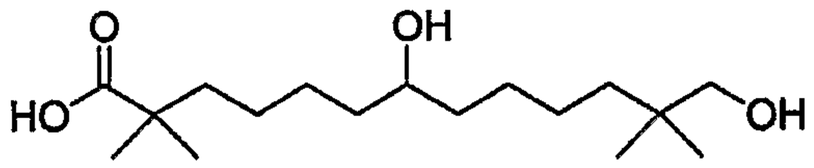


Compound F

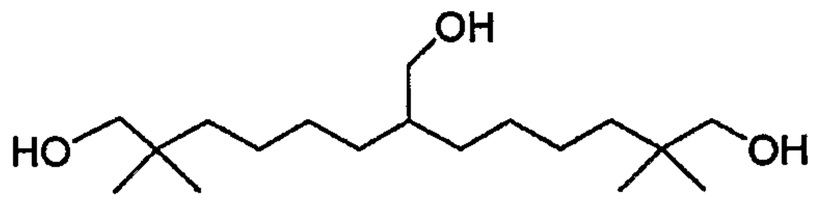


Compound G

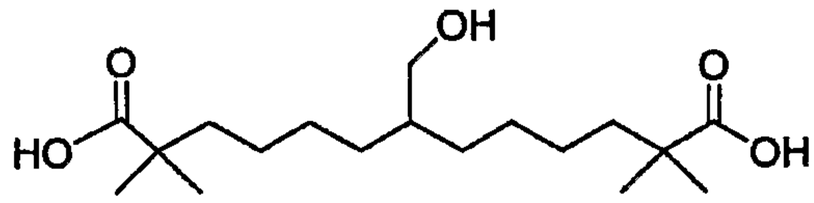
Compound H



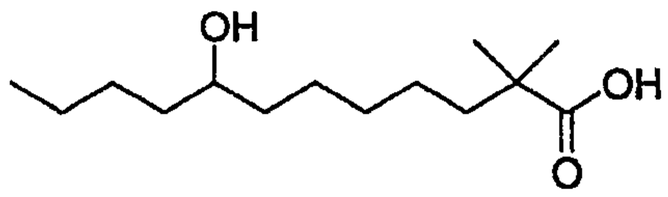
Compound I



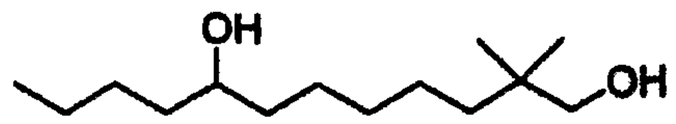
Compound J



Compound K



Compound L



Compound M

7.2 Effects of Illustrative Compounds of the Invention on the *in Vitro* Lipid Synthesis in Isolated Hepatocytes

Compounds were tested for inhibition of lipid synthesis in primary cultures of rat hepatocytes. Male Sprague-Dawley rats were anesthetized with intraperitoneal injection of sodium pentobarbital (80mg/kg). Rat hepatocytes were isolated essentially as described by the method of Seglen (Seglen, P. O. Hepatocyte suspensions and cultures as tools in experimental carcinogenesis. *J. Toxicol. Environ. Health* **1979**, *5*, 551-560). Hepatocytes were suspended in Dulbecco's Modified Eagles Medium containing 25 mM D-glucose, 14 mM HEPES, 5 mM L-glutamine, 5 mM leucine, 5 mM alanine, 10 mM lactate, 1 mM pyruvate, 0.2 % bovine serum albumin, 17.4 mM non-essential amino acids, 20 % fetal bovine serum, 100 nM insulin and 20μg/mL gentamycin) and plated at a density of 1.5 $\times 10^5$ cells/cm^2 on collagen-coated 96-well plates. Four hours after plating, media was replaced with the same media without serum. Cells were grown overnight to allow formation of monolayer cultures. Lipid synthesis incubation conditions were initially assessed to ensure the linearity of [1-^{14}C]-acetate incorporation into hepatocyte lipids for up to 4 hours. Hepatocyte lipid synthesis inhibitory activity was assessed during incubations in the presence of 0.25 μCi [1-^{14}C]-acetate/well (final radiospecific activity in assay is 1 Ci/mol) and 0, 1, 3, 10, 30, 100 or 300 μM of compounds for 4 hours. At the end of the 4-hour incubation period, medium was discarded and cells were washed twice with ice-cold phosphate buffered saline and stored frozen prior to analysis. To determine total lipid synthesis, 170 μl of MicroScint-E® and 50 μl water was added to each well to extract and partition the lipid soluble products to the upper organic phase containing the scintillant. Lipid radioactivity was assessed by scintillation spectroscopy in a Packard TopCount NXT. Lipid synthesis rates were used to determine the IC_{50}s of the compounds that are presented in Table 3.

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Table 1. Examples of effects of oral daily treatment of obese female Zucker rats with compounds A-K of the invention for fourteen days

				Percent of Pre-treatment									
Compound	Expt. #	n	Dose (mg/kg/day)	% wt. gain	HDL-C/ non-HDL-C	TG	TC	Non-HDL-C	HDL-C	Glucose	Insulin	NEFA	BHA
Vehicle	LR63	5		13	2	6	-17	7	-22	2	-1	50	211
A		4	100	12	5	-59	14	-41	50	-2	43	-11	231
Vehicle	LR92	4		7	2	1	-3	24	-10	-5	-9	11	62
B		4	100	1	35	-87	105	-81	237	-3	-52	-28	199
Vehicle	LR107	4		8	8	3	-4	3	-3	-14	-11	-13	139
C		4	100	3	40	-90	105	-80	169	-11	-57	-42	171
Vehicle	LR28	5		1	1	-41	-14	-39	58	-16	-43	-37	236
F		2	100	3	2	-46	53	-15	222	10	-4	-43	1056
Vehicle	LR98	5		9	2	23	1	116	-26	8	19	6	29
G		2	100	9	12	-80	21	-68	68	14	-38	-62	163
Vehicle	LR98	5		9	2	23	1	116	-26	8	19	6	29
H		3	100	9	3	-36	61	-5	115	19	-30	-30	97
Vehicle	LR52	4		8	2	-6	-14	-16	-7	3	-36	-7	31
J		3	100	12	2	-23	-6	-12	-2	21	-11	-32	183
Vehicle	LR119	5		11	4	9	20	-6	28	6	3	-2	65
K		3	100	10	9	-45	35	-38	62	3	41	-32	253

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Table 2. Examples of effects of oral daily treatment of obese female Zucker rats with compounds L and M of the invention for fourteen days days

				Percent of Pre-treatment									
Compound	Expt. #	n	Dose (mg/kg/day)	% wt. gain	HDL-C/ non-HDL-C	TG	TC	Non-HDL-C	HDL-C	Glucose	Insulin	NEFA	BHA
Vehicle	LR118	5		10	4	8	1	43	-8	-2	-24	14	81
L		3	100	12	4	-37	-3	-11	-2	13	-37	-27	88
Vehicle	LR118	5		10	4	8	1	43	-8	-2	-24	14	81
M		3	100	10	3	-11	15	7	19	5	-5	-23	63

n is number of animals per experiment

Table 3: Effect of Illustrative Compounds A-K on the Lipid Synthesis in Primary Rat Hepatocytes.

Compound	IC_{50} (μM)	95% Confidence Interval		r^2
		Lower	Upper	
A	3.4	2.5	4.5	0.99
B	5.1	3.6	7.3	0.99
C	1.0	0.5	2.0	0.99
D	1.6	1.2	2.0	0.99
E	8.3	4.6	15.1	0.98
F	6.4	3.7	11.1	0.99
G	7.8	6.7	8.9	0.99
H	2.6	1.5	4.4	0.98
I	2.3	1.4	3.7	0.99
J	17	8.7	34.4	0.98
K	14	12.2	15.8	0.99

5

7.3 Effects of Compound B of the Invention on VLDL Cholesterol, LDL Cholesterol, HDL Cholesterol, Triglyceride Levels, Glycemic Control Indicators, Body Weight and Bile Acids in Female Syrian Hamsters

Ten week old female Syrian hamsters were acclimated for 21 days to a

10 shortened light and dark cycle (10 hours of light/14 hours of darkness). During the

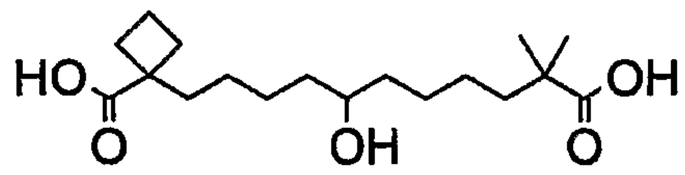
acclimation and drug intervention period animals were allowed free access to rodent chow (Purina 5001) and water except for a 6 hour period prior to blood sampling. Following the 21 day acclimation period ESP 55015 was administered daily for three weeks, between 8 10 AM, at a dose of 100mg/Kg by oral gavage in a dosing vehicle consisting of 20% Ethanol/80% Polyethylene glycol 200 [v/v]. Prior to and in the afternoon following the 13th and 21st doses blood samples were collected, between 2PM and 4PM, by administering O_2/CO_2 anesthesia and bleeding from the orbital venous plexus. All blood samples were processed for separation of serum. Serum samples were subsequently assayed for total cholesterol, total cholesterol lipoprotein profiles (HDL cholesterol, LDL cholesterol and VLDL cholesterol), the ratio of HDL cholesterol, LDL cholesterol and VLDL cholesterol), the ratio of HDL cholesterol to non HDL cholesterol (LDL C, VLDL C) and triglycerides (Table 4). Percent body weight gain and ratio of liver weight to body weight were also determined.

Table 4: Effect of Compound B in chow-fed hamster after 3 weeks of dosing

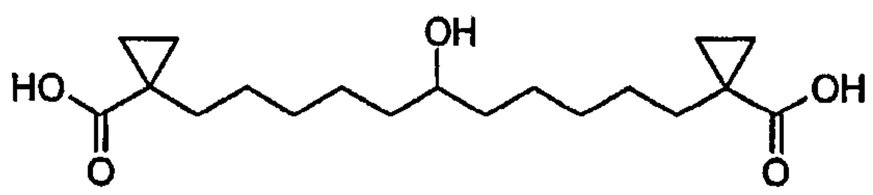
Compound	Expt. #	n	Dose (mg/kg/day)	Body wt. (gm)	VLDL-C (mg/dl)	LDL-C (mg/dl)	HDL-C (mg/dl)	TG (mg/dl)	Glucose	Insulin	Bile Acids (ng/ml)
Vehicle	LR100	5	0	148±4	9±1	41±2	83±4	325±	122±4		30,600±
B	LR100	5	100	146±2	4±2	44±4	63±4	128±37	122±3	2.4±0.7	67,108±17,529

7.4 Effects of Illustrative Compounds N-S on NonHDL Cholesterol, HDL Cholesterol, Triglyceride Levels, Glycemic Control indicators and Body Weight Control in Obese Female Zucker Rats

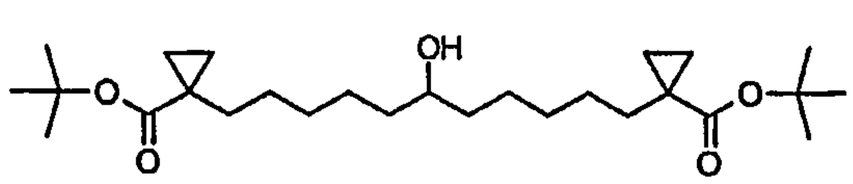
In a number of different experiments, illustrative compounds of the invention are administered daily at a dose of up to 100 mg/kg to chow fed obese female Zucker rats for fourteen days in the morning by oral gavage in 1.5% carboxymethylcellulose/0.2% Tween 20 or 20% ethanol/80% polyethylene glycol (dosing vehicles). Animals are weighed daily. Animals are allowed free access to rodent chow and water throughout the study except on days of blood sampling where food is restricted for six hours prior to blood sampling. Blood glucose is determined after the 6 hour fast in the afternoon without anesthesia from a tail vein. Serum is also prepared from pretreatment blood samples subsequently obtained from the orbital venous plexus (with O_2/CO_2 anesthesia) and following the fourteenth dose at sacrifice from the heart following O_2/CO_2 anesthesia. Serums are assayed for lipoprotein cholesterol profiles, triglycerides, total cholesterol, Non-HDL cholesterol, HDL cholesterol, the ratio of HDL cholesterol to that of Non-HDL cholesterol, insulin, non-esterified fatty acids, and beta-hydroxy butyric acid. The percent body weight gain and the ratio of liver to body weight is also determined. These are shown as absolute values or as a percent change of the pretreatment values in Table 5.



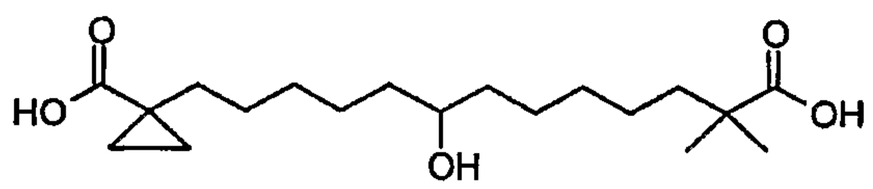
Compound N



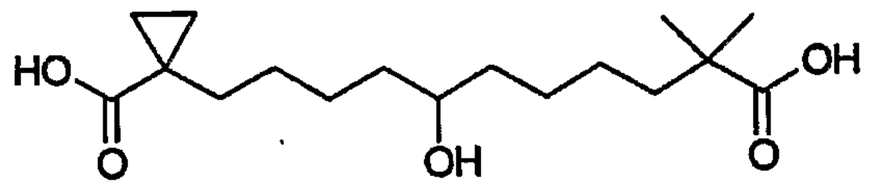
Compound O



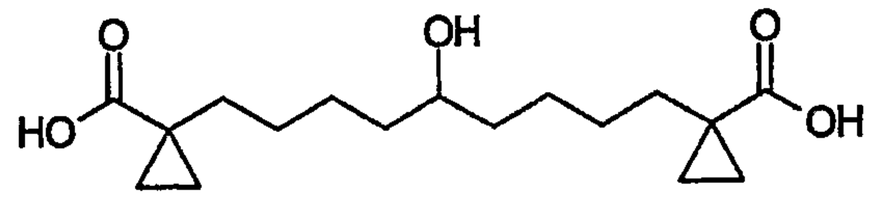
Compound P



Compound Q



Compound R



Compound S

Table 5: Examples of effects of oral daily treatment of obese female Zucker rats with illustrative compounds N-Q for fourteen days

Percent of Pre-treatment													
Compound	Expt. #	n	Dose (mg/kg/day)	% wt. gain	HDL-C/ non-HDL-C	TG	TC	Non-HDL-C	HDL-C	Glucose	Insulin	NEFA	BHA
Vehicle	LR132	4		10.50%	4	3	5	-8	10	-2	42	-3	78
N		4	30	12.3	4	-23	37	-20	76	-1	-8	-30	150
Vehicle	LR132	4		10.5	4	3	5	-8	10	-2	42	-3	78
O		4	100	4.2	153	-91	13	-94	54	-24	-51	-23	254
Vehicle	LR132	4		10.5	4	3	5	-8	10	-2	42	-3	78
P		4	100	-1.7	785	-97	-11	-98	15	-13	-70	-44	195
Vehicle	LR132	4		10.5	4	3	5	-8	10	-2	42	-3	78
Q		3	100	10.4	5	-34	101	1	162	-2	2	-24	223

n is number of animals per experiment

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7.5 Effects of Illustrative Compounds N-S on the *in Vitro* Lipid Synthesis in Isolated Hepatocytes

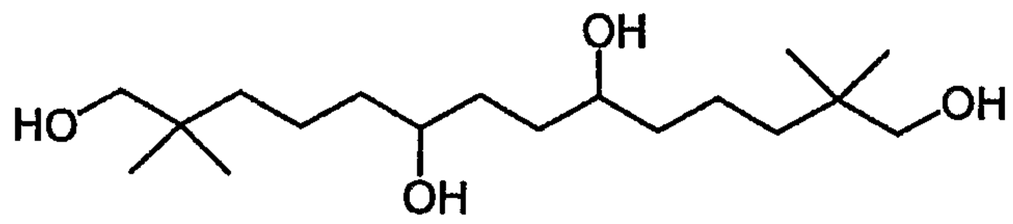
Compounds were tested for inhibition of lipid synthesis in primary cultures of rat hepatocytes. Male Sprague-Dawley rats were anesthetized with intraperitoneal injection of sodium pentobarbital (80mg/kg). Rat hepatocytes were isolated essentially as described by the method of Seglen (Seglen, P. O. Hepatocyte suspensions and cultures as tools in experimental carcinogenesis. *J. Toxicol. Environ. Health* **1979**, *5*, 551-560). Hepatocytes were suspended in Dulbecco's Modified Eagles Medium containing 25 mM D-glucose, 14 mM HEPES, 5 mM L-glutamine, 5 mM leucine, 5 mM alanine, 10 mM lactate, 1 mM pyruvate, 0.2 % bovine serum albumin, 17.4 mM non-essential amino acids, 20 % fetal bovine serum, 100 nM insulin and 20µg/mL gentamycin) and plated at a density of 1.5 $\times 10^5$ cells/cm^2 on collagen-coated 96-well plates. Four hours after plating, media was replaced with the same media without serum. Cells were grown overnight to allow formation of monolayer cultures. Lipid synthesis incubation conditions were initially assessed to ensure the linearity of [1-^{14}C]-acetate incorporation into hepatocyte lipids for up to 4 hours. Hepatocyte lipid synthesis inhibitory activity was assessed during incubations in the presence of 0.25 µCi [1-^{14}C]-acetate/well (final radiospecific activity in assay is 1 Ci/mol) and 0, 1, 3, 10, 30, 100 or 300 µM of compounds for 4 hours. At the end of the 4-hour incubation period, medium was discarded and cells were washed twice with ice-cold phosphate buffered saline and stored frozen prior to analysis. To determine total lipid synthesis, 170 µl of MicroScint-E® and 50 µl water was added to each well to extract and partition the lipid soluble products to the upper organic phase containing the scintillant. Lipid radioactivity was assessed by scintillation spectroscopy in a Packard TopCount NXT. Lipid synthesis rates were used to determine the IC_{50}s of the compounds that are presented in Table 6.

Table 6: Effect of Illustrative Compounds N, O, and Q-S on Lipid Synthesis in Primary Rat Hepatocytes.

Compound	IC_{50} (μM)	95% Confidence Interval		r^2
		Lower	Upper	
N	12.0	5.4	26.3	0.98
O	0.9	0.8	1.1	0.99
Q	1.4	1.2	1.6	0.99
R	3.0	2.6	3.4	0.98
S	1.8	1.4	2.3	0.96

7.6 Effects of Illustrative Compound T on NonHDL Cholesterol, HDL Cholesterol, Triglyceride Levels, Glycemic Control indicators and Body Weight Control in Obese Female Zucker Rats

In a number of different experiments, illustrative compounds of the invention are administered daily at a dose of up to 100 mg/kg to chow fed obese female Zucker rats for fourteen days in the morning by oral gavage in 1.5% carboxymethylcellulose/0.2% Tween 20 or 20% ethanol/80% polyethylene glycol (dosing vehicles). Animals are weighed daily. Animals are allowed free access to rodent chow and water throughout the study except on days of blood sampling where food is restricted for six hours prior to blood sampling. Blood glucose is determined after the 6 hour fast in the afternoon without anesthesia from a tail vein. Serum is also prepared from pretreatment blood samples subsequently obtained from the orbital venous plexus (with O_2/CO_2 anesthesia) and following the fourteenth dose at sacrifice from the heart following O_2/CO_2 anesthesia. Serums are assayed for lipoprotein cholesterol profiles, triglycerides, total cholesterol, Non-HDL cholesterol, HDL cholesterol, the ratio of HDL cholesterol to that of Non-HDL cholesterol, insulin, non-esterified fatty acids, and beta-hydroxy butyric acid. The percent body weight gain and the ratio of liver to body weight is also determined. These are shown as absolute values or as a percent change of the pretreatment values in Table 7.



Compound T

Table 7: Examples of effects of oral da daily treatment of obese female Zucker rats with compound T for fourteen days

			Percent of Pre-treatment										
Compound	Expt. #	n	Dose (mg/kg/day)	% wt. gain	HDL-C/ non-HDL-C	TG	TC	Non-HDL-C	HDL-C	Glucose	Insulin	NEFA	BHA
Vehicle	LR90	4	0	12	1	27	1	15	-11	7	26	79	9
T		4	100	13	1	43	4	30	-19	11	70	143	73

n is number of animals per experiment

7.7 Effects of Illustrative Compound T on the *in Vitro* Lipid Synthesis in Isolated Hepatocytes

Compounds were tested for inhibition of lipid synthesis in primary cultures of rat hepatocytes. Male Sprague-Dawley rats were anesthetized with intraperitoneal injection of sodium pentobarbital (80mg/kg). Rat hepatocytes were isolated essentially as described by the method of Seglen (Seglen, P. O. Hepatocyte suspensions and cultures as tools in experimental carcinogenesis. *J. Toxicol. Environ. Health* **1979**, *5*, 551-560). Hepatocytes were suspended in Dulbecco's Modified Eagles Medium containing 25 mM D-glucose, 14 mM HEPES, 5 mM L-glutamine, 5 mM leucine, 5 mM alanine, 10 mM lactate, 1 mM pyruvate, 0.2 % bovine serum albumin, 17.4 mM non-essential amino acids, 20 % fetal bovine serum, 100 nM insulin and 20μg/mL gentamycin) and plated at a density of 1.5×10^5 cells/cm^2 on collagen-coated 96-well plates. Four hours after plating, media was replaced with the same media without serum. Cells were grown overnight to allow formation of monolayer cultures. Lipid synthesis incubation conditions were initially assessed to ensure the linearity of [1-^{14}C]-acetate incorporation into hepatocyte lipids for up to 4 hours. Hepatocyte lipid synthesis inhibitory activity was assessed during incubations in the presence of 0.25 μCi [1-^{14}C]-acetate/well (final radiospecific activity in assay is 1 Ci/mol) and 0, 1, 3, 10, 30, 100 or 300 μM of compounds for 4 hours. At the end of the 4-hour incubation period, medium was discarded and cells were washed twice with ice-cold phosphate buffered saline and stored frozen prior to analysis. To determine total lipid synthesis, 170 μl of MicroScint-E® and 50 μl water was added to each well to extract and partition the lipid soluble products to the upper organic phase containing the scintillant. Lipid radioactivity was assessed by scintillation spectroscopy in a Packard TopCount NXT. Lipid synthesis rates were used to determine the IC_{50}s of the compounds that are presented in Table 8.

Table 8: Effect of Compounds on Lipid Synthesis in Primary Rat Hepatocytes.

Compound	IC_{50} (μM)	95% Confidence Interval		r^2
		Lower	Upper	
A	1.1	1.0	1.2	0.99

The present invention is not to be limited in scope by the specific embodiments disclosed in the examples which are intended as illustrations of a few aspects of the invention and any embodiments which are functionally equivalent are within the scope of this invention. Indeed, various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art and are intended to fall within the appended claims.

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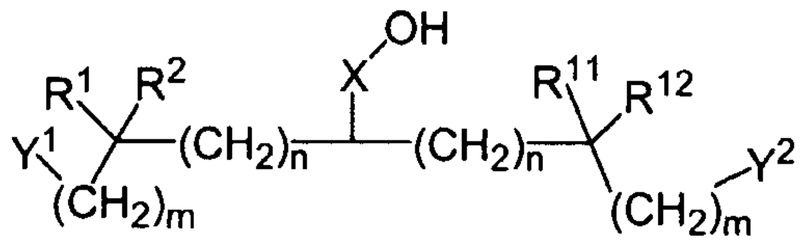
CLAIMS:

1. A compound of the formula I:



I

or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein:

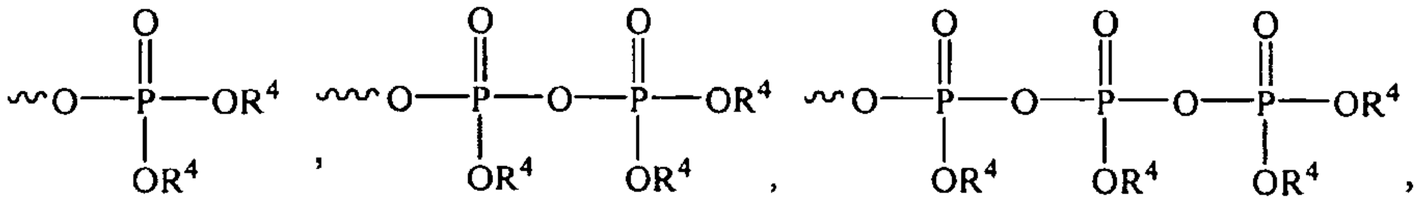
(a) each occurrence of m is independently an integer ranging from 0 to 5;

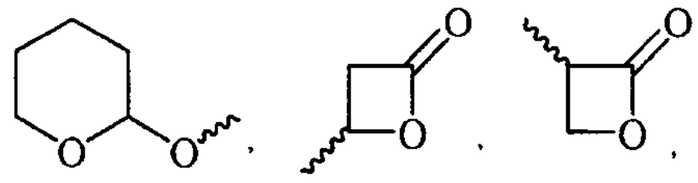
(b) each occurrence of n is independently an integer ranging from 3 to 7;

(c) X is $(CH_2)_z$, wherein z is 0;

(d) each occurrence of R^1, R^2, R^{11}, and R^{12} is independently H, $(C_1$-$C_6)$alkyl, $(C_2$–$C_6)$alkenyl, $(C_2$–$C_6)$alkynyl, phenyl, or benzyl, wherein R^1, R^2, R^{11}, and R^{12} are not each simultaneously H; and

(e) each occurrence of Y^1 and Y^2 is independently OH, COOH, $COOR^3$, SO_3H,





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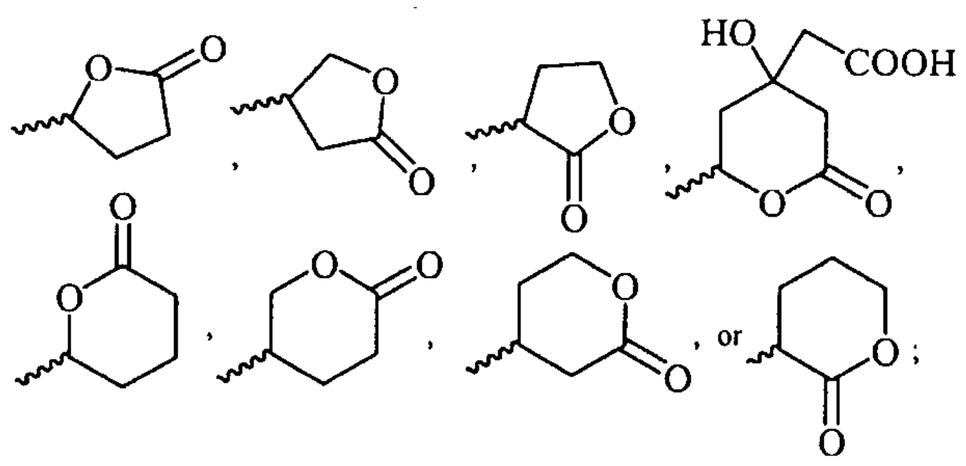

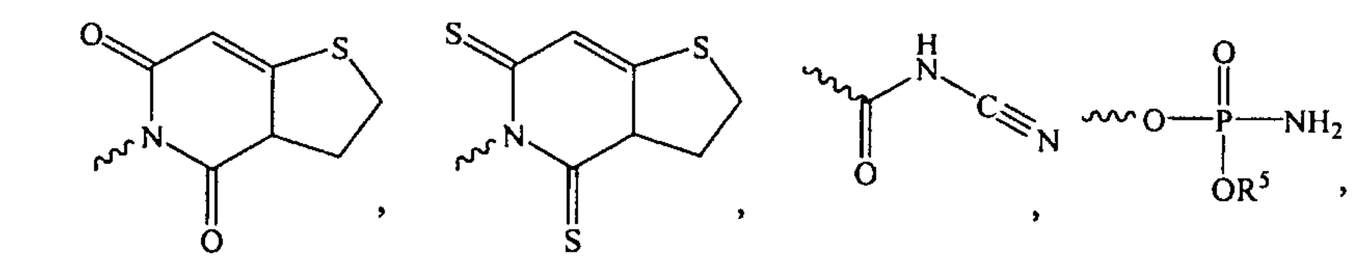

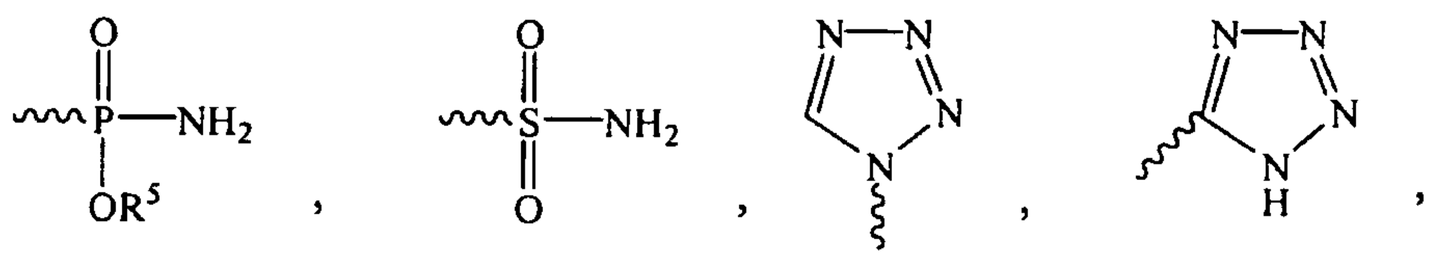

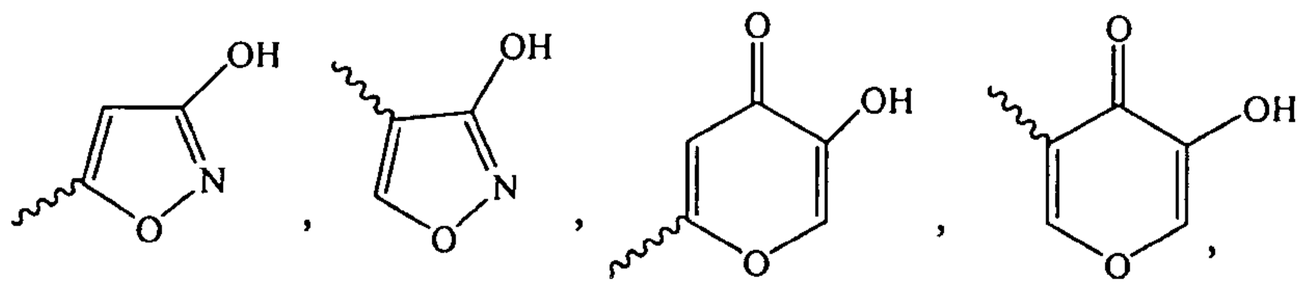

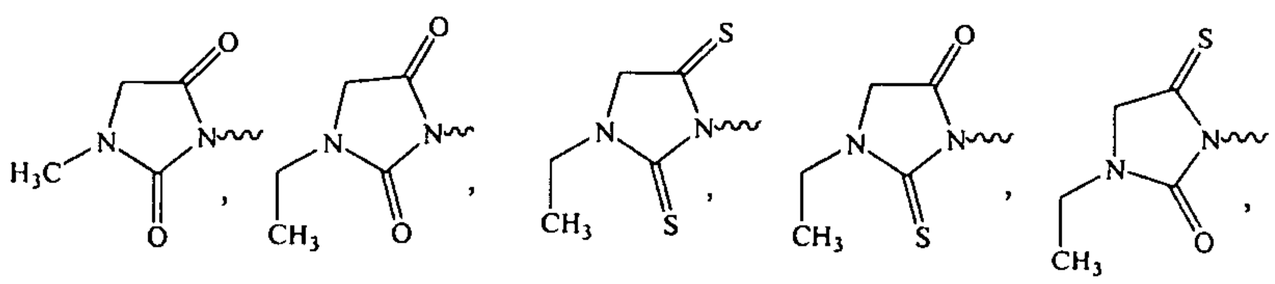

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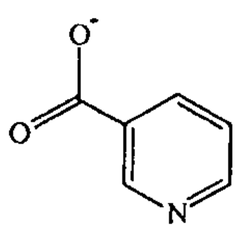

or ;

wherein:

(i) R^3 is $(C_1–C_6)$alkyl, (C_2C_6)alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or

10 phenyl groups,

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(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, (C_2-C_6)alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups; and

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, (C_2-C_6)alkenyl, or $(C_2–C_6)$alkynyl.

2. The compound of claim 1, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein each occurrence of Y_1 and Y_2 is independently OH, $COOR^3$, or COOH.

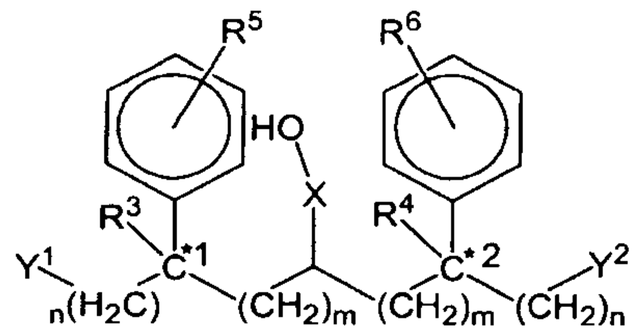
3. The compound of claim 1, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein m is 0.

4. The compound of claim 1, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein m is 1.

5. The compound of claim 1, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein n is 4.

6. The compound of claim 1, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein n is 5.

7. A compound of formula II:



II

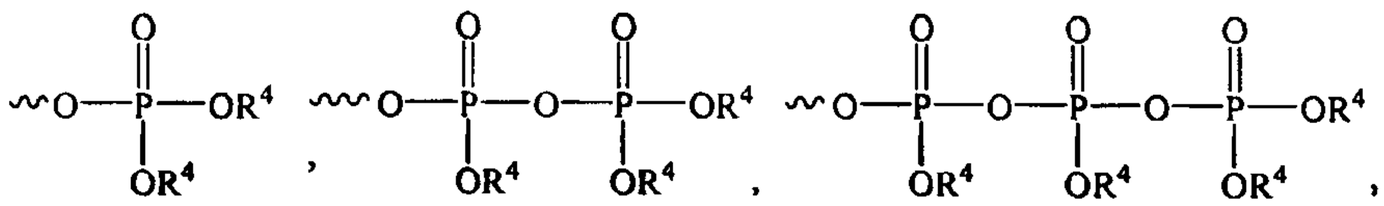
or a pharmaceutically acceptable salt, hydrate, solvate, or mixture thereof, wherein:

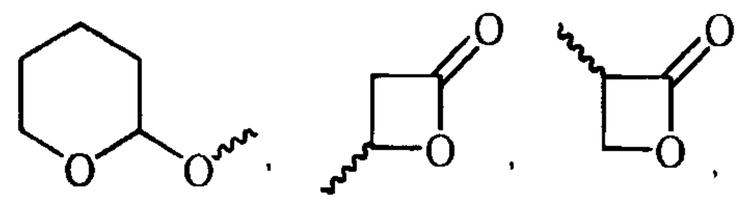
(a) each occurrence of m is independently an integer ranging from 3 to 7;

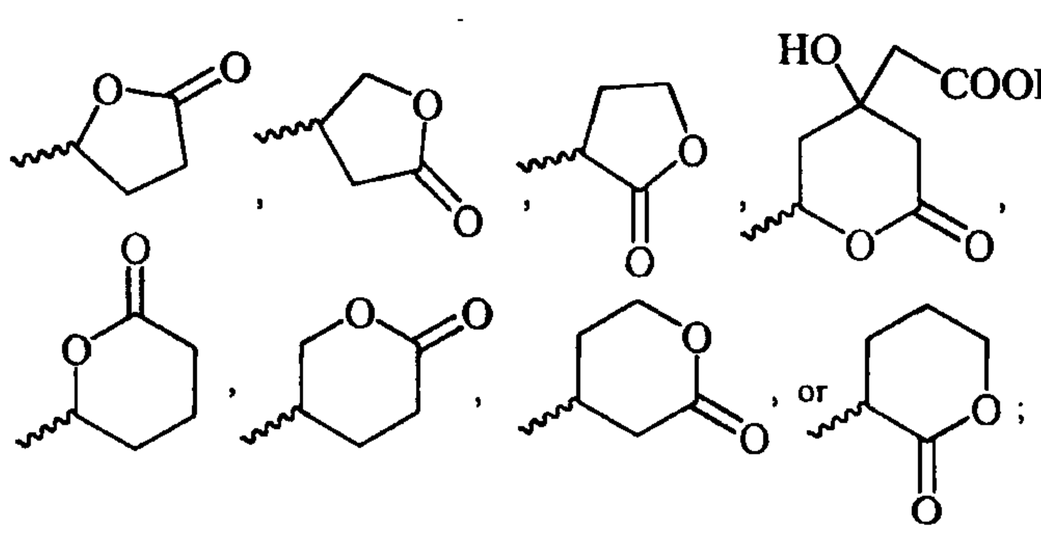
(b) each occurrence of n is independently an integer ranging from 0 to 5;

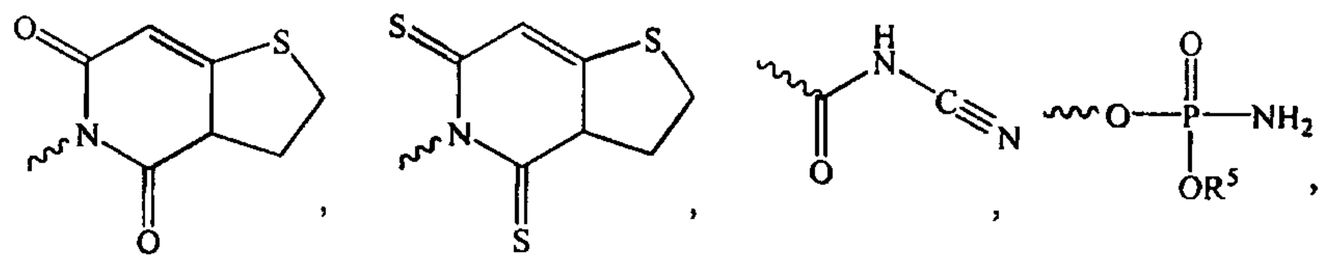
(c) X is $(CH_2)_z$, wherein z is 0;

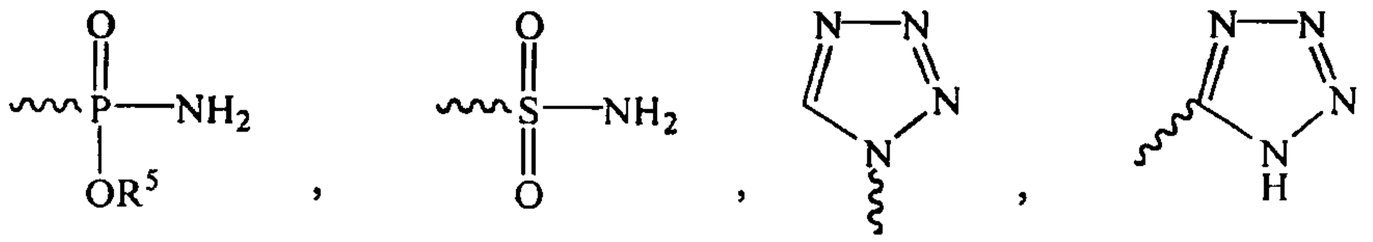
(d) each occurrence of Y^1 and Y^2 independently $(C_1–C_6)$alkyl, OH, COOH, $COOR^7$, SO_3H,











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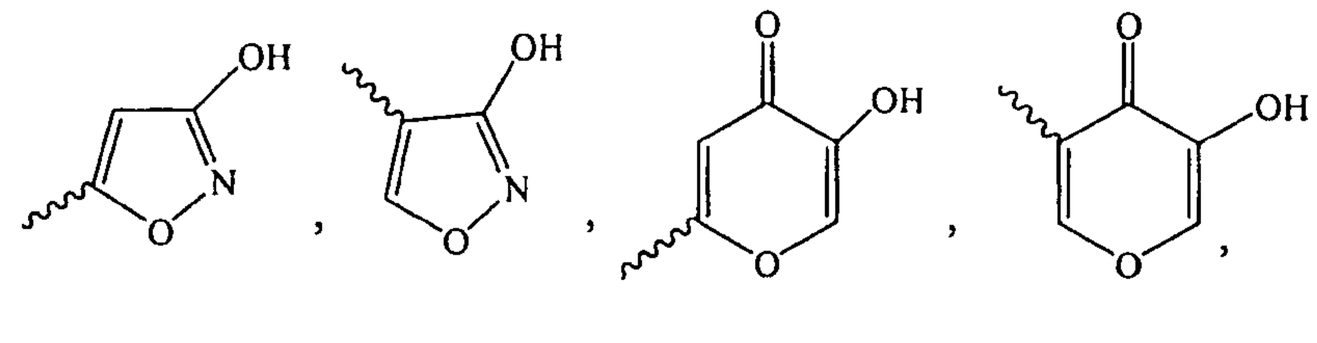
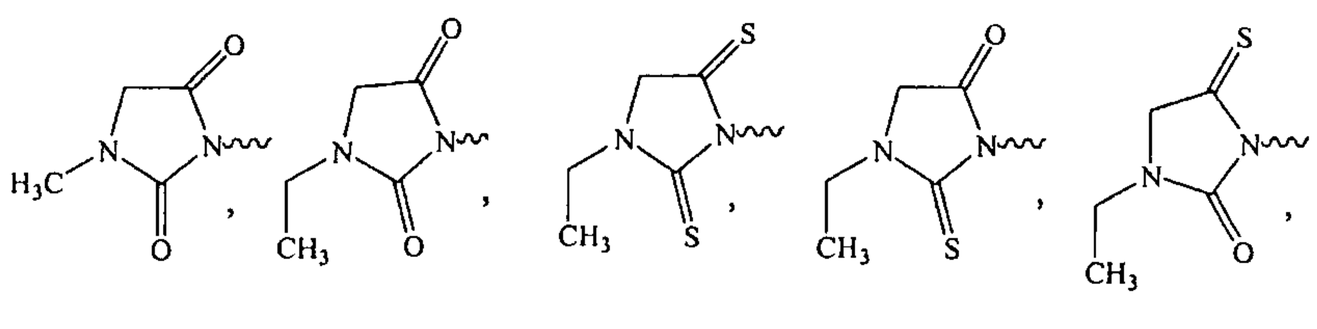
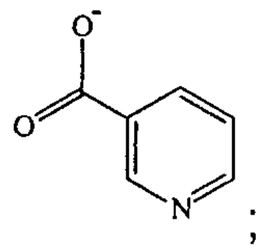






;

wherein:

(i) R^7 is $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^8 is independently H, $(C_1–C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(iii) each occurrence of R^9 is independently H, $(C_1–C_6)$alkyl, $(C_2\text{-}C_6)$alkenyl, or $(C_2–C_6)$alkynyl;

(e) R^3 and R^4 are $(C_1–C_6)$alkyl, $(C_2–C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl;

(f) R^5 and R^6 are H, halogen, $(C_1–C_4)$alkyl, $(C_1–C_4)$alkoxy, (C_6)aryloxy, CN, or NO_2, $N(R^5)_2$ where R^5 is H, $(C_1–C_4)$alkyl, phenyl, or benzyl;

(g) C^{*1} and C^{*2} represent independent chiral–carbon centers wherein each center may independently be R or S.

8. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein each occurrence of Y^1 and Y^2 is independently OH, $COOR^7$, or COOH.

9. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein m is 4.

10. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein m is 5.

11. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein each of Y^1 and Y^2 is C(O)OH or CH_2OH.

12. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein R^3 and R^4 are each independently $(C_1\text{-}C_6)$alkyl.

13. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein R^3 and R^4 are each methyl.

14. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein C^{*1} is of the stereochemical configuration R or substantially R.

15. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein C^{*1} is of the stereochemical configuration S or substantially S.

16. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein C^{*2} is of the stereochemical configuration R or substantially R.

17. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein C^{*2} is of the stereochemical configuration S or substantially S.

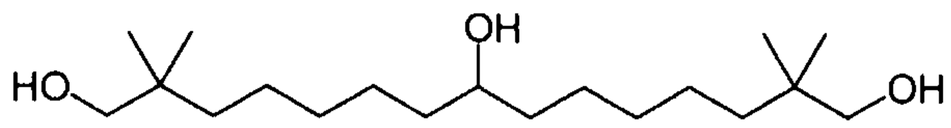
18. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein C^{*1} and C^{*2} are of the stereochemical configuration (S^1, S^2) or substantially (S^1, S^2).

19. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein C^{*1} and C^{*2} are of the stereochemical configuration (S^1, R^2) or substantially (S^1, R^2).

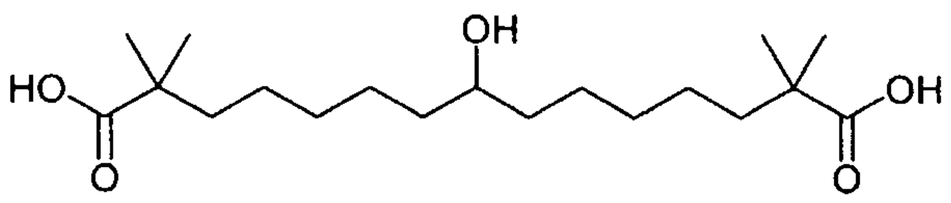
20. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein C^{*1} and C^{*2} are of thestereochemical configuration (R^1, R^2) or substantially (R^1, R^2).

21. The compound of claim 7, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein C^{*1} and C^{*2} are of thestereochemical configuration (R^1, S^2) or substantially (R^1, S^2).

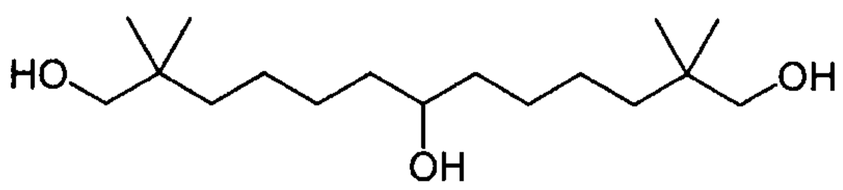
22. A compound of structure:



2,2,14,14-Tetramethyl-pentadecane-1,8,15-triol;



8-Hydroxy-2,2,14,14-tetramethyl-pentadecanedioic acid;



2,2,12,12-Tetramethyl-tridecane-1,7,13-triol; or

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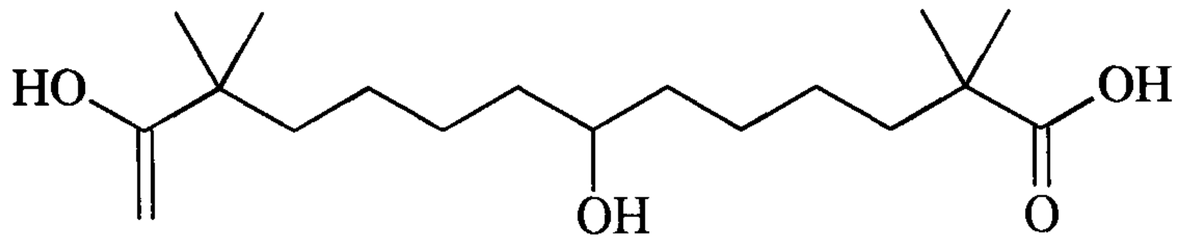
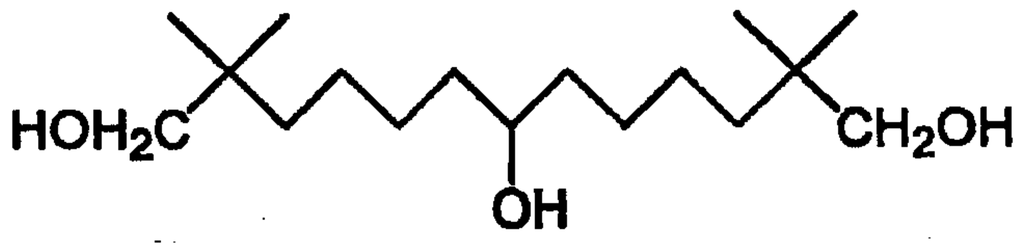


7-Hydroxy-2,2,12,12-tetramethyl-tridecanedioic acid.

23. A compound of structure:



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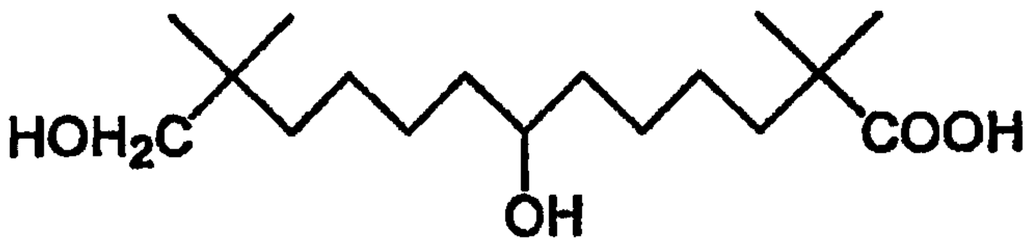

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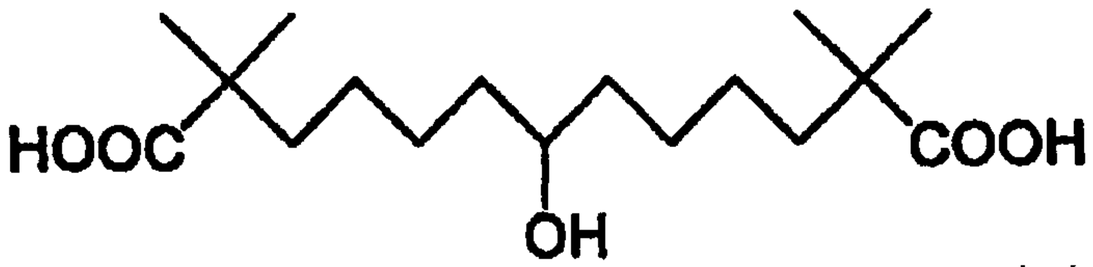

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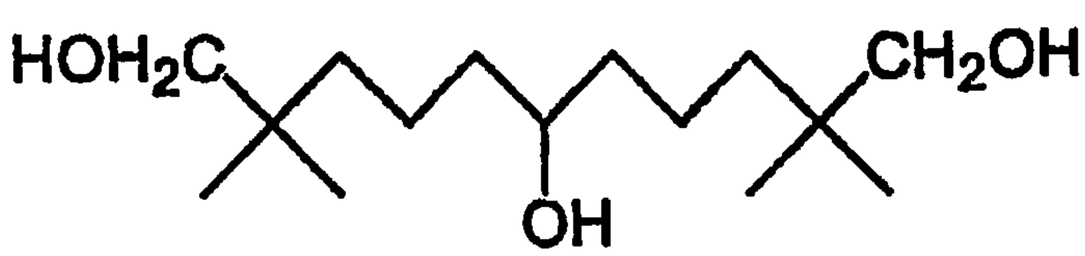

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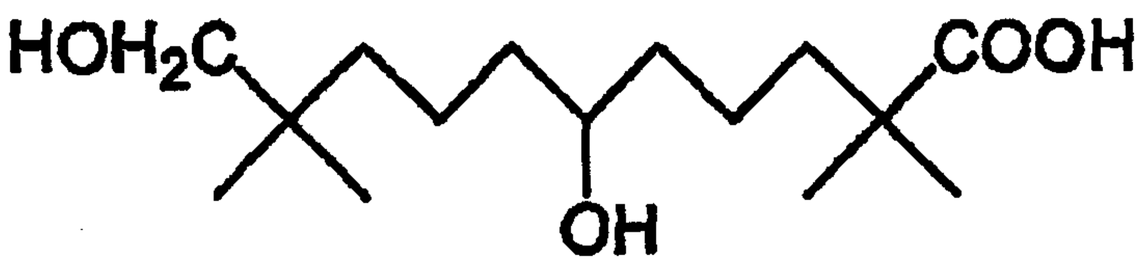

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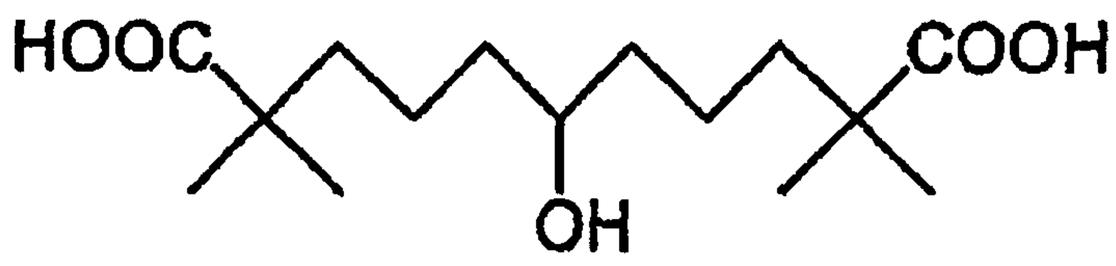
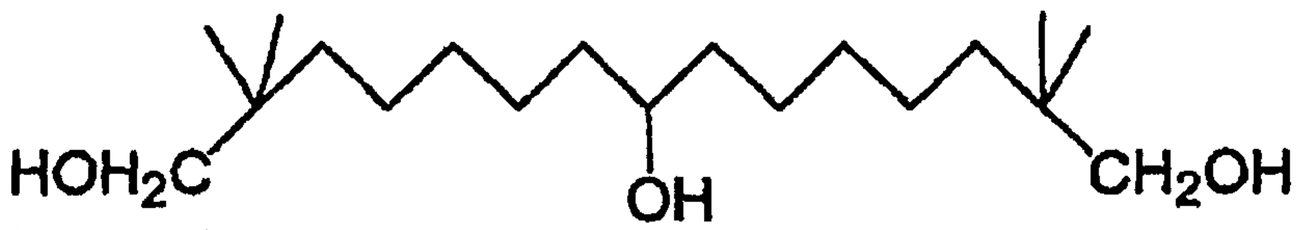
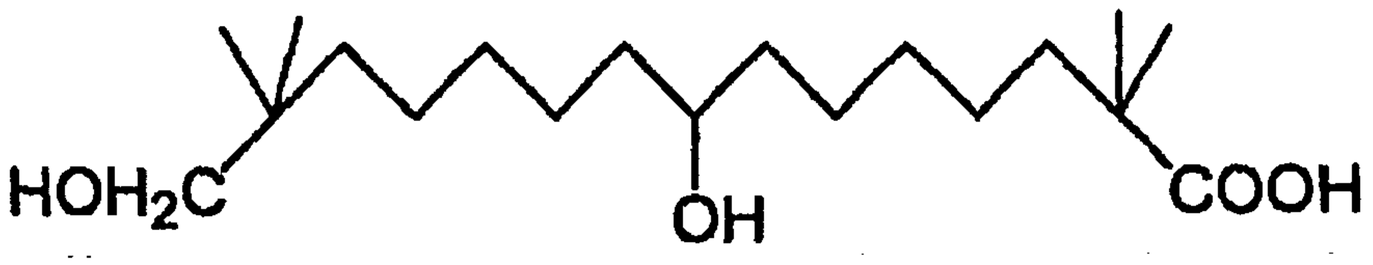

HOOC
COOH
OH

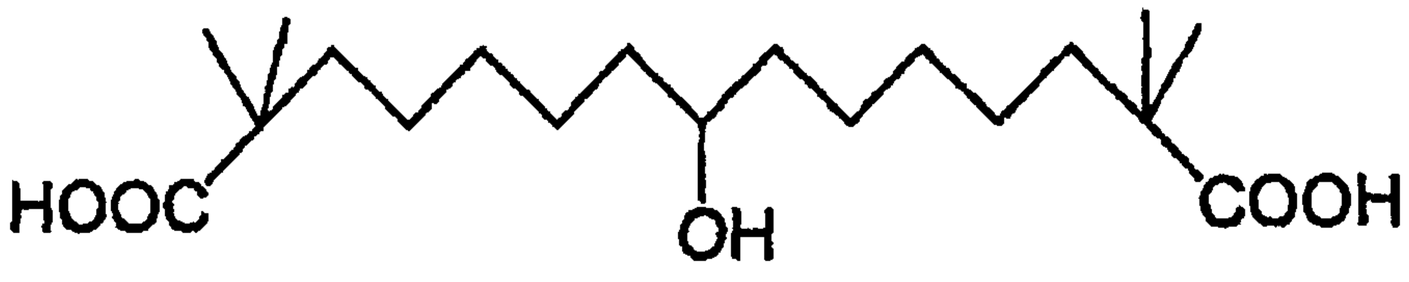
;


HOH2C
OH
CH2OH

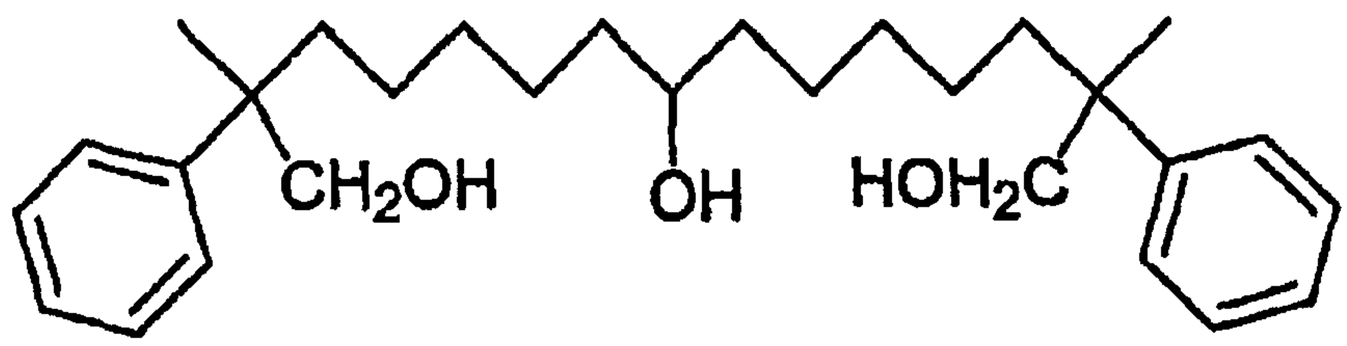
.


HOH2C
OH
COOH

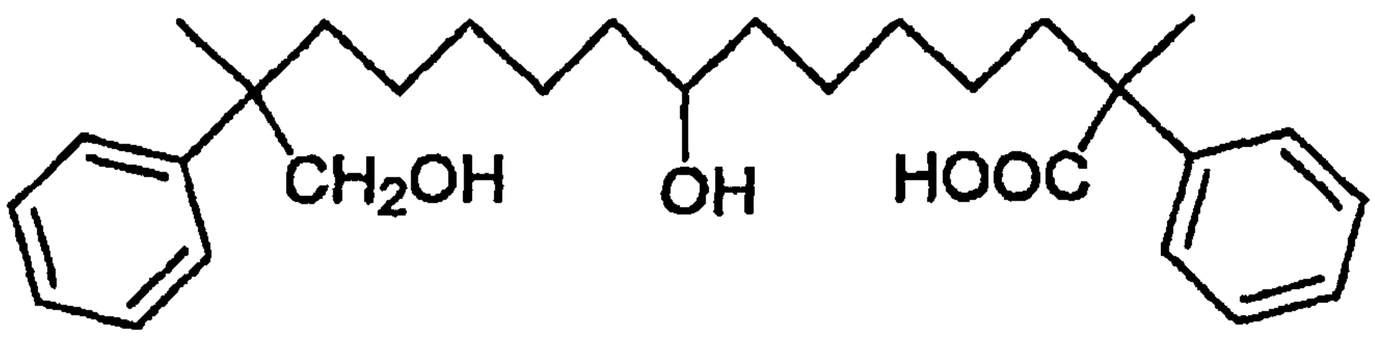
;


HOOC
OH
COOH

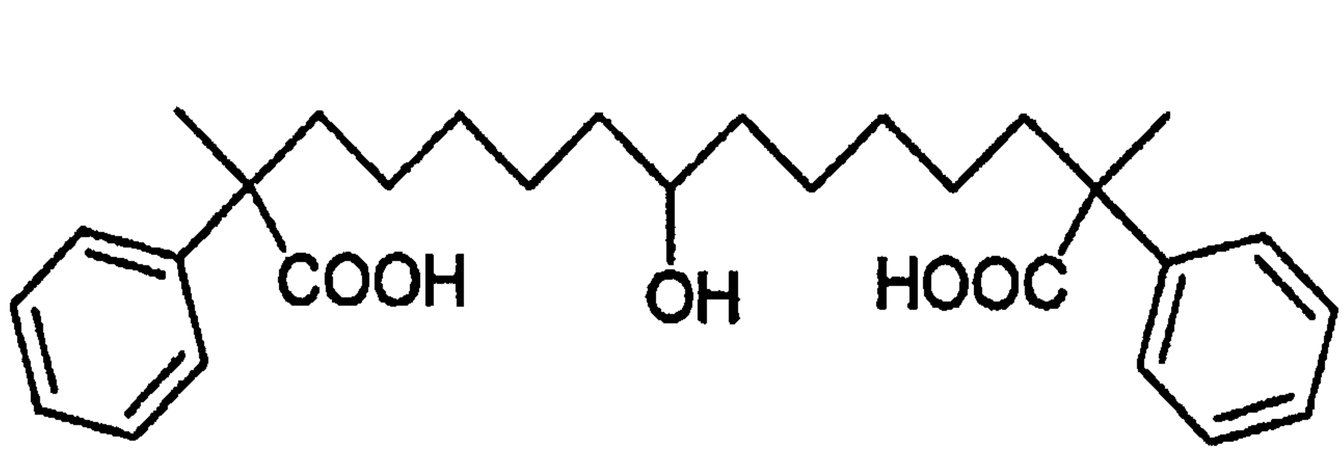
;


CH2OH
OH
HOH2C

;


CH2OH
OH
HOOC

;


COOH
OH
HOOC

;

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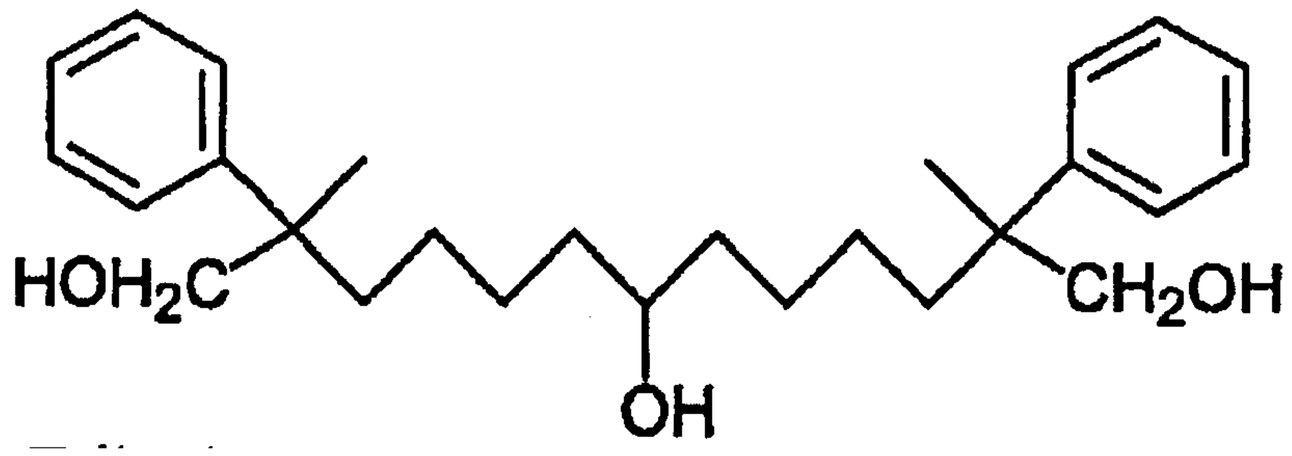

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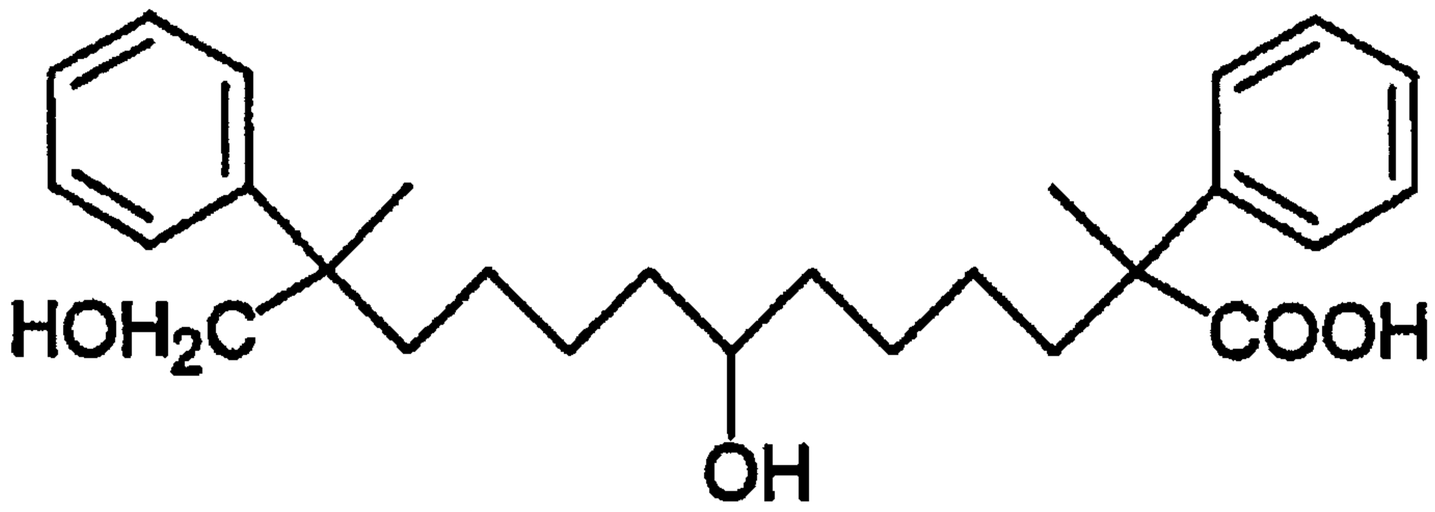

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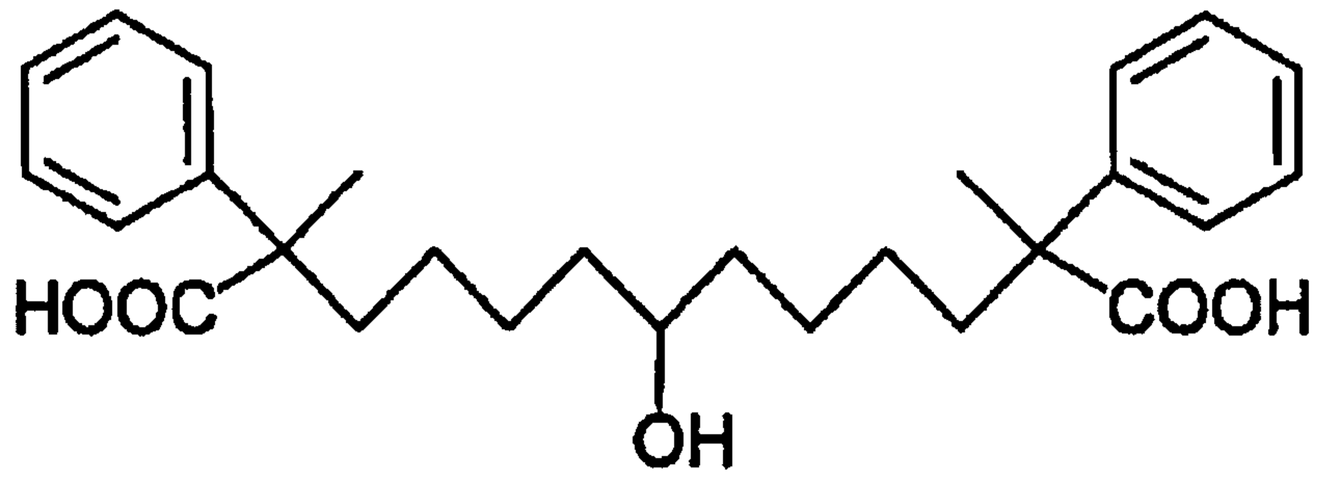

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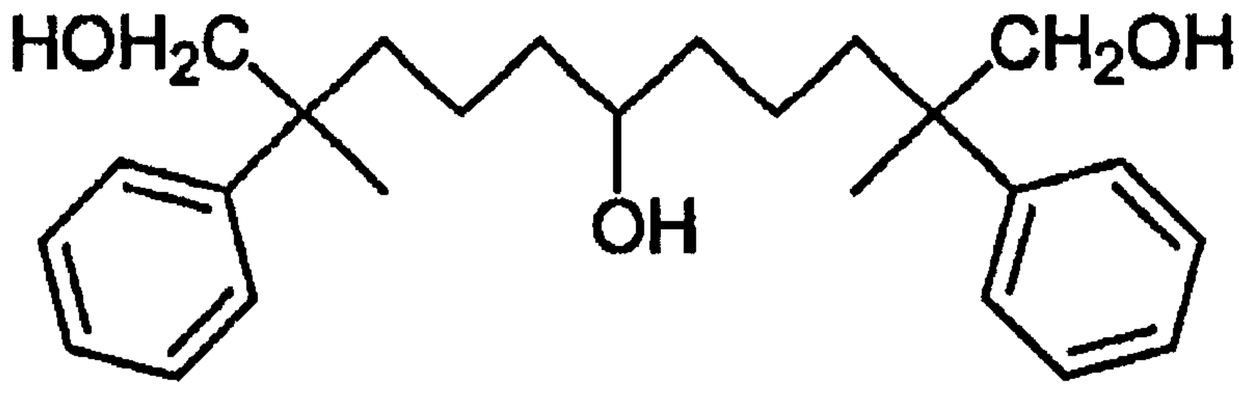

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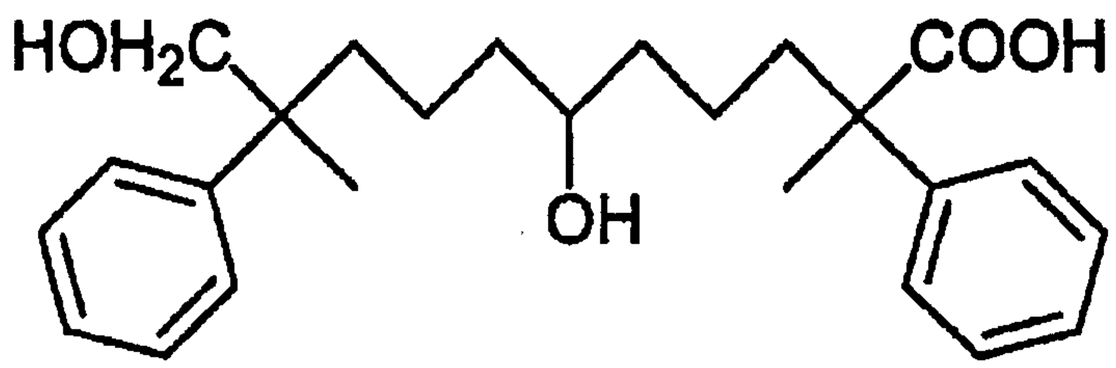

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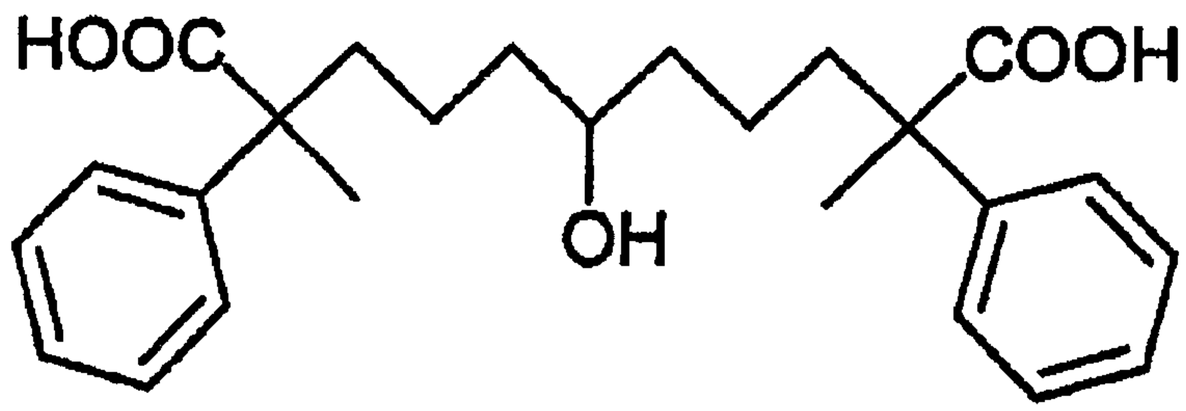
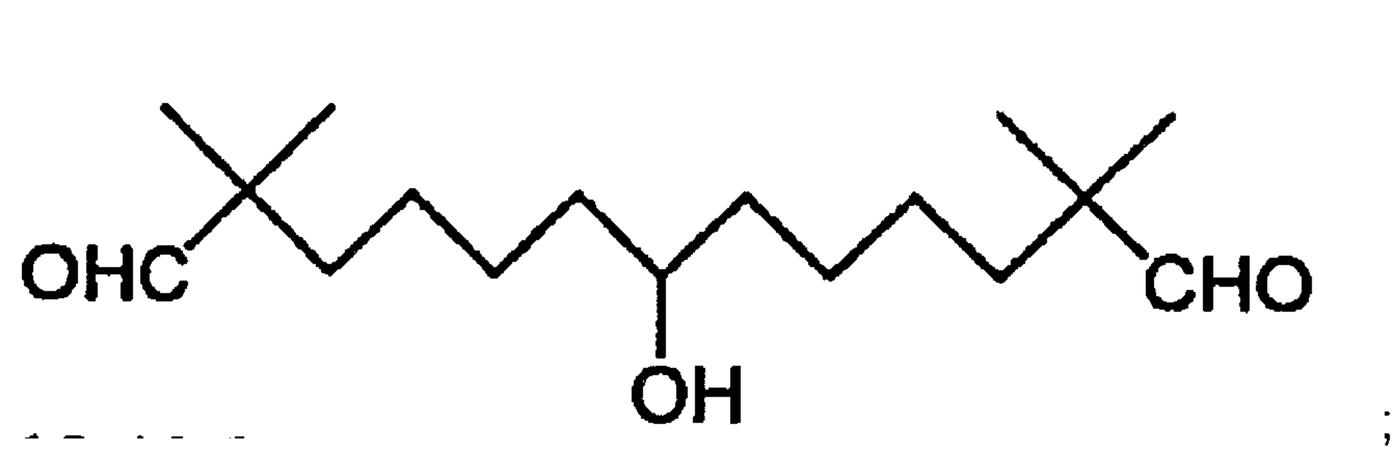
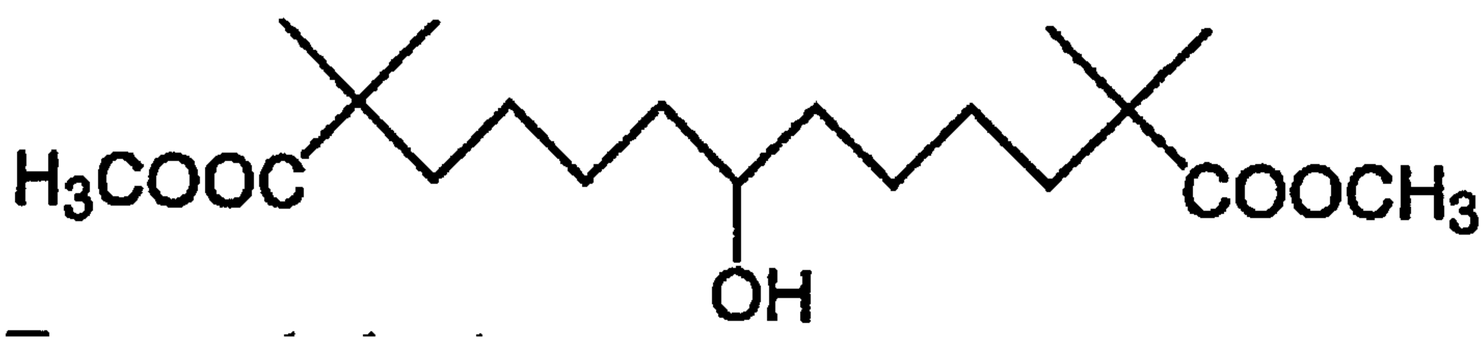
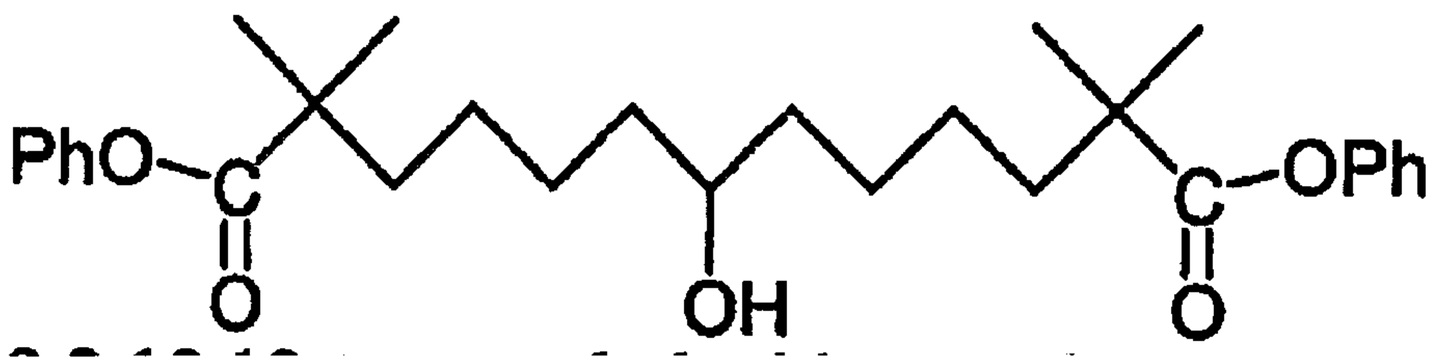
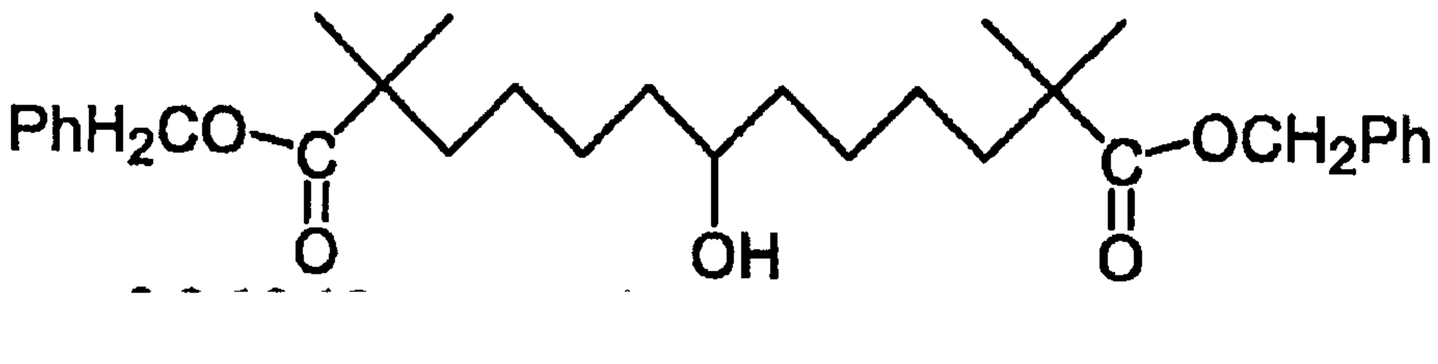

HOOC
COOH
OH


OHC
CHO
OH


H3COOC
COOCH3
OH


PhO
C
O
OH
C
O
OPh


PhH2CO
C
O
OH
C
O
OCH2Ph

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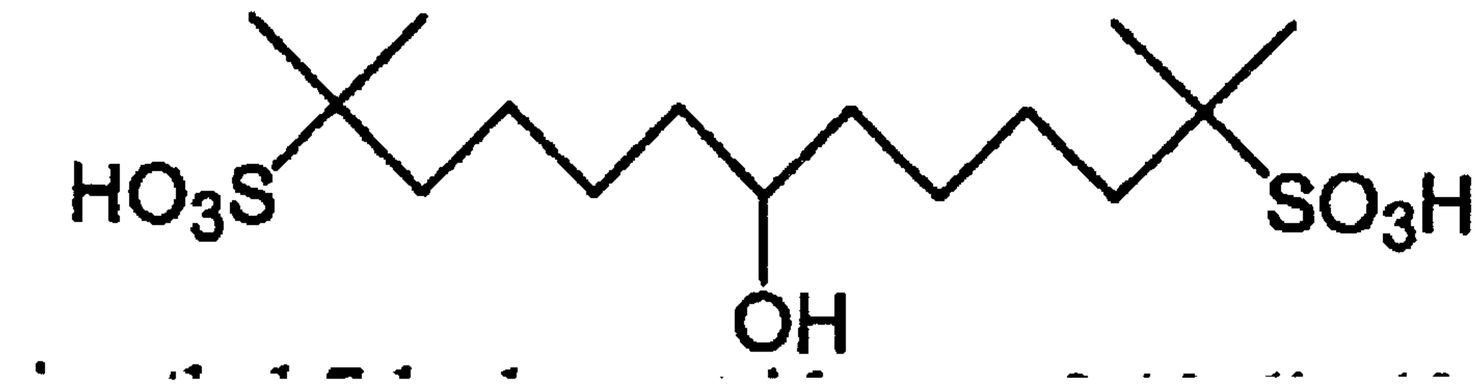
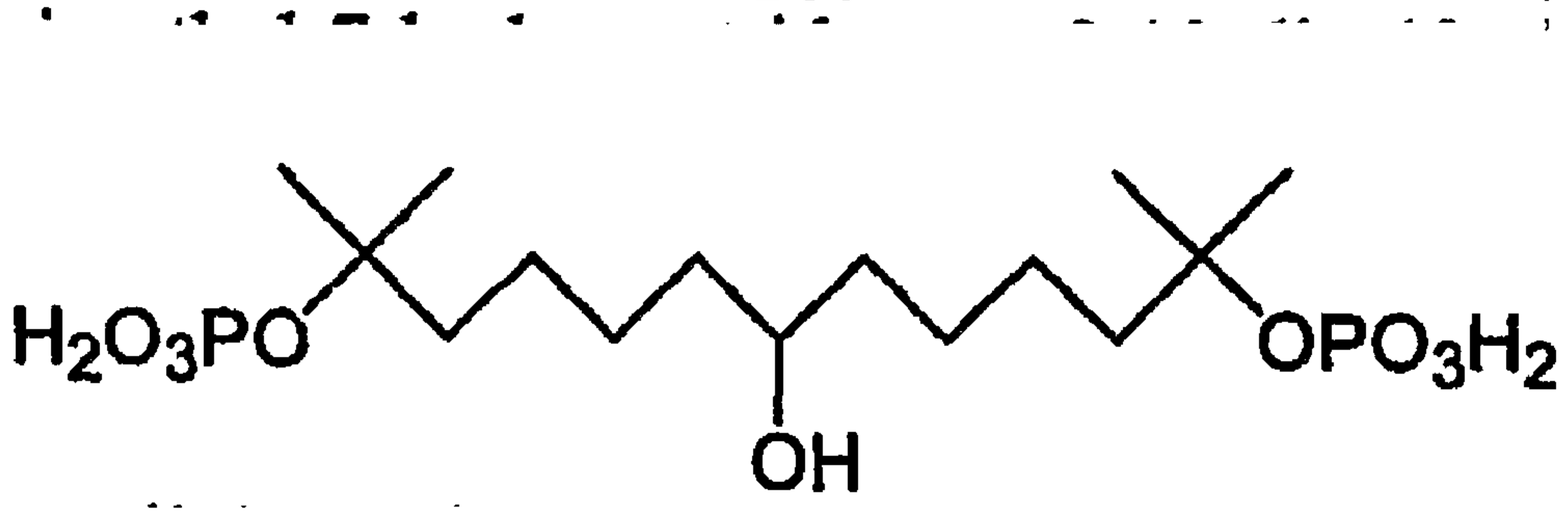
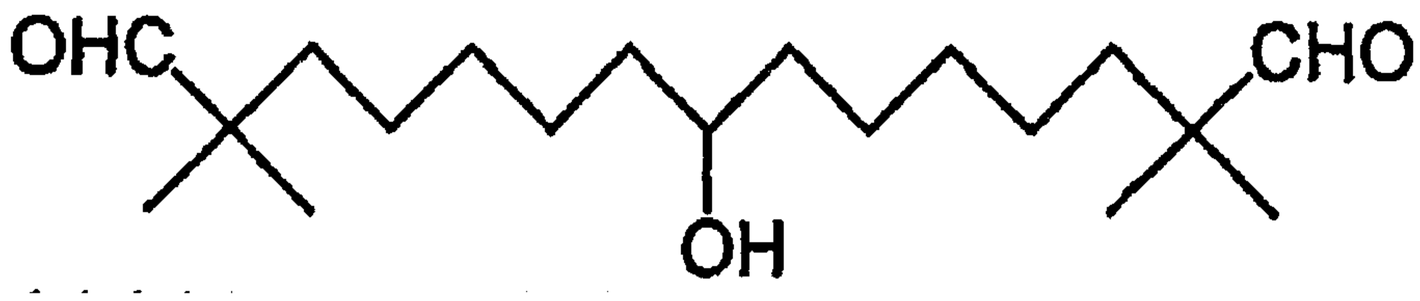

HO3S
SO3H
OH


H2O3PO
OPO3H2
OH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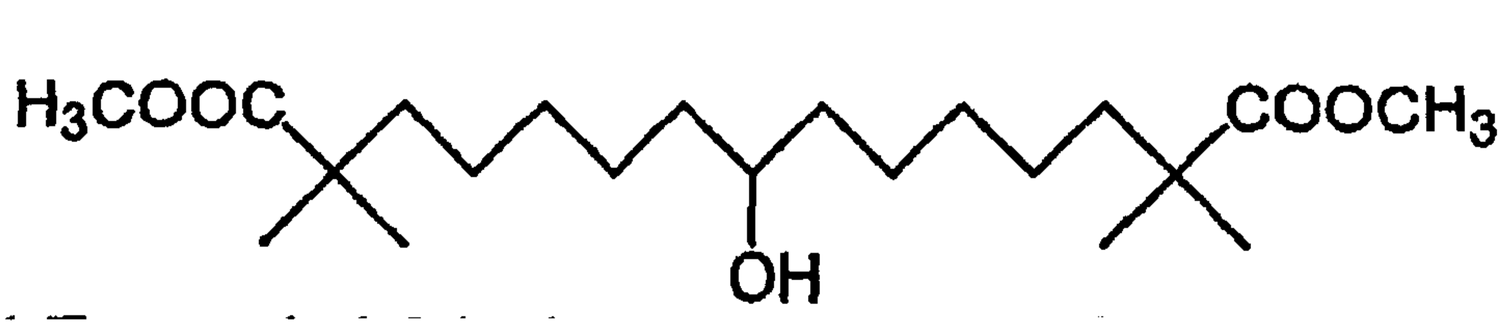
CHO
OH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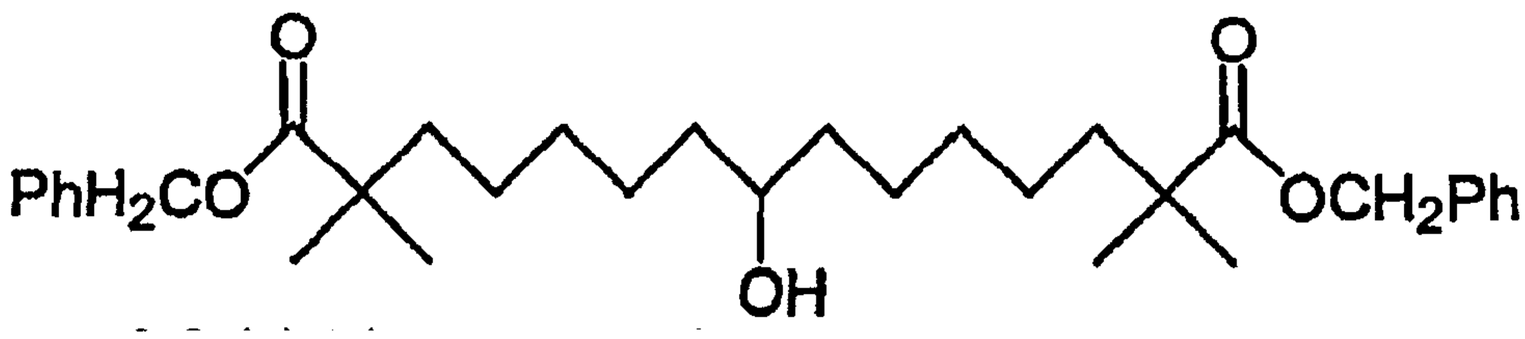
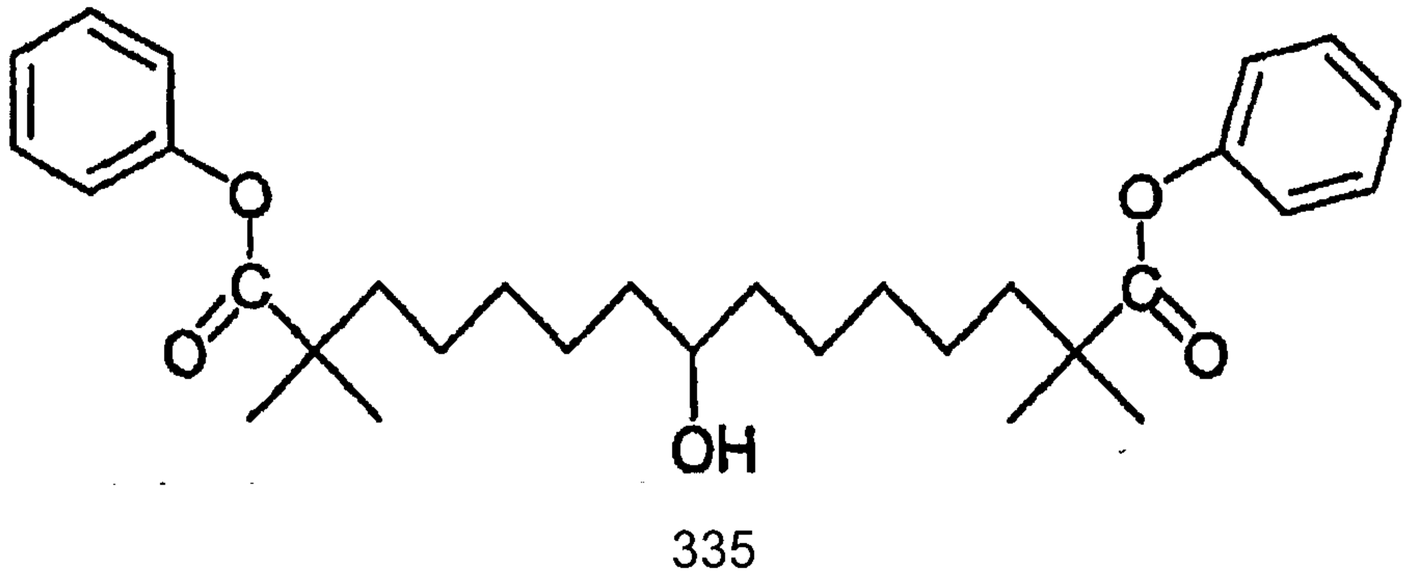
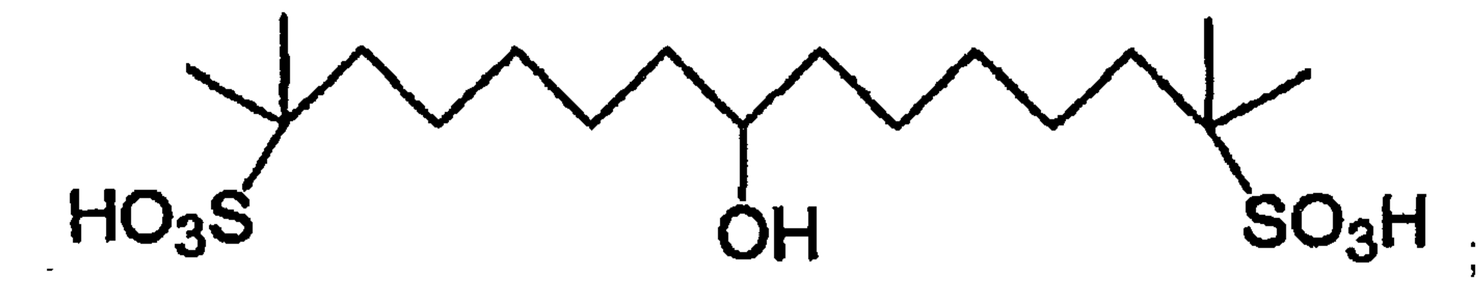
COOCH3
OH


O
PhH2CO
OCH2Ph
OH


O
C
O
O
C
O
OH

335

71636-10



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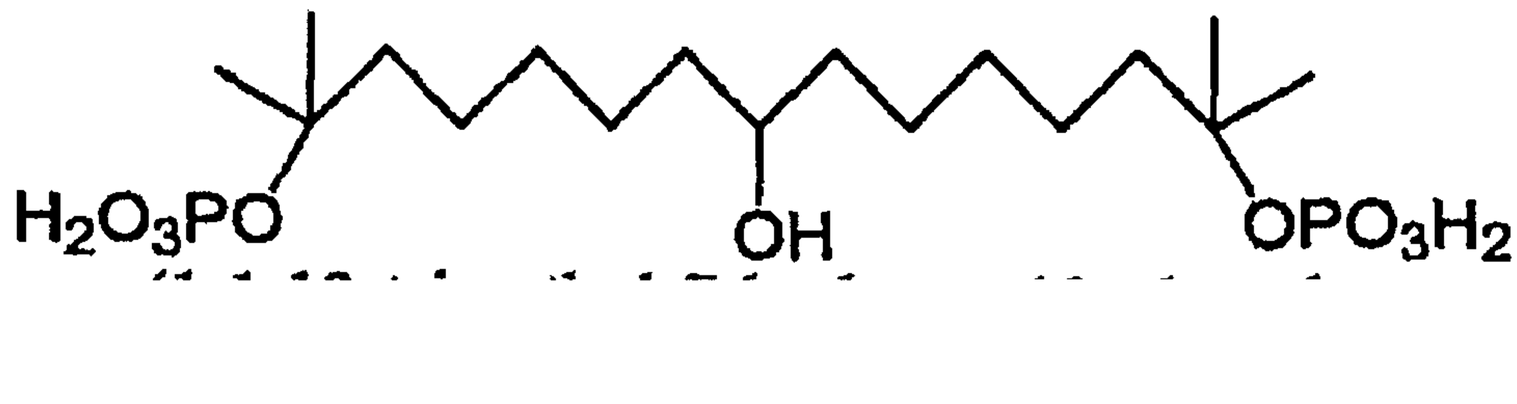

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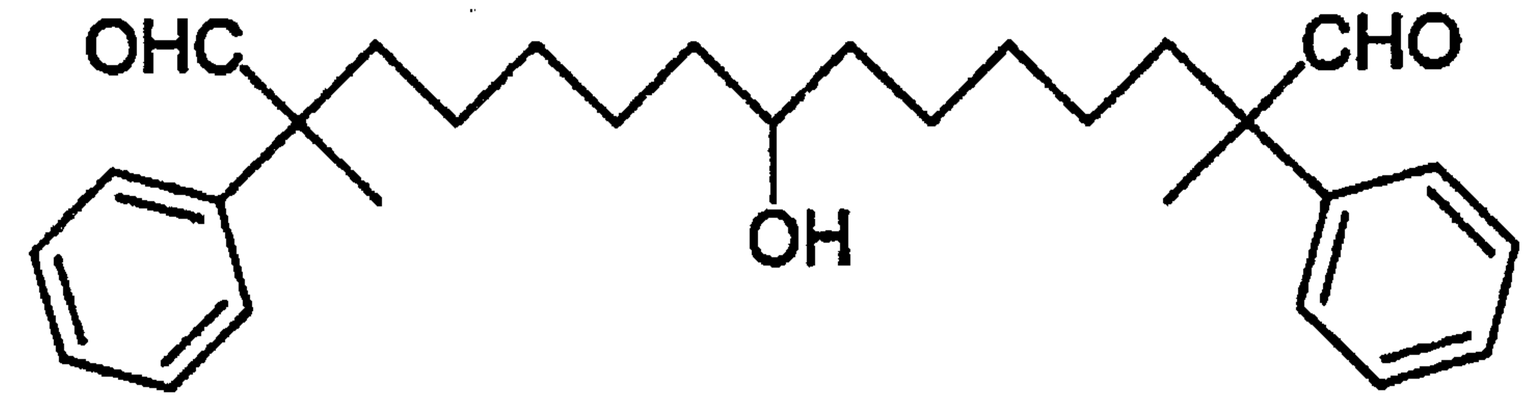

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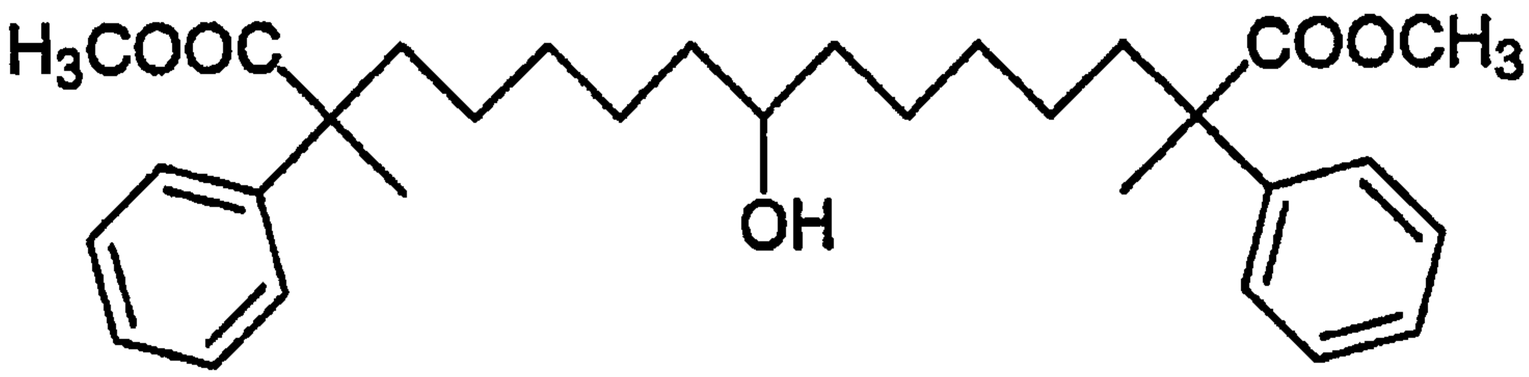

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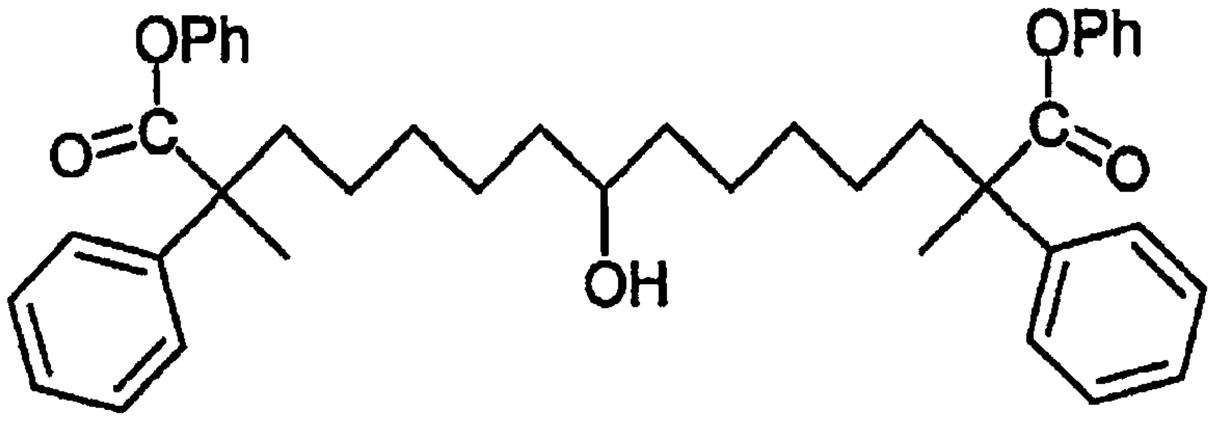

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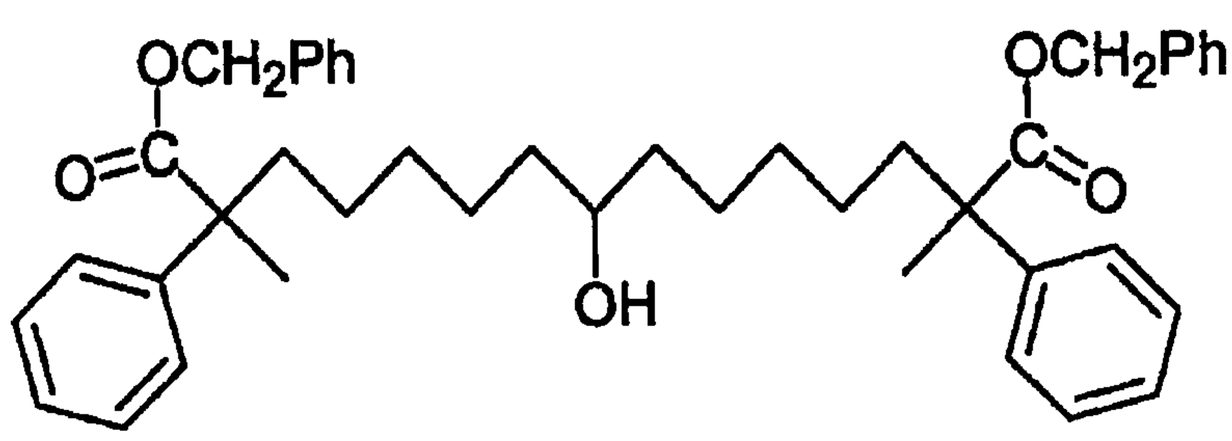

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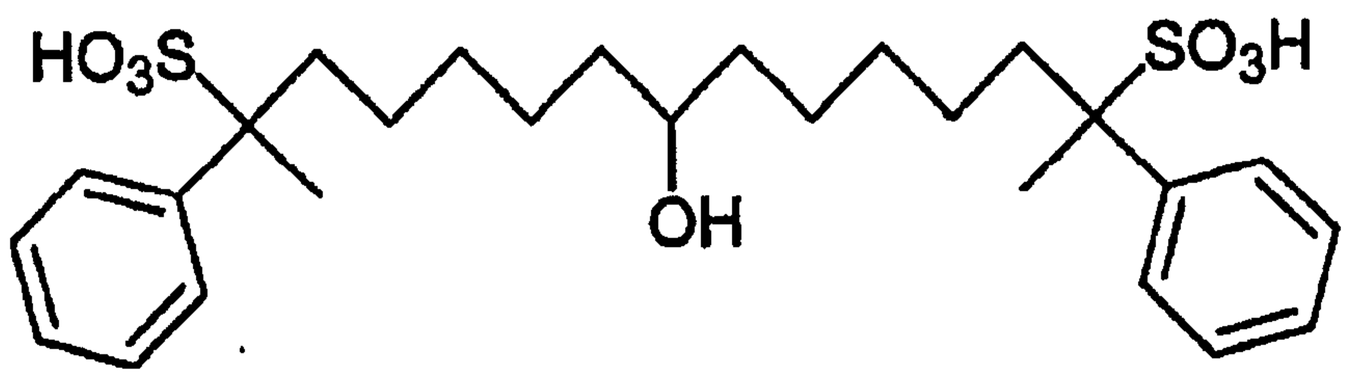

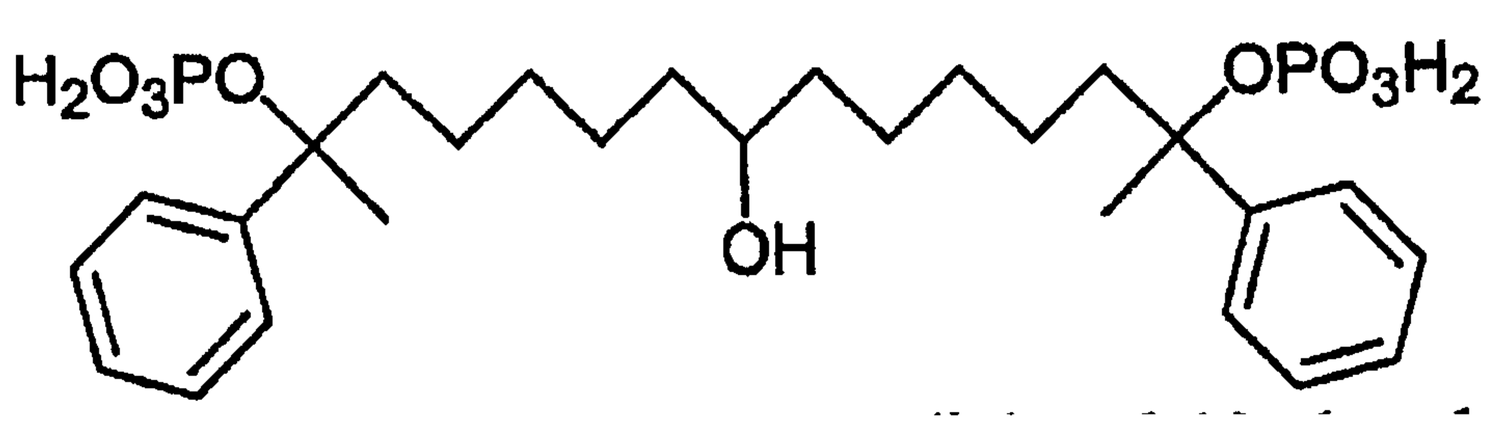

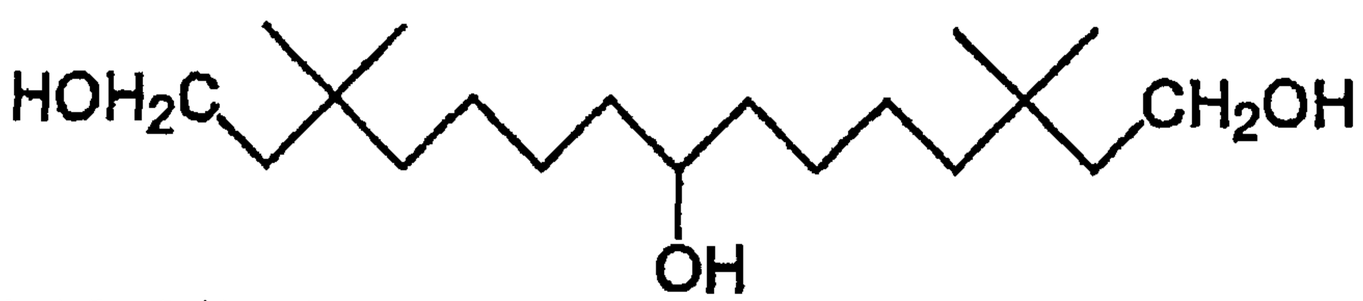

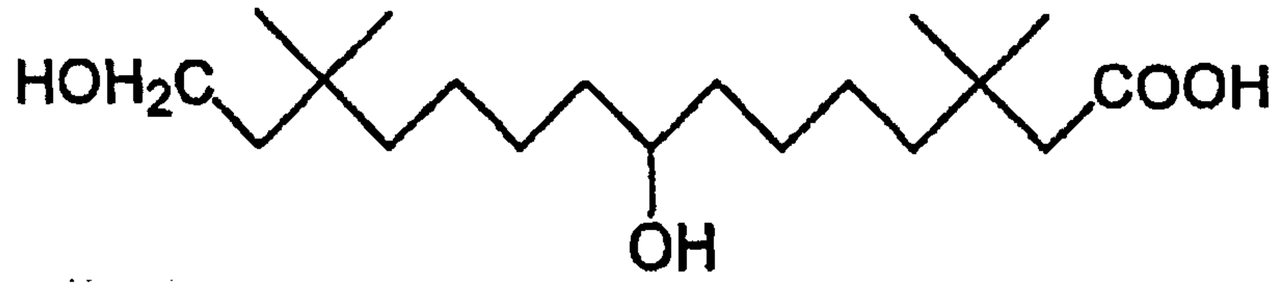

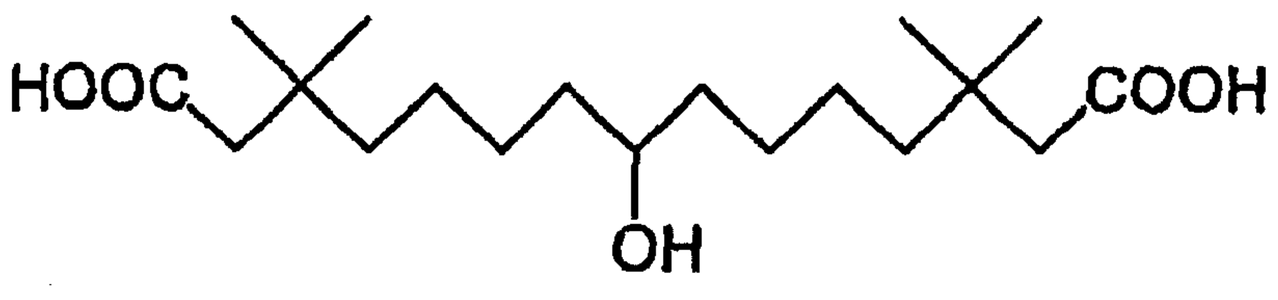

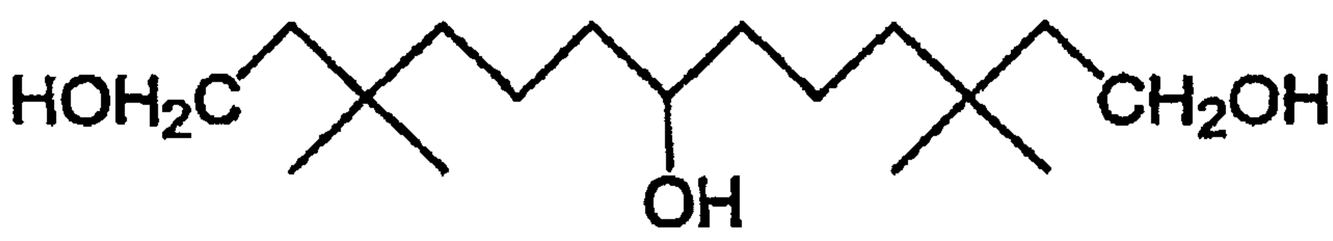

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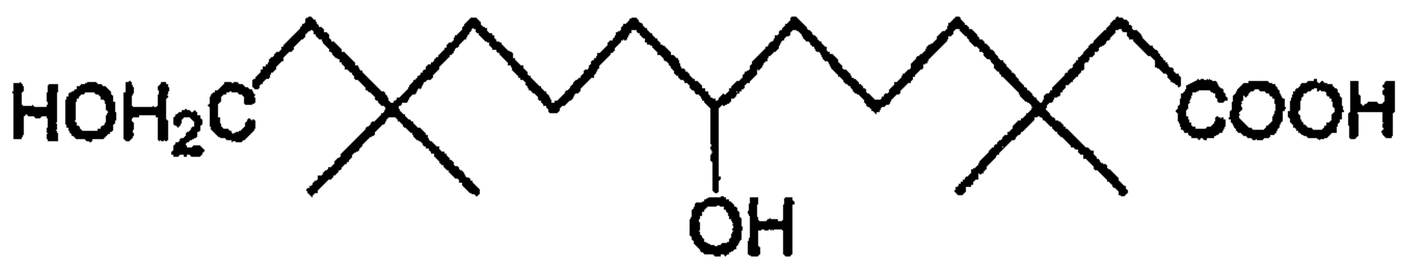

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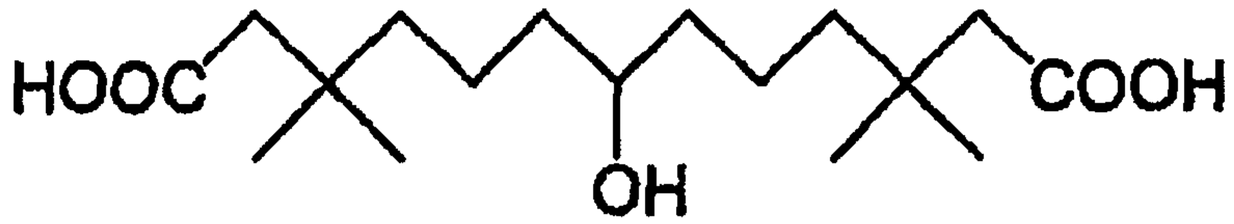

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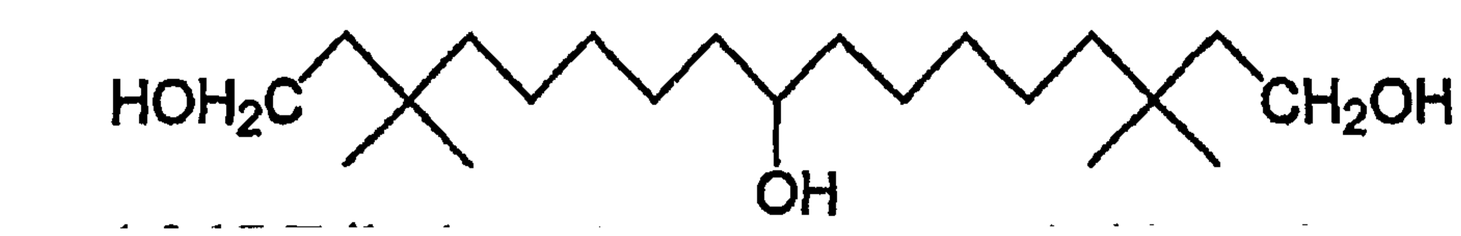

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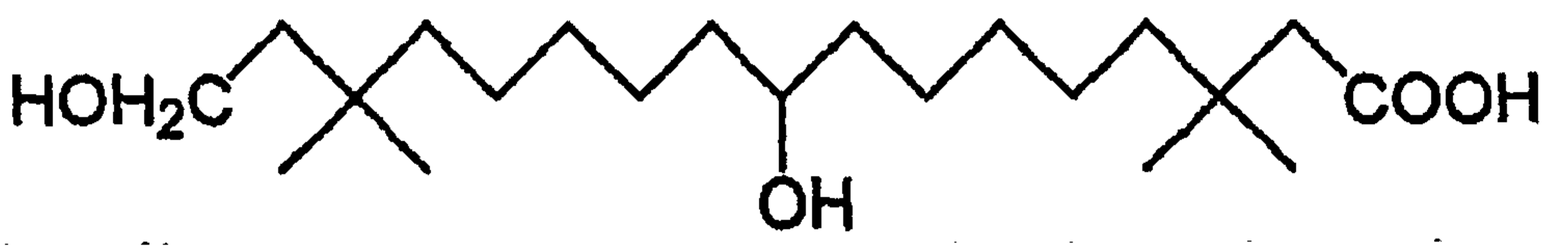

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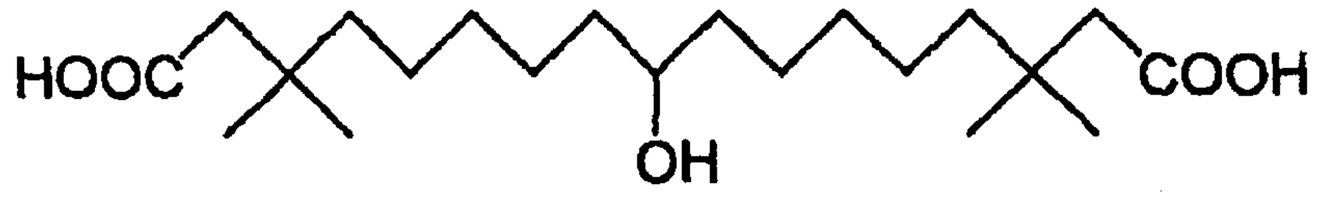

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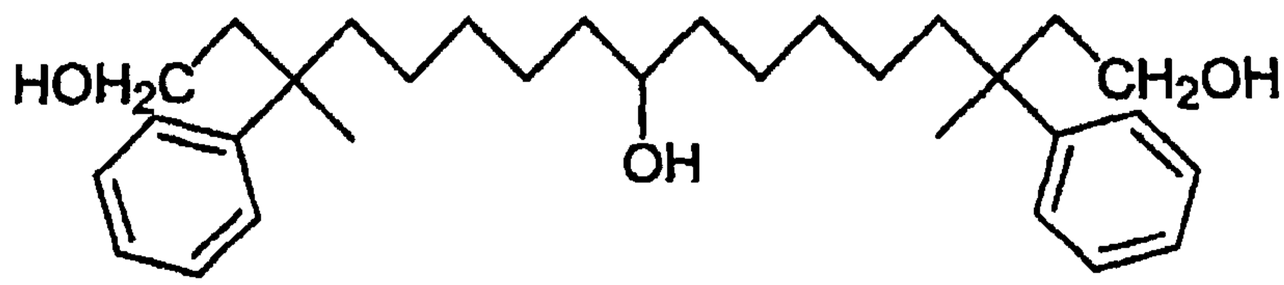

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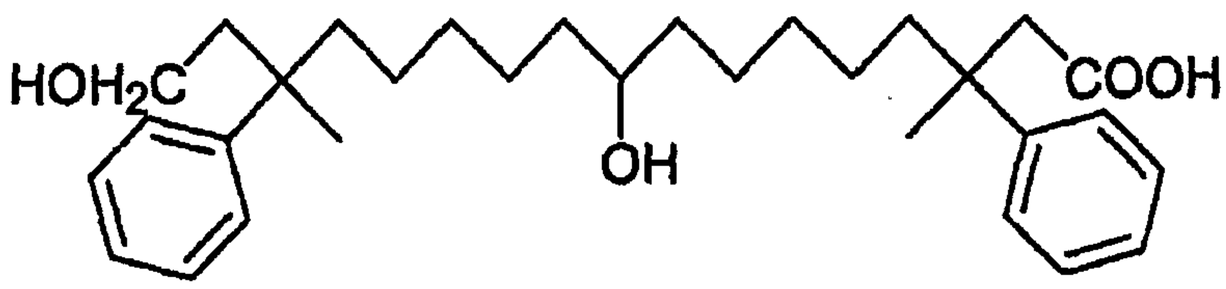

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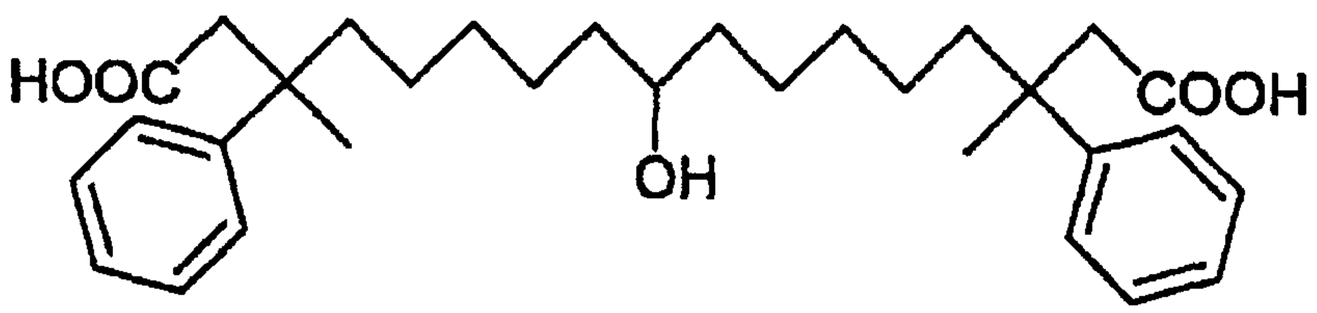
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OH
COOH

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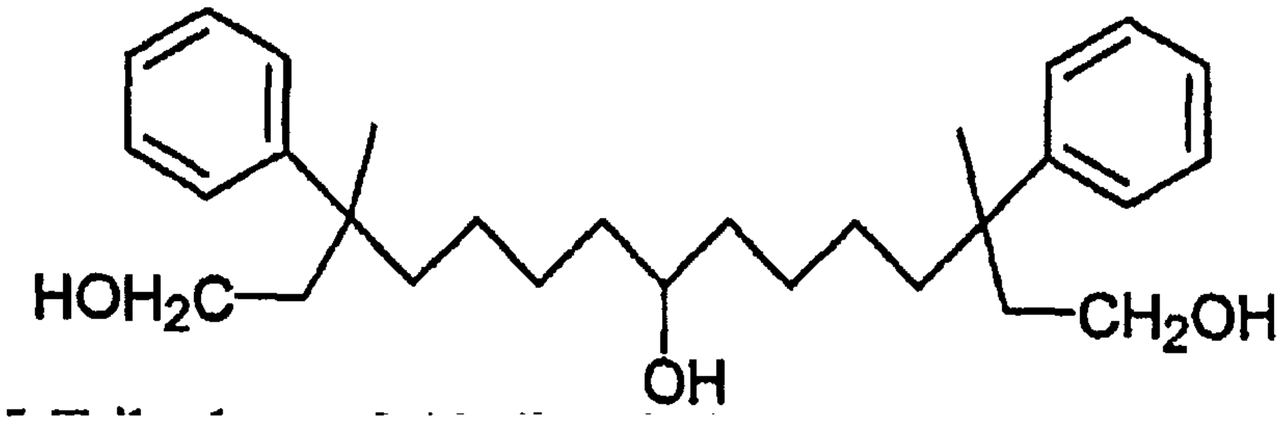
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CH2OH

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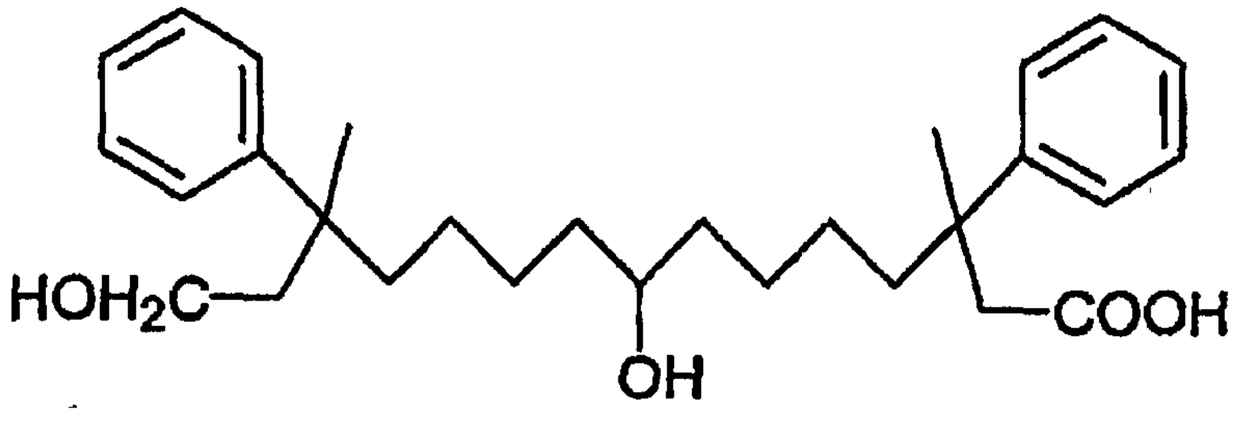
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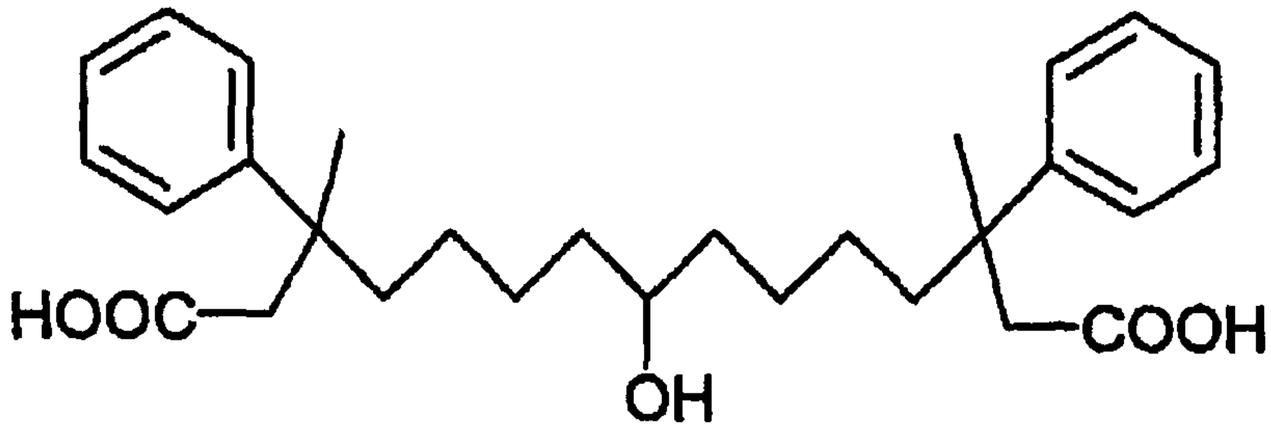
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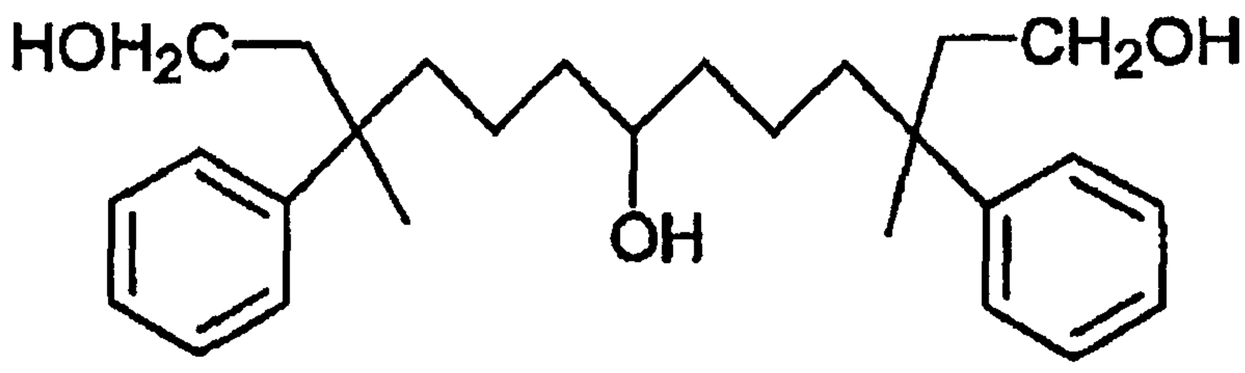
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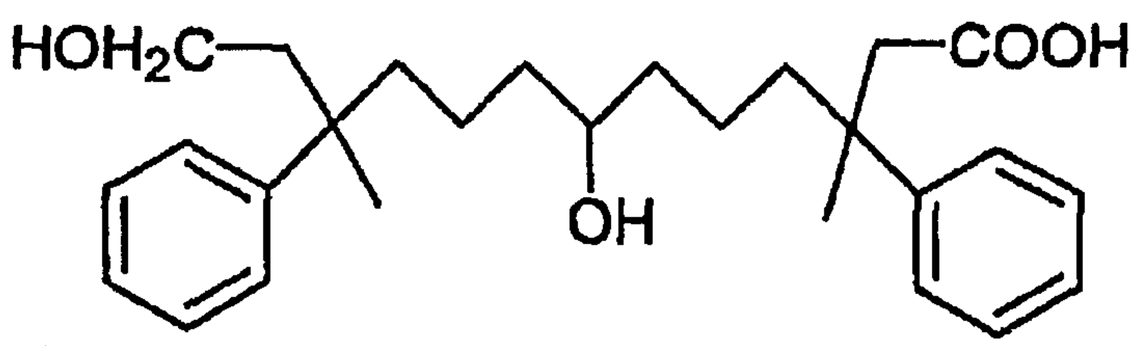

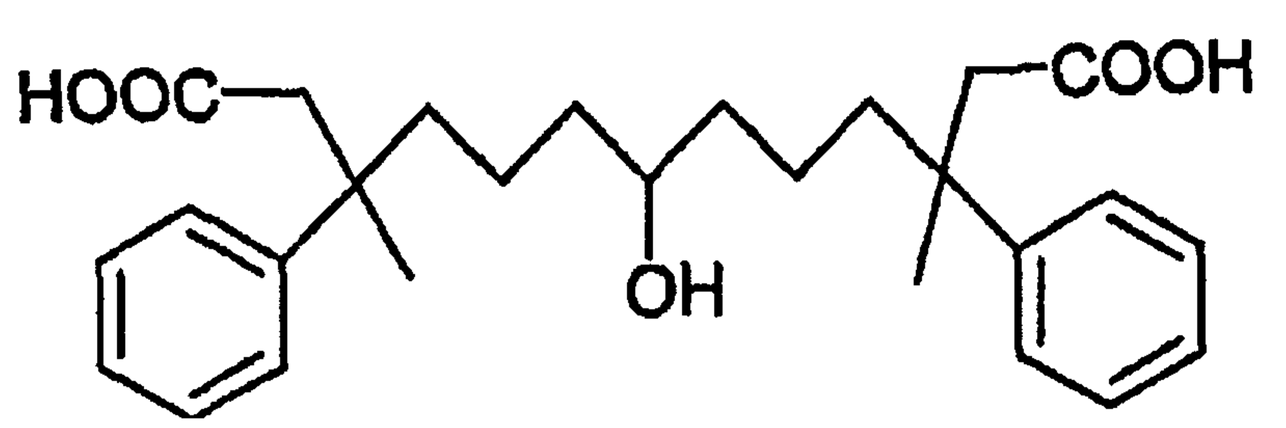

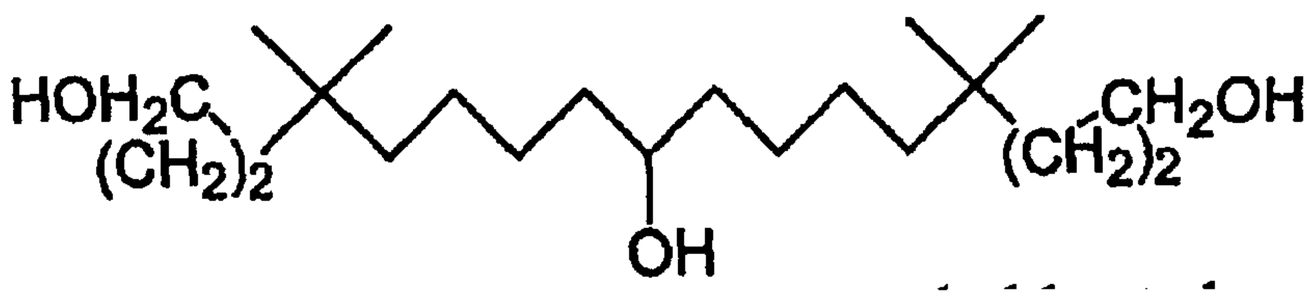

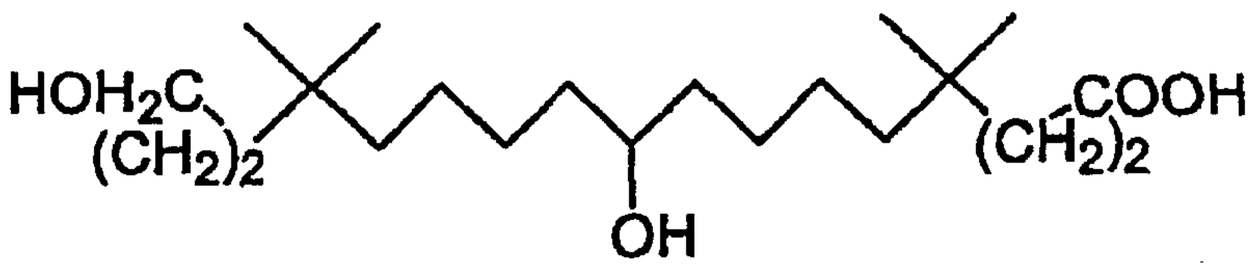

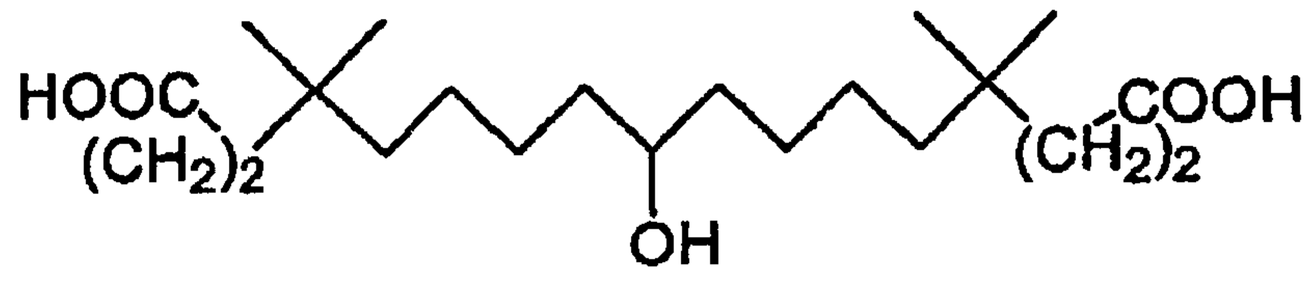

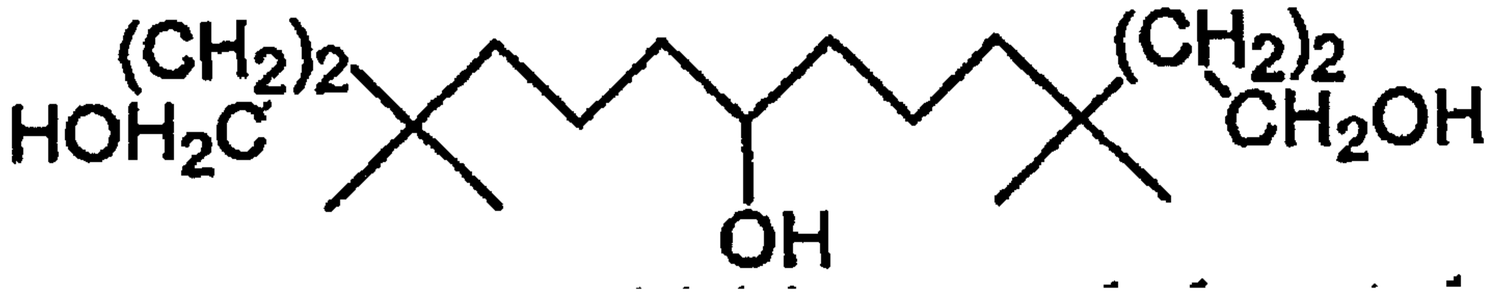

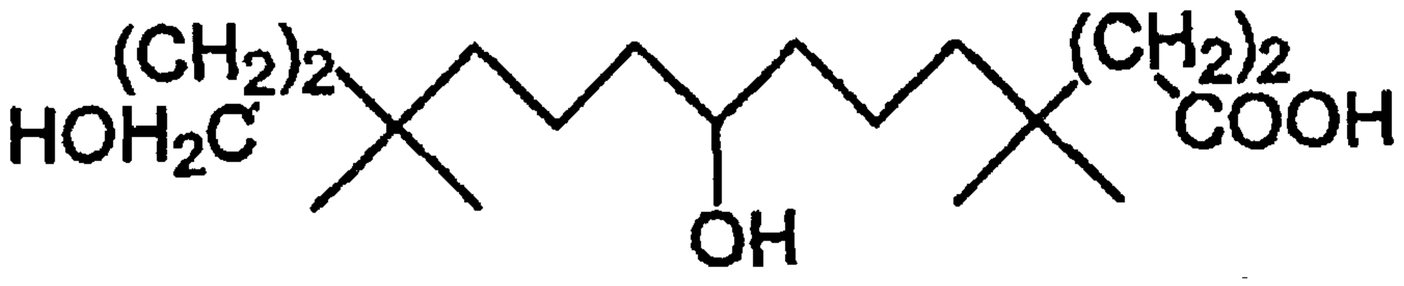

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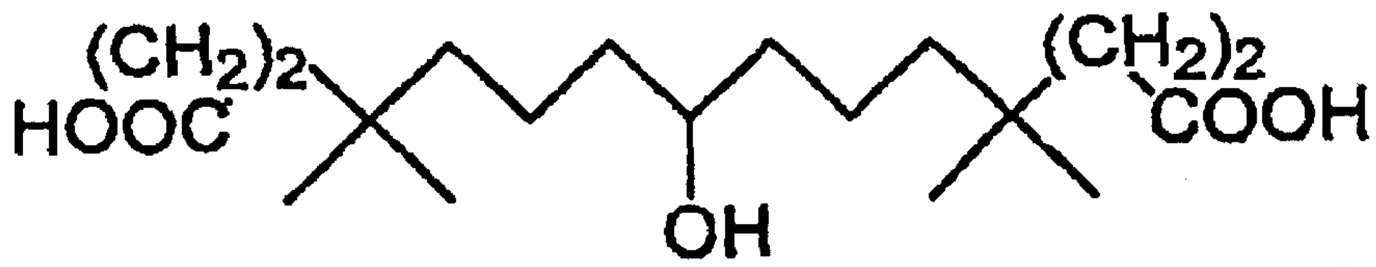

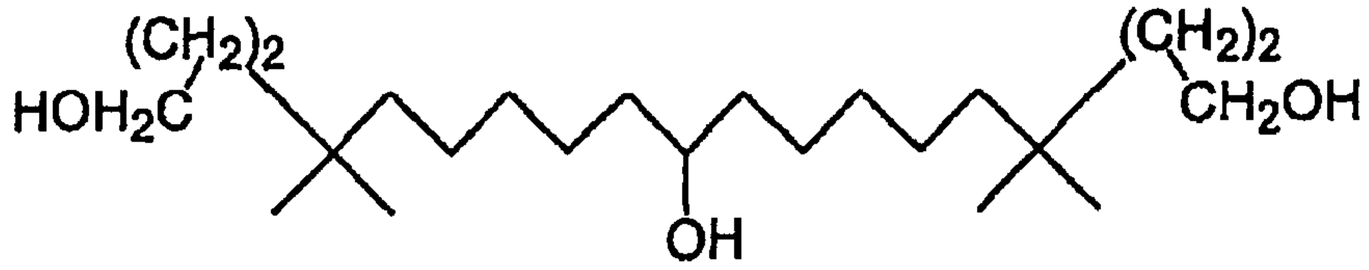

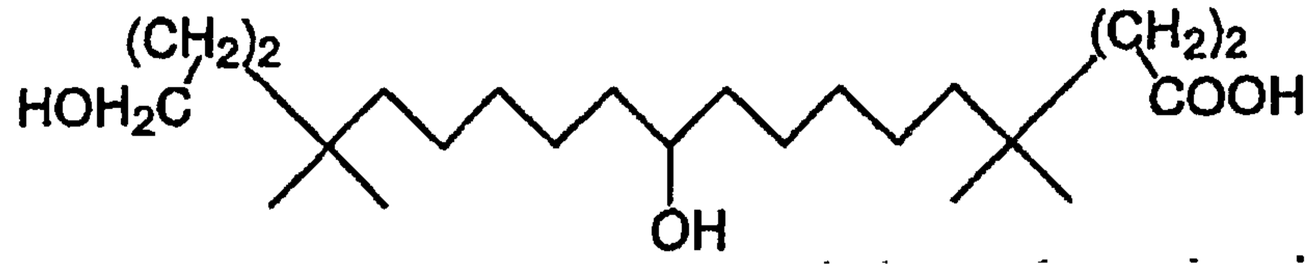

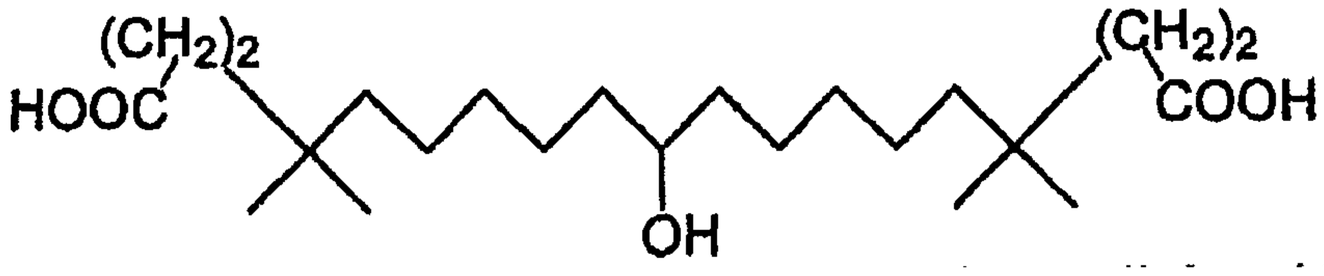

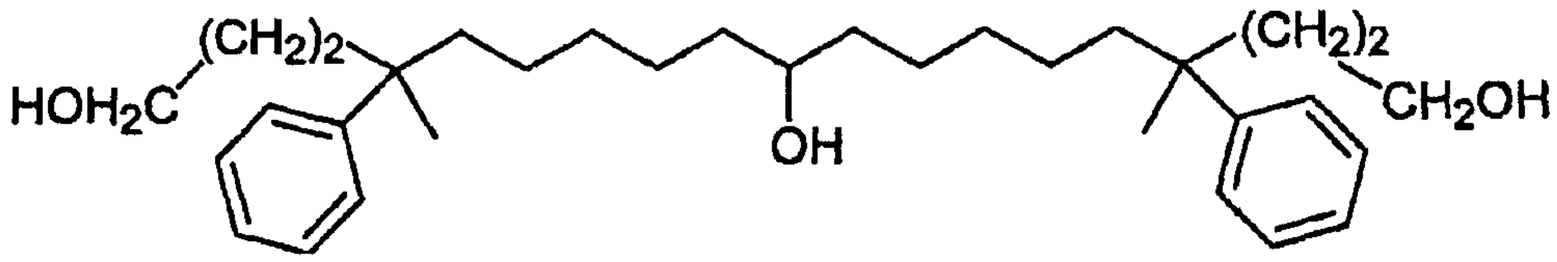

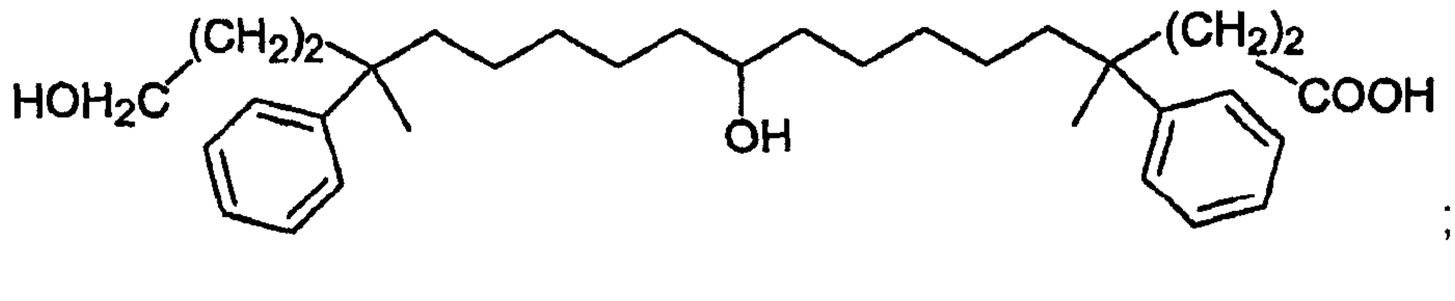

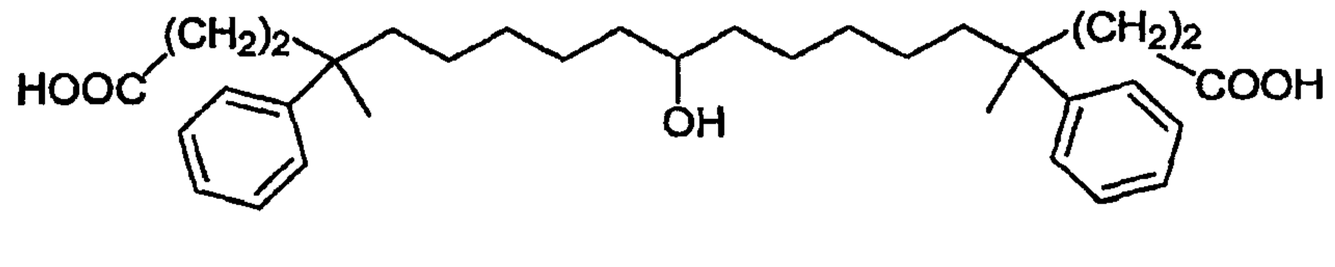

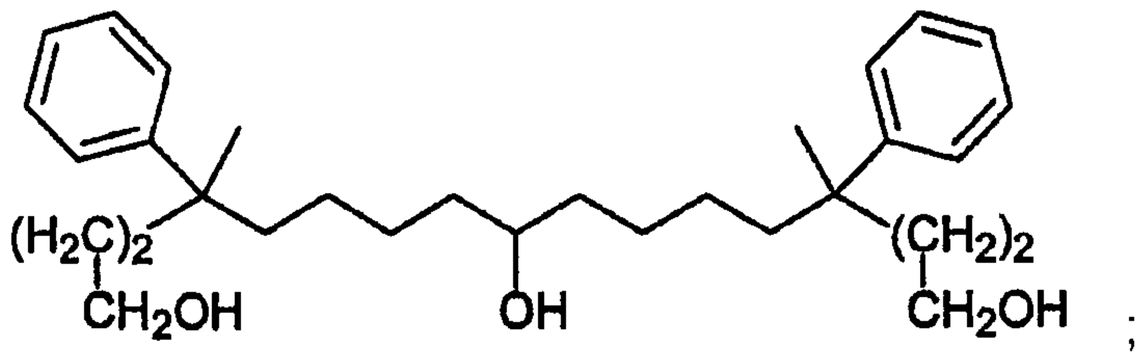

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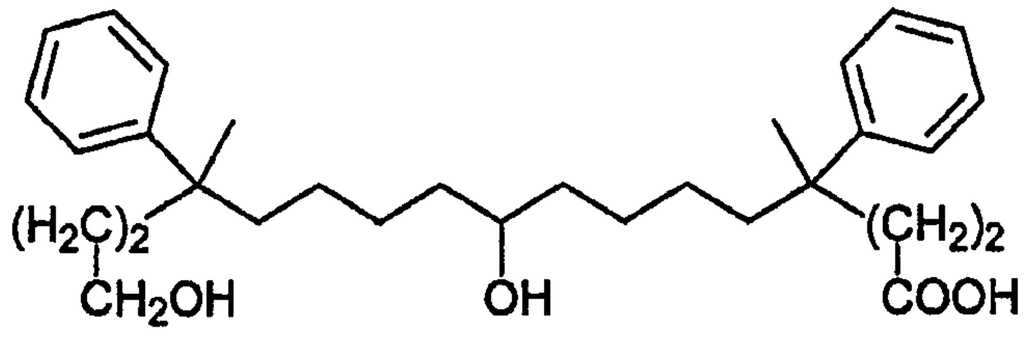

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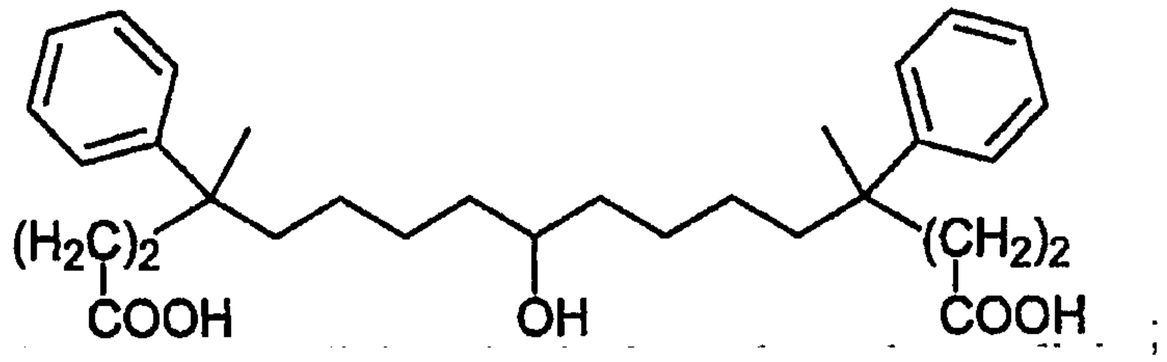

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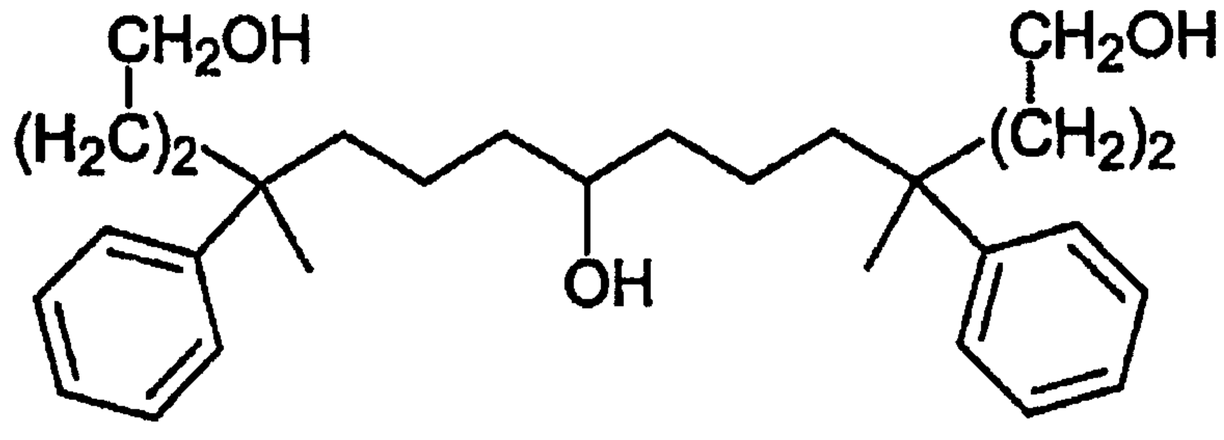

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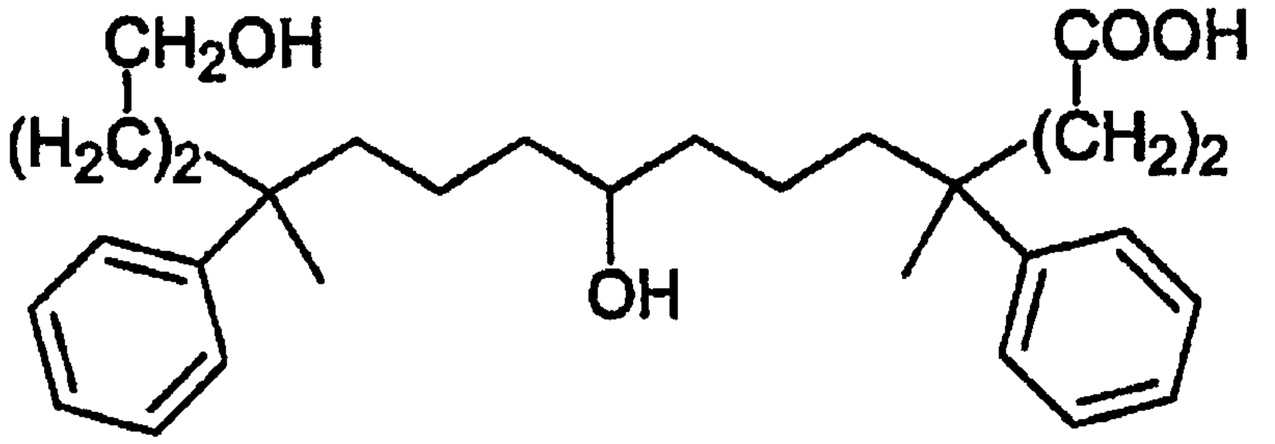
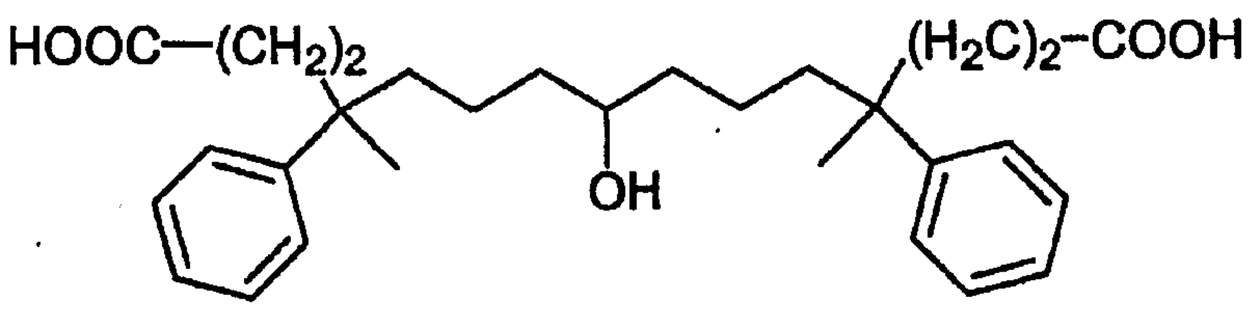


;or



;

or a pharmaceutically acceptable salt thereof.

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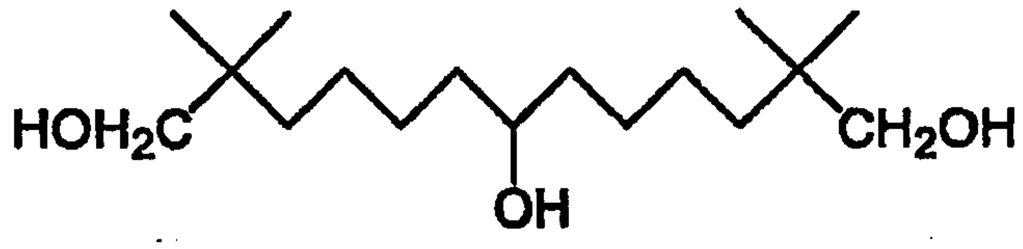
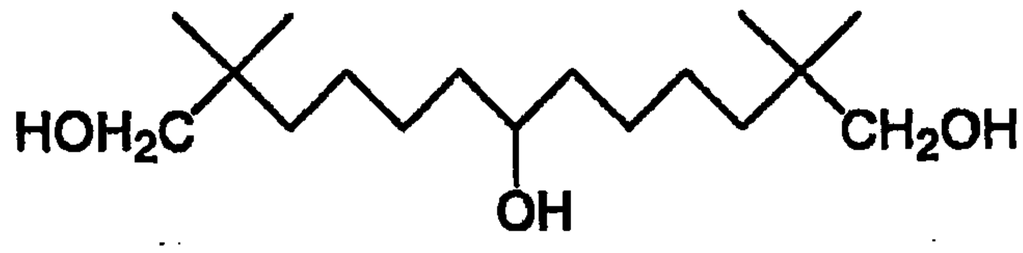
24. A compound of structure:



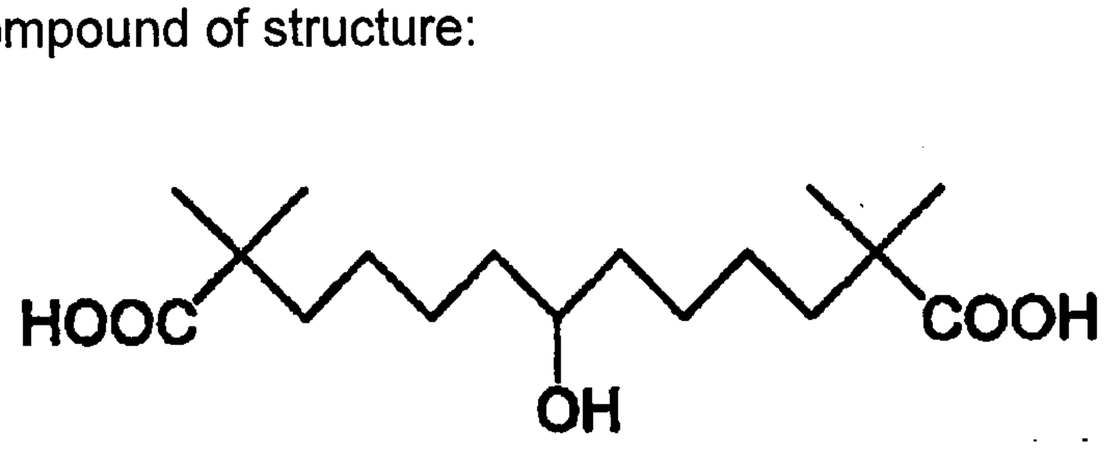
;

or a pharmaceutically acceptable salt thereof.

25. A compound of structure:



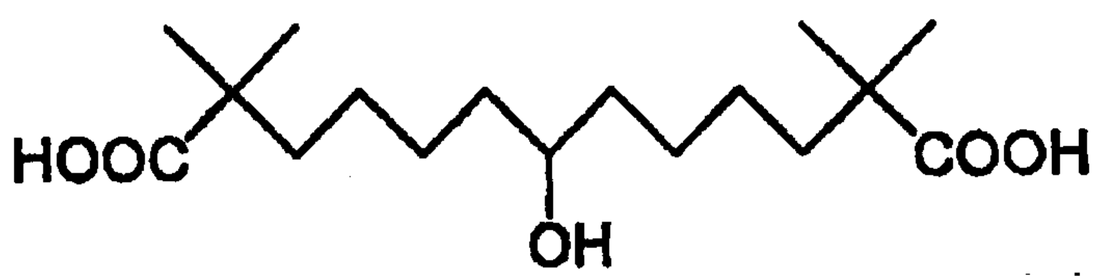
26. A compound of structure:



;

or a pharmaceutically acceptable salt thereof.

27. A compound of structure:



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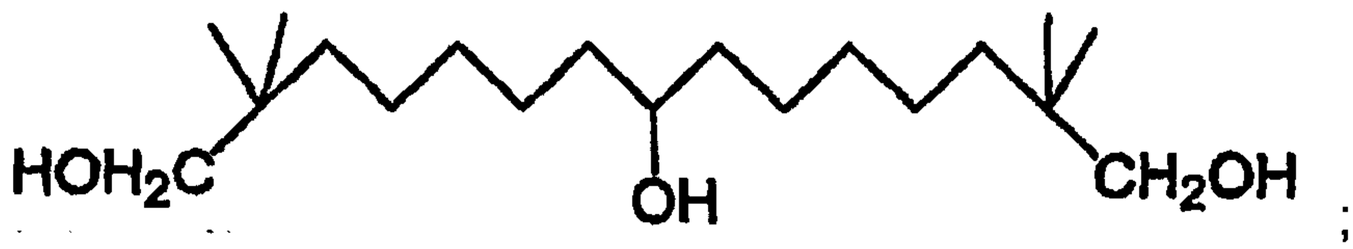
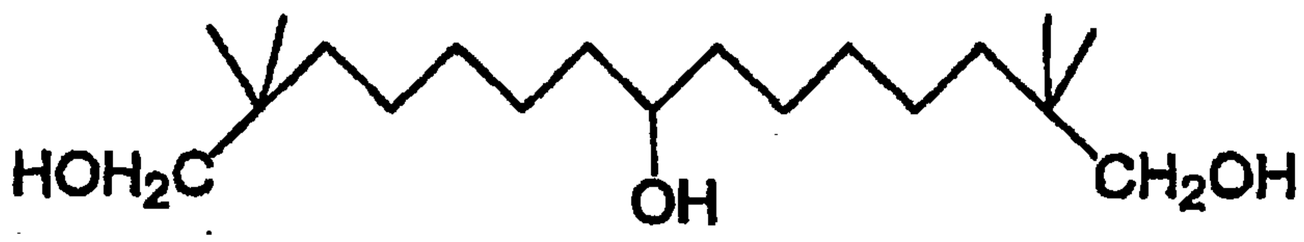
28. A compound of structure:



;

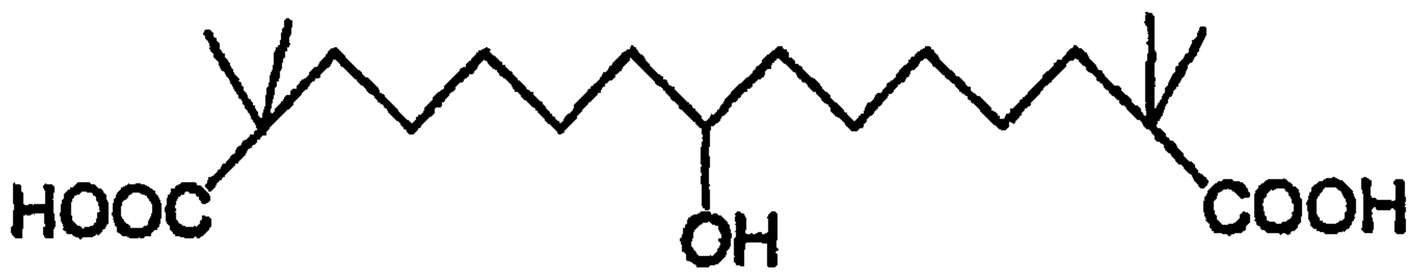
or a pharmaceutically acceptable salt thereof.

29. A compound of structure:



.

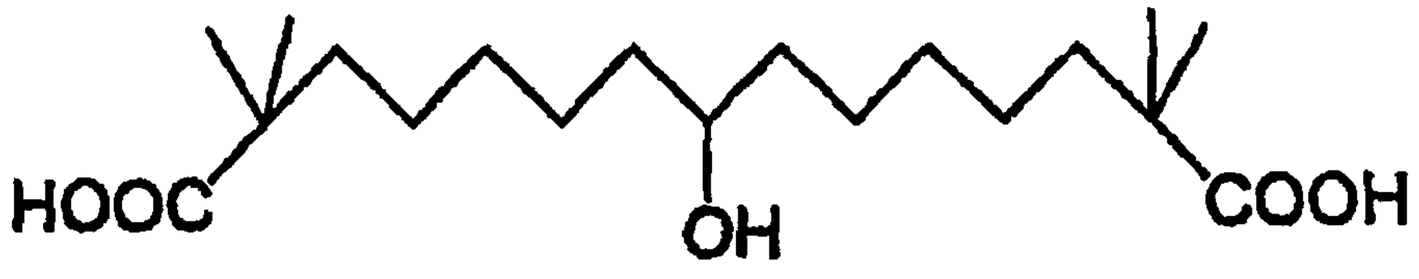
30. A compound of structure:



;

or a pharmaceutically acceptable salt thereof.

31. A compound of the structure:



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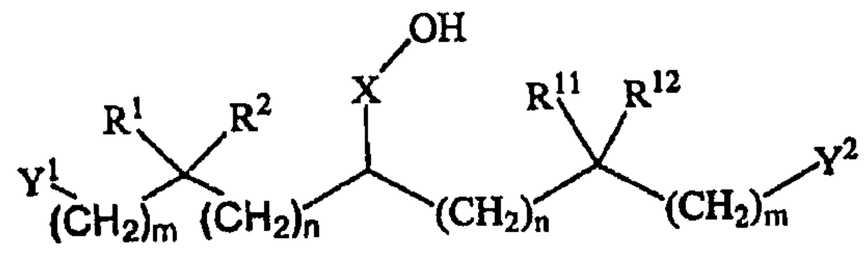
32. A compound of the formula XVIII:



XVIII

or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein:

(a) each occurrence of m is independently an integer ranging from 0 to 5;

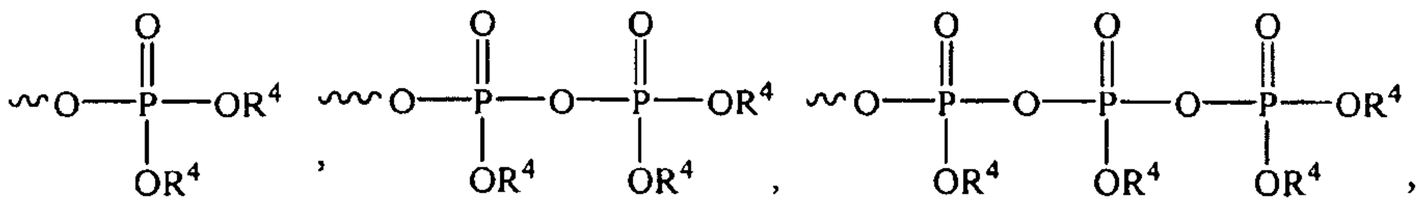
(b) each occurrence of n is independently an integer ranging from 3 to 7;

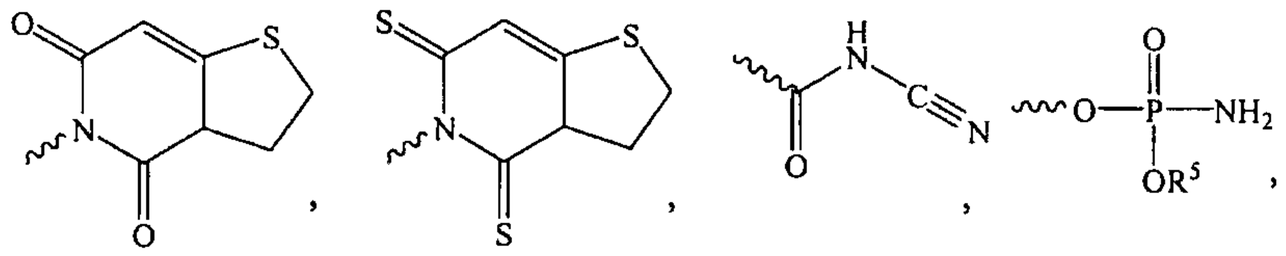
(c) X is $(CH_2)_z$, wherein z is 0;

(d) each occurrence of R^1 and R^2 is independently $(C_1–C_6)$alkyl, $(C_2$-$C_6)$alkenyl, $(C_2–C_6)$alkynyl, phenyl, benzyl, or R^1 and R^2 and the carbon to which they are both attached are taken together to form a $(C_3–C_7)$cycloalkyl group;

(e) each occurrence of R^{11} and R^{12} and the carbon to which they are both attached are taken together to form a $(C_3–C_7)$cycloalkyl group;

(f) each occurrence of Y^1 and Y^2 is independently $(C_1–C_6)$alkyl, OH, COOH, $COOR^3$, SO_3H,





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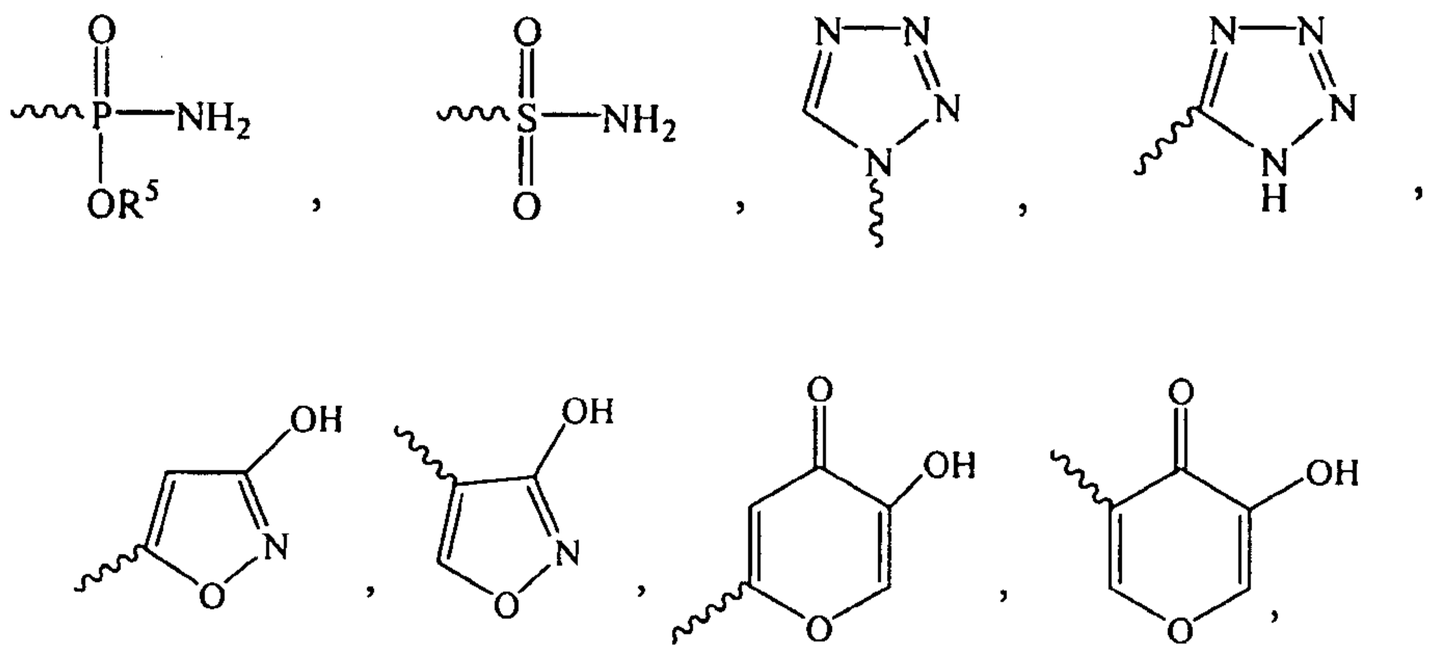

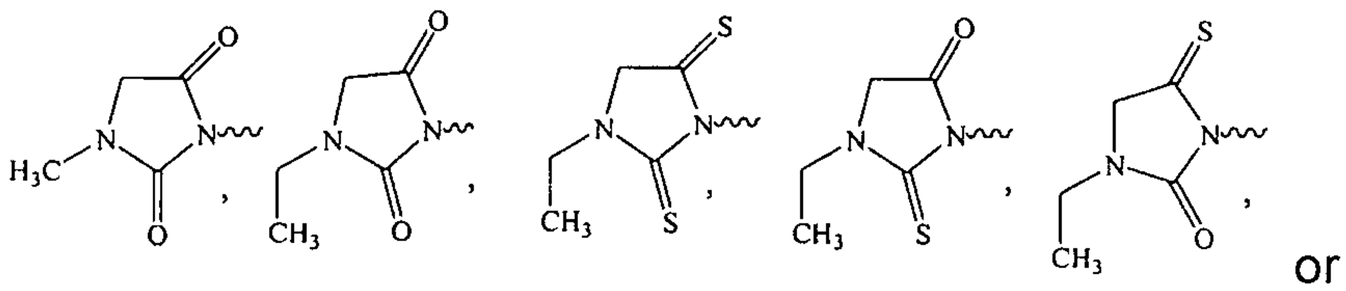

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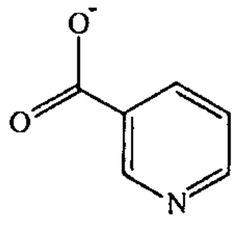

wherein:

(i) R^3 is $(C_1–C_6)$alkyl, (C_2C_6)alkenyl, $(C_2–C_6)$alkynyl, phenyl, or benzyl and is unsubstituted or substituted with one or more halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups,

(ii) each occurrence of R^4 is independently H, $(C_1–C_6)$alkyl, $(C_2$-$C_6)$alkenyl, or $(C_2–C_6)$alkynyl and is unsubstituted or substituted with one or two halo, OH, $(C_1–C_6)$alkoxy, or phenyl groups; and

(iii) each occurrence of R^5 is independently H, $(C_1–C_6)$alkyl, $(C_2$-$C_6)$alkenyl, or $(C_2–C_6)$alkynyl.

33. The compound of claim 32, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein each occurrence of Y_1 and Y_2 is independently OH, $COOR^3$, or COOH.

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34. The compound of claim 32, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein m is 0.

35. The compound of claim 32, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein m is 1.

36. The compound of claim 32, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein n is 4.

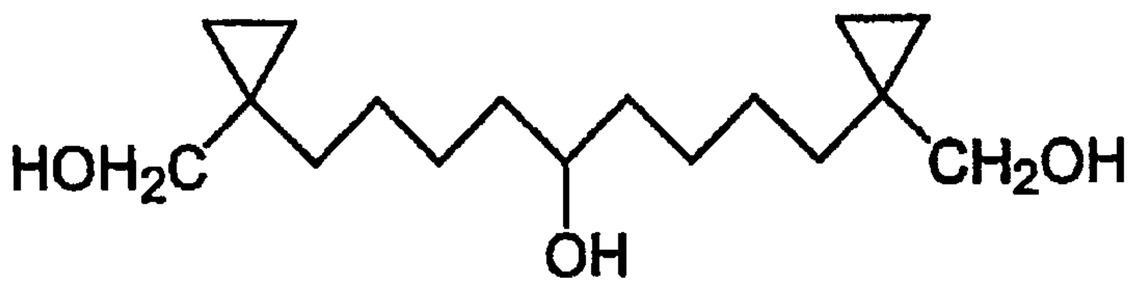
37. The compound of claim 32, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein n is 5.

38. The compound of claim 32, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein Y^1 and Y^2 are each independently $(C_1\text{-}C_6)$alkyl.

39. The compound of claim 32, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein Y^1 and Y^2 are each methyl.

40. The compound of claim 32, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, wherein each occurrence of R^1 and $R^2$and the carbon to which they are both attached are taken together to form a $(C_3–C_7)$cycloalkyl group.

41. A compound of the structure:



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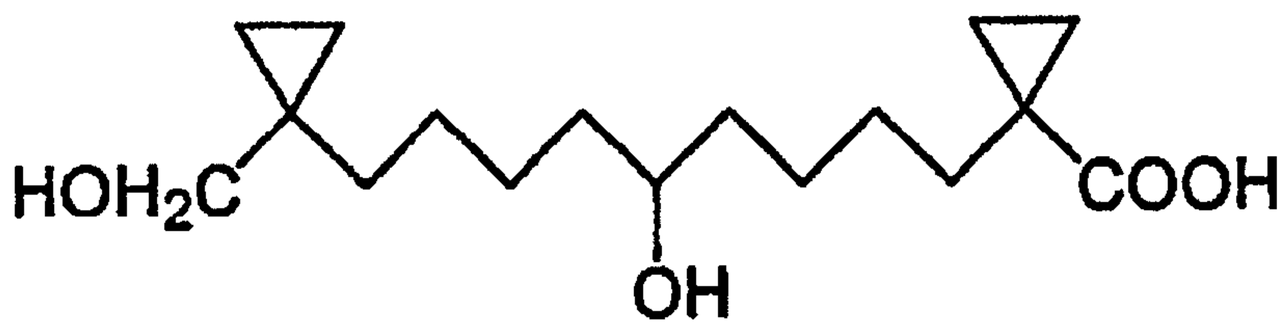

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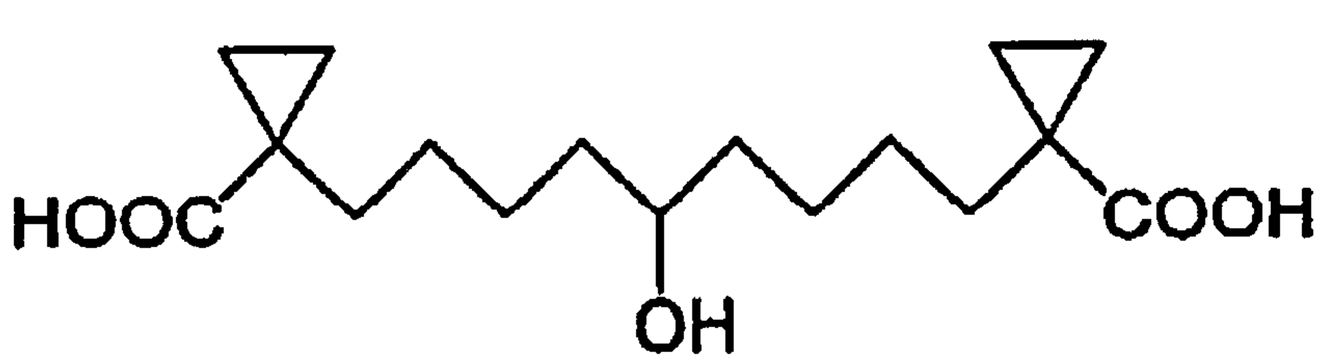

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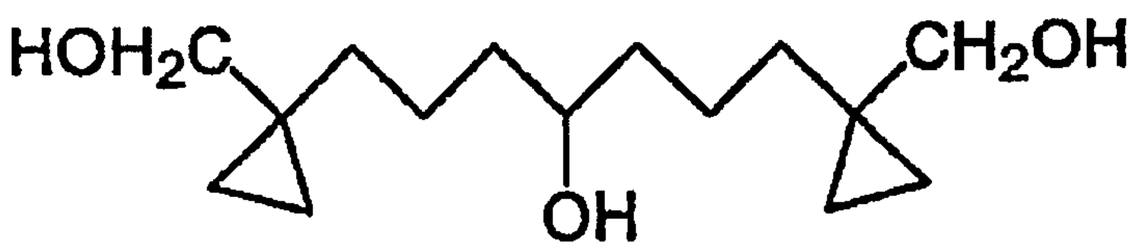

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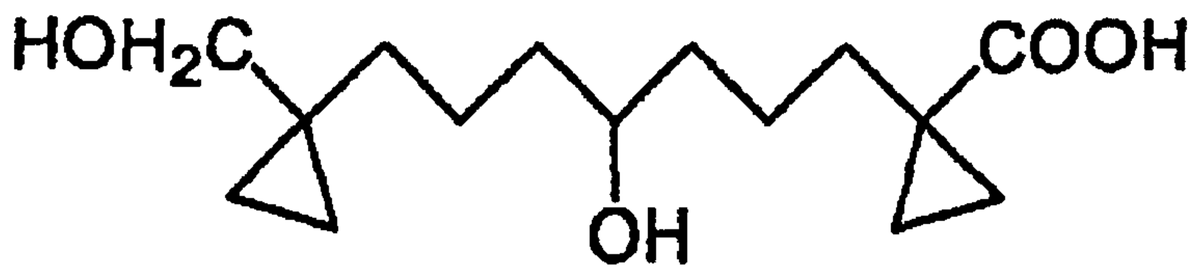

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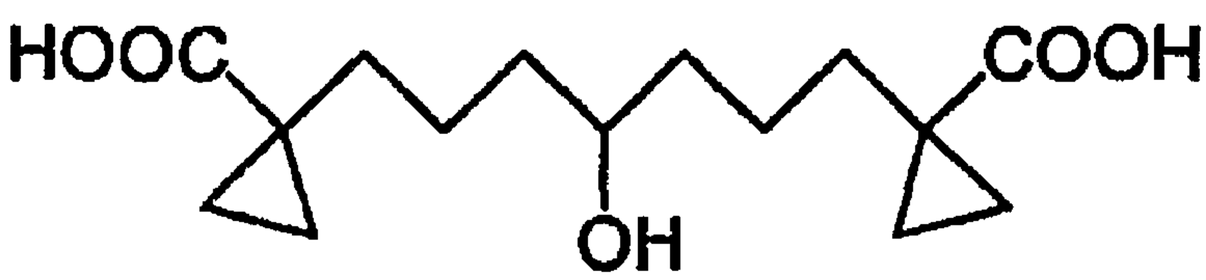

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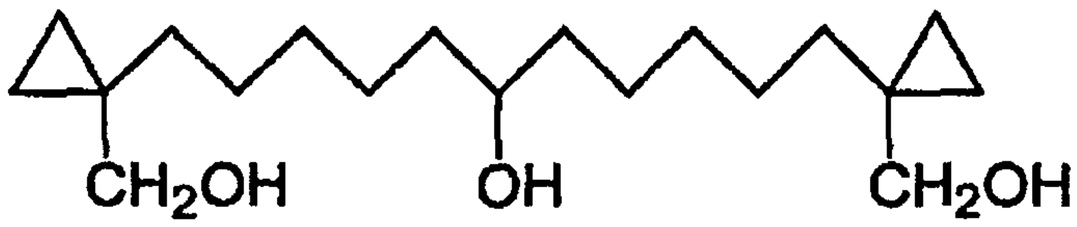

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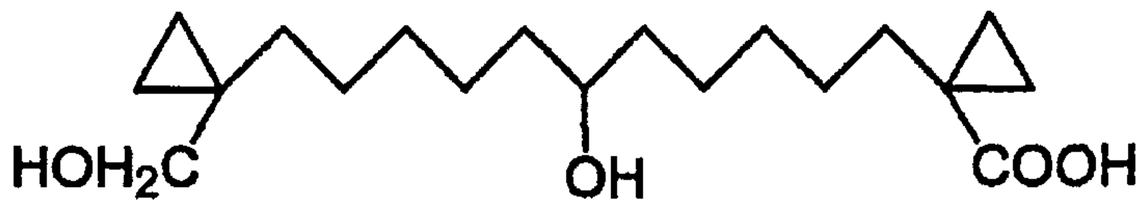

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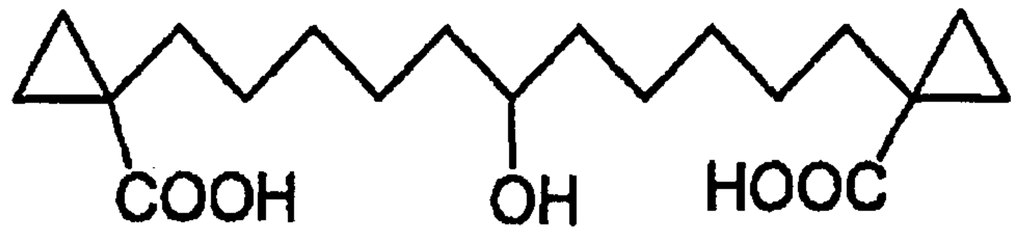
COOH
OH
HOOC

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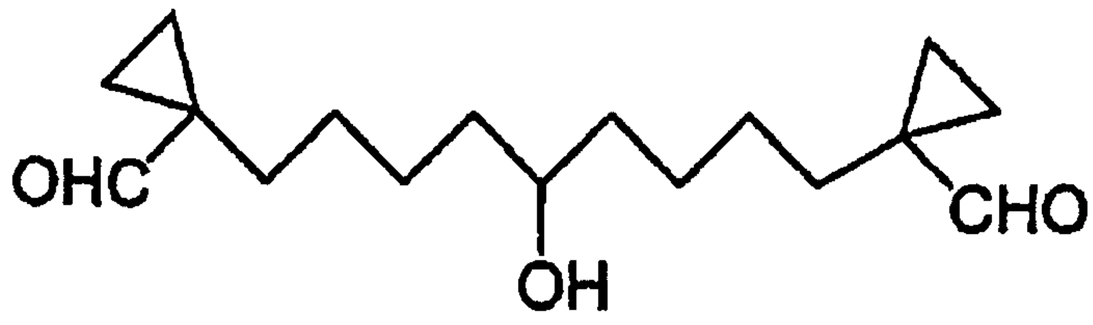
OHC
CHO
OH

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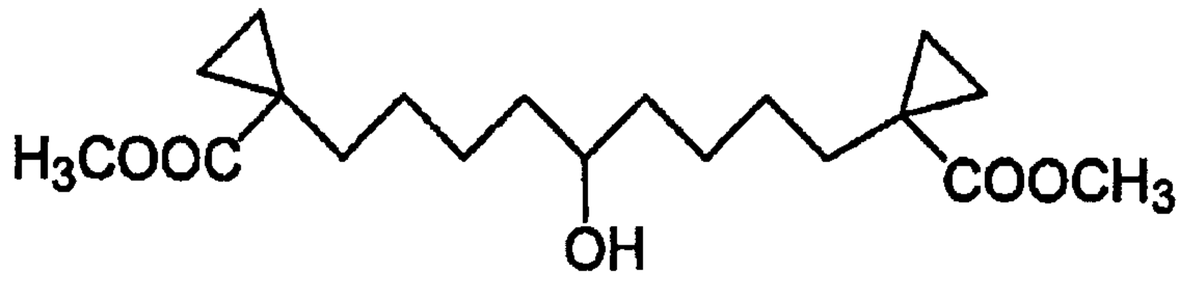
H3COOC
COOCH3
OH

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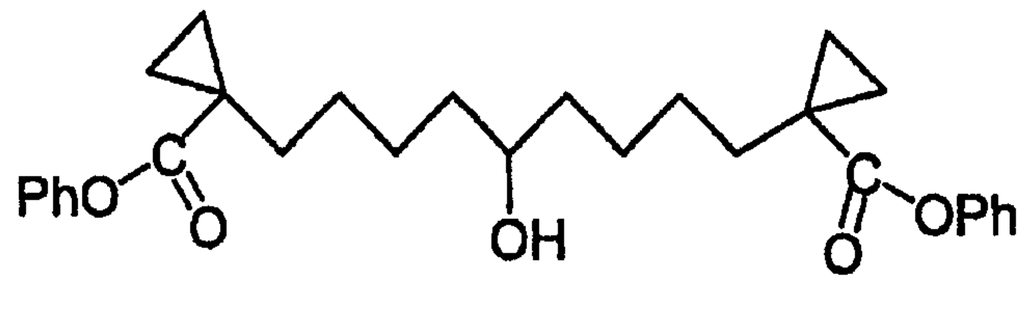
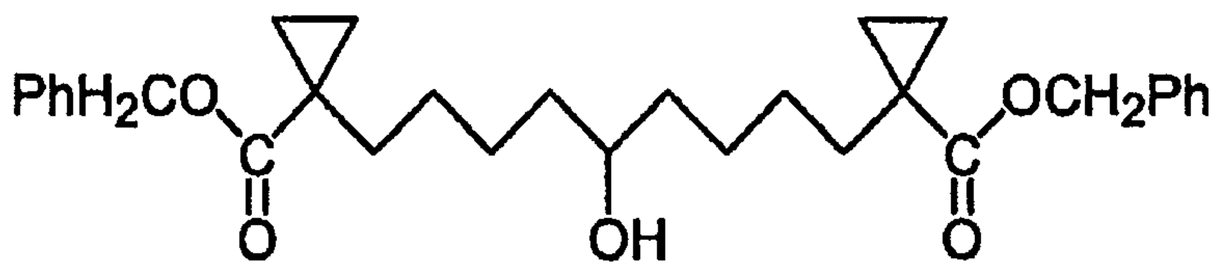

PhO
C
O
OH
C
O
OPh

;


PhH2CO
C
O
OH
C
O
OCH2Ph

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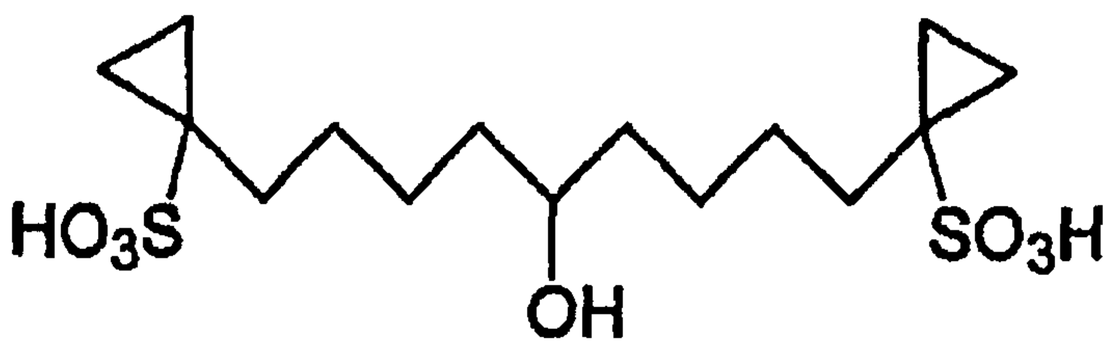
HO3S
OH
SO3H

;

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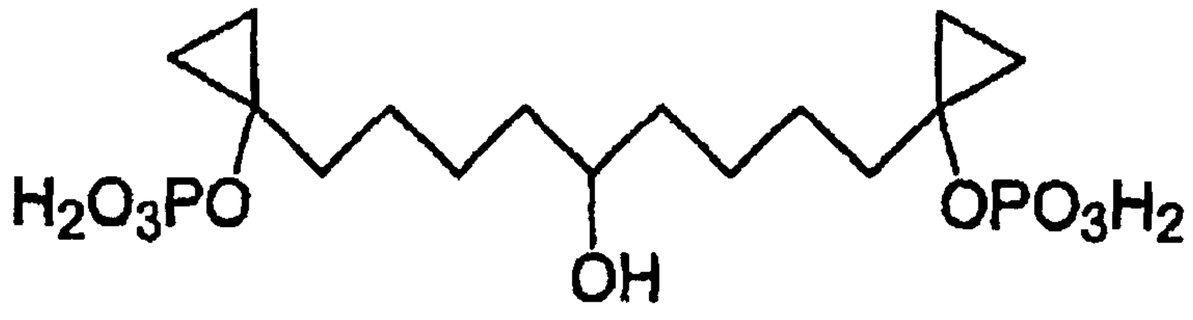
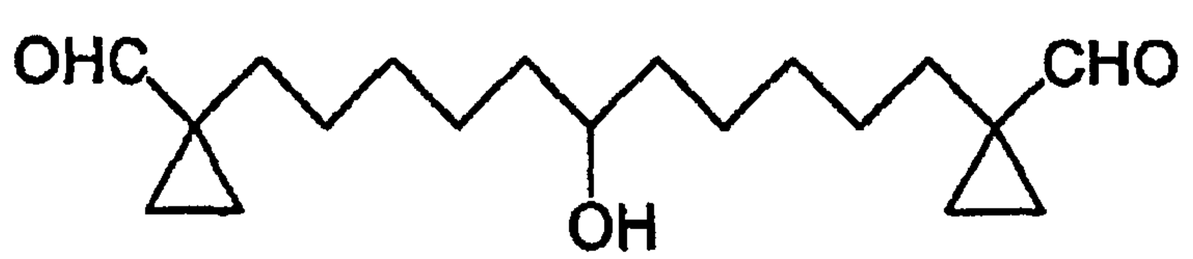

H2O3PO
OH
OPO3H2

;


OHC
OH
CHO

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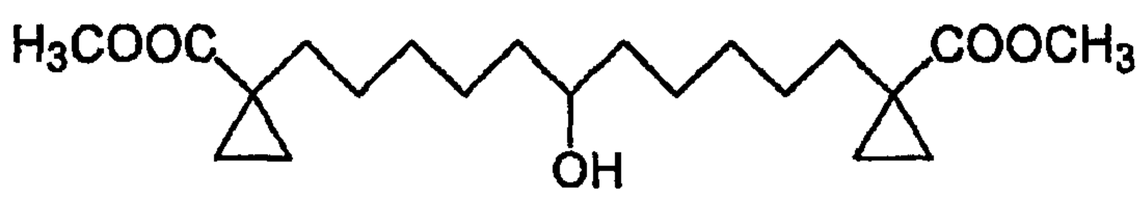
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OH
COOCH3

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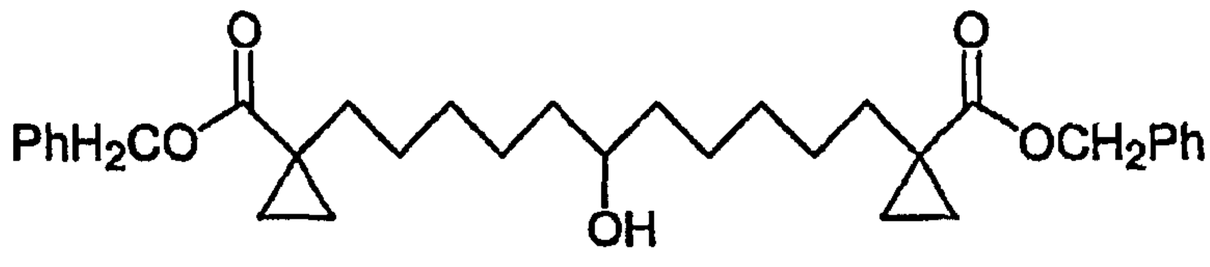
O
PhH2CO
OH
O
OCH2Ph

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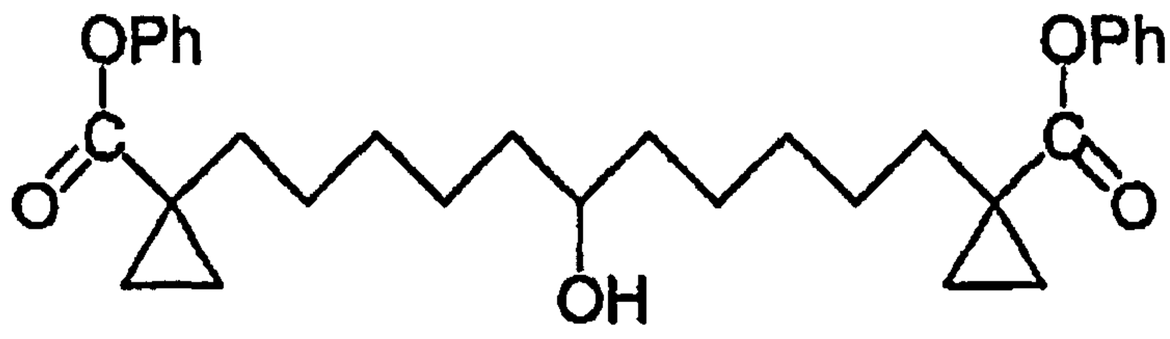
OPh
O
C
OH
OPh
C
O

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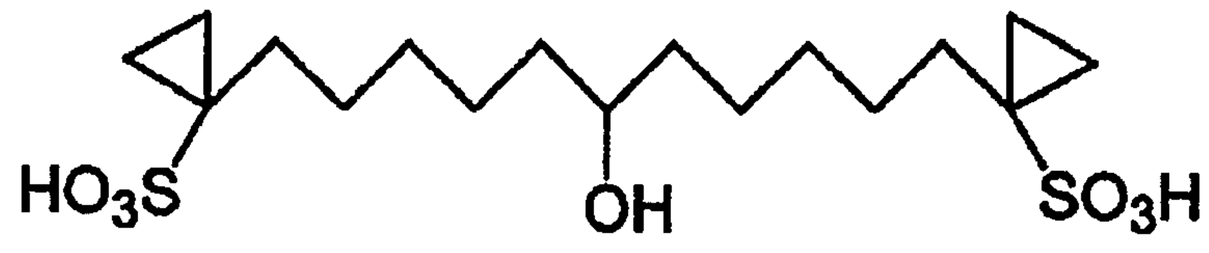
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OH
SO3H

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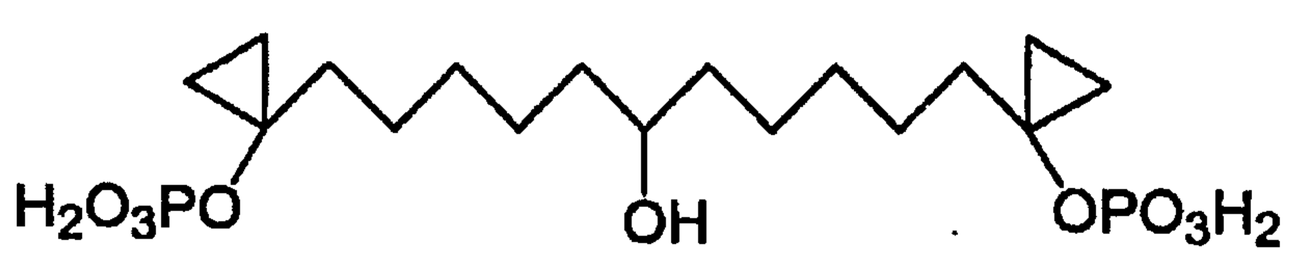
H2O3PO
OH
OPO3H2

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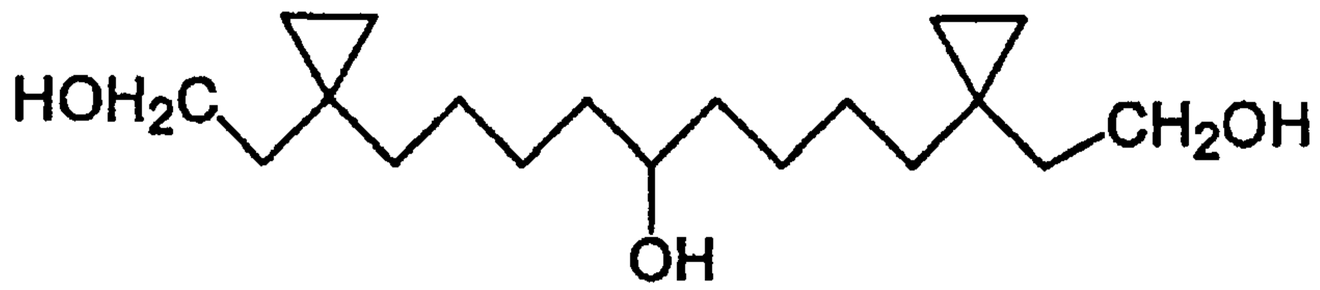

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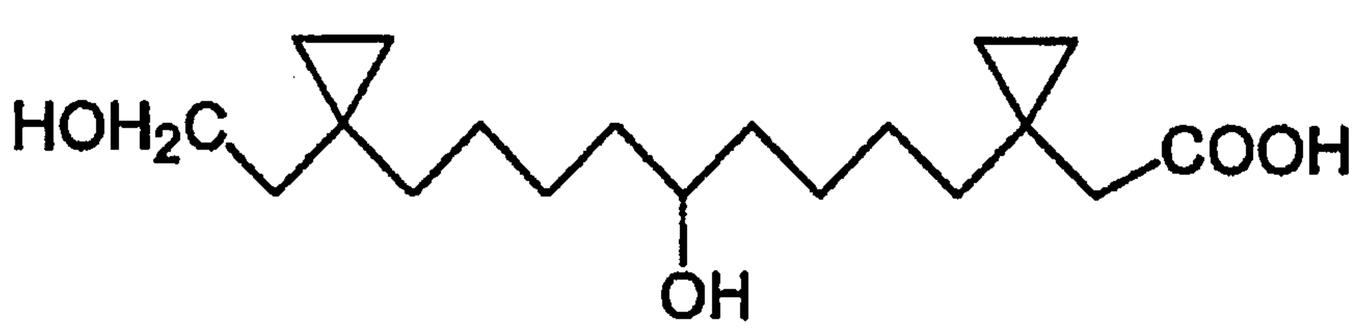

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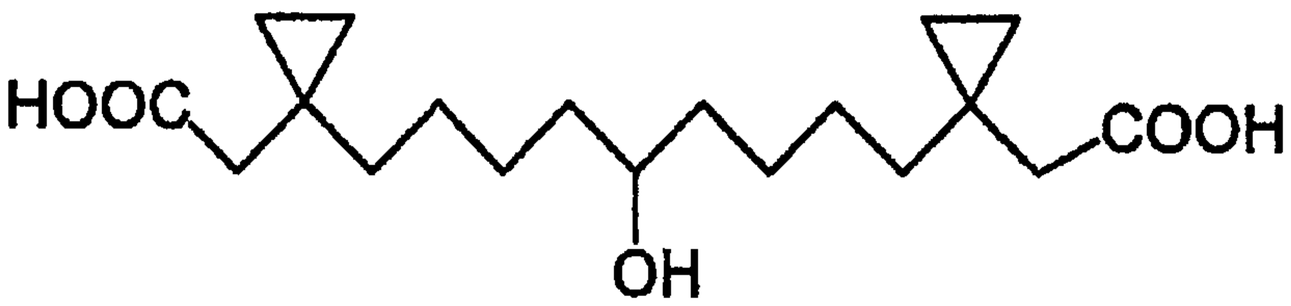

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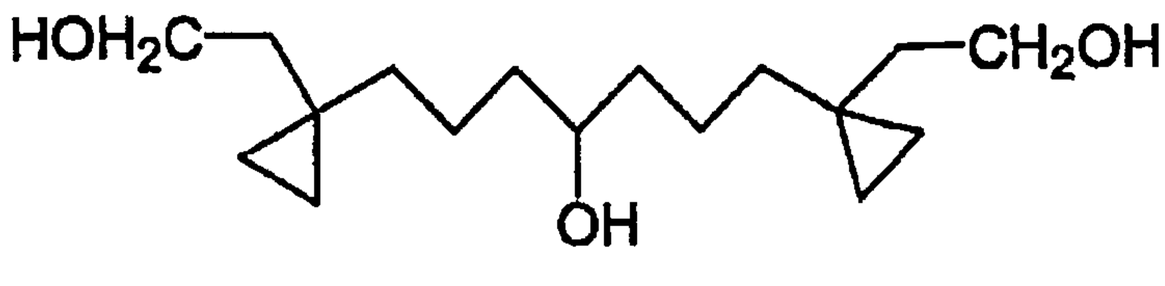

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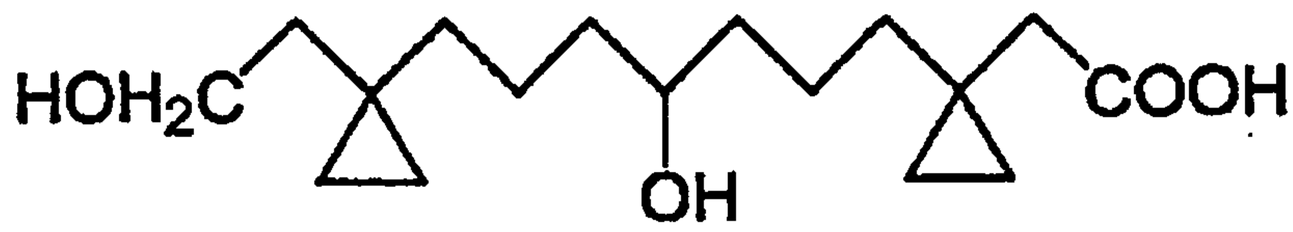

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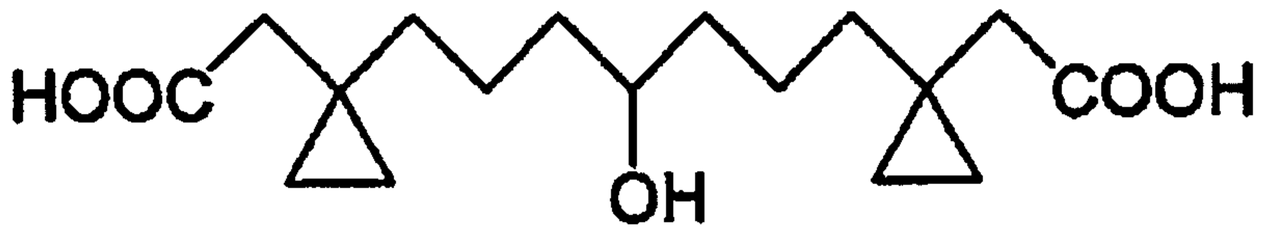

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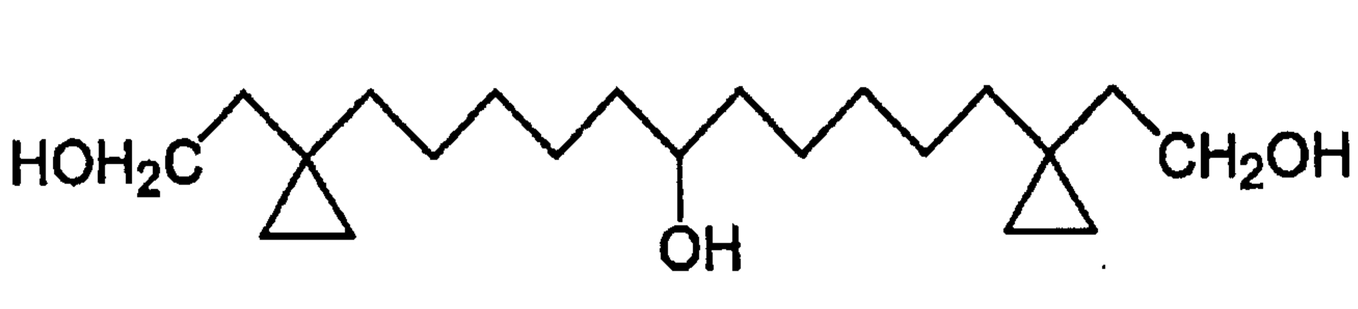

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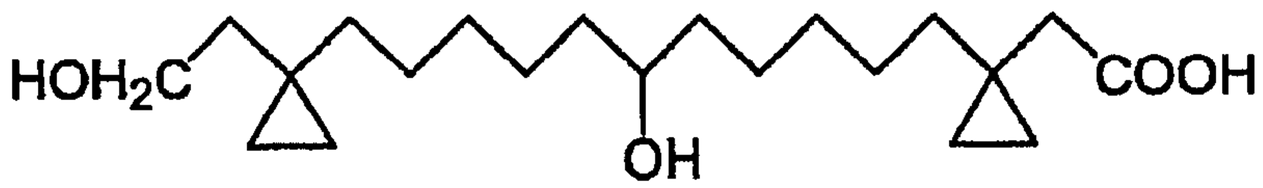
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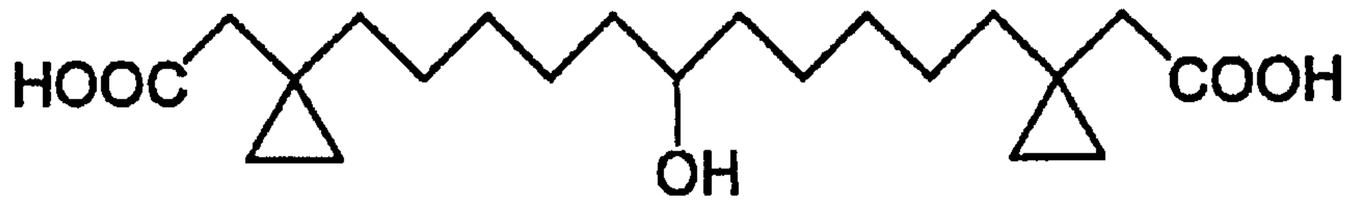
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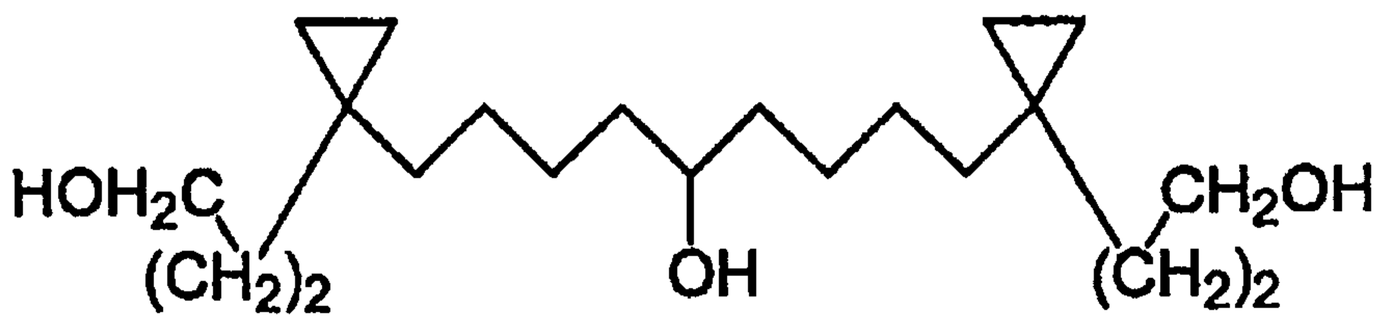
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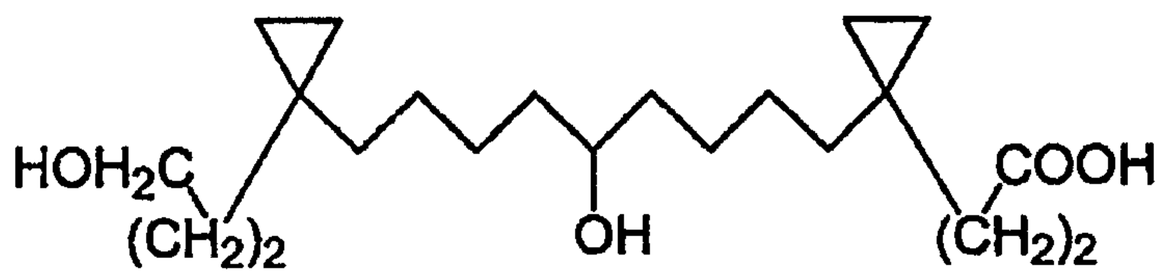
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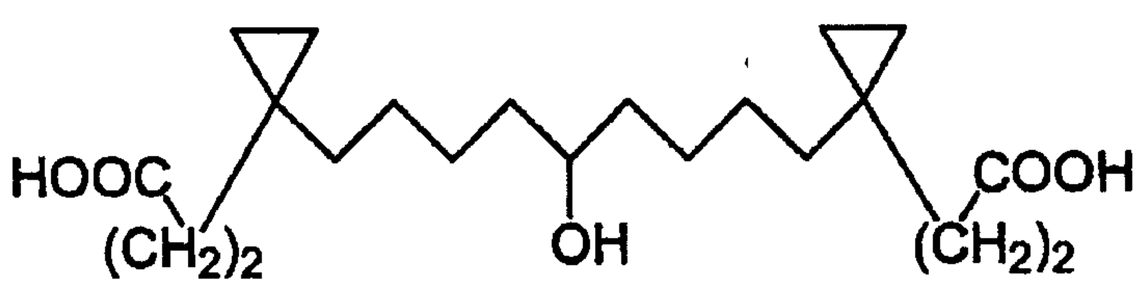
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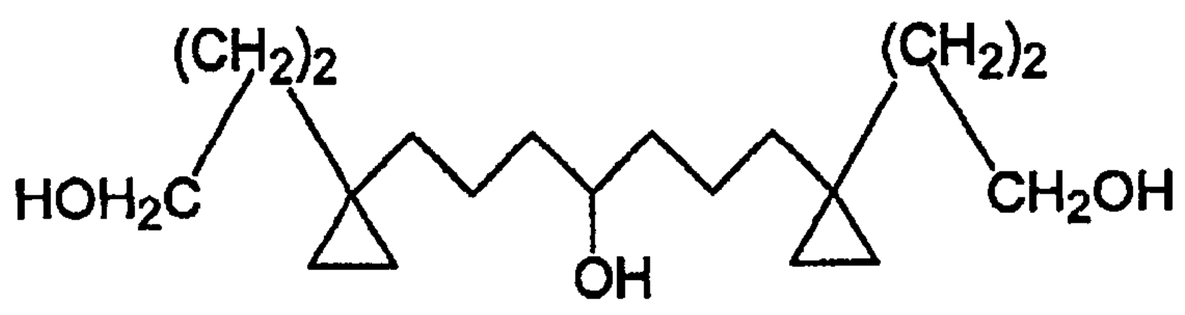
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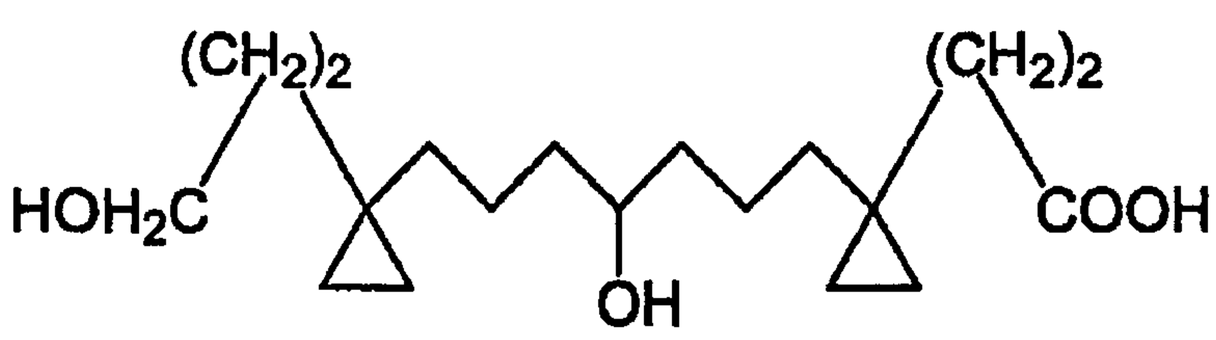
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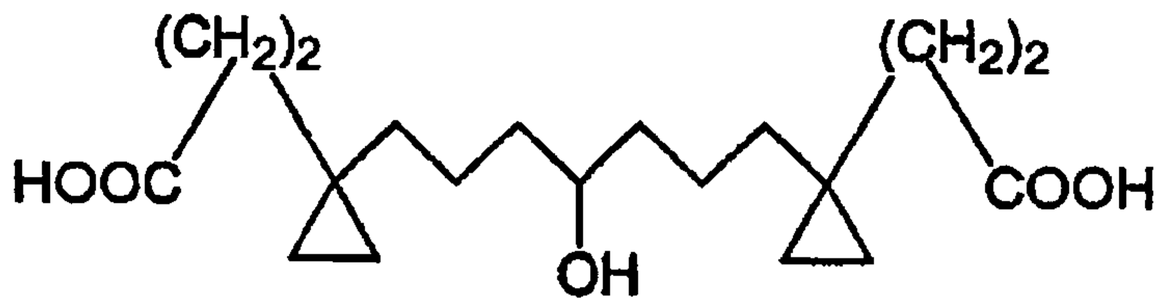

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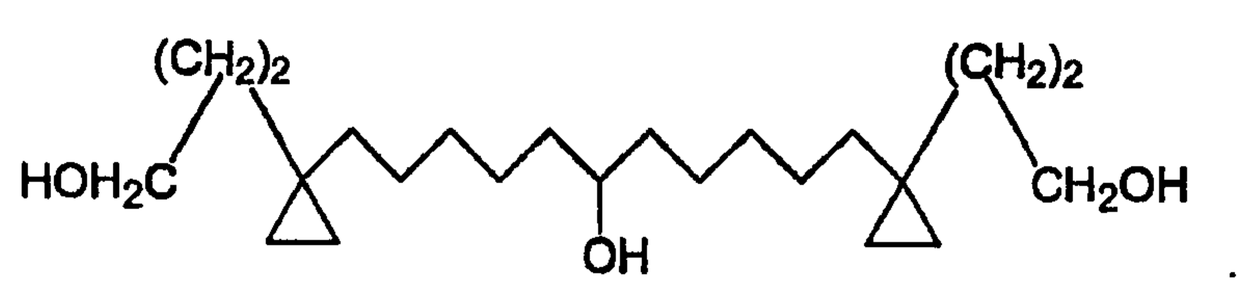

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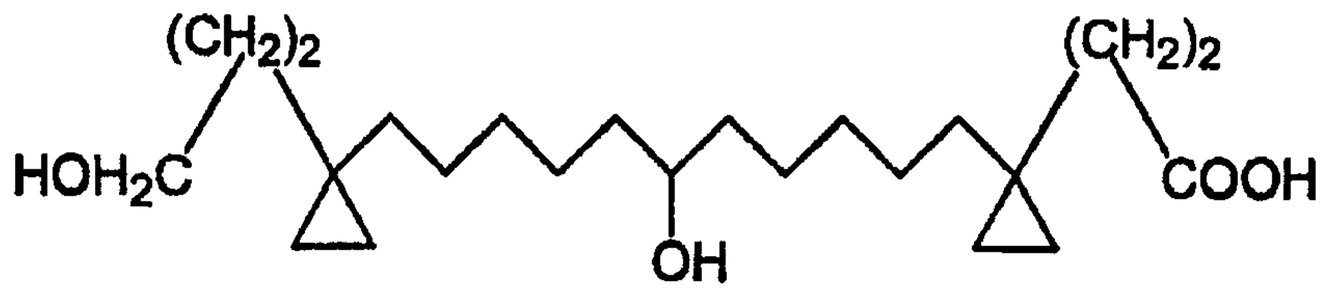

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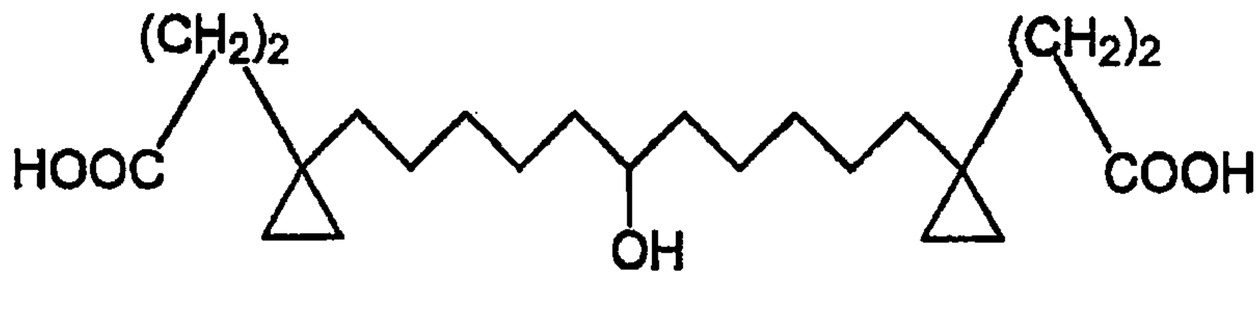

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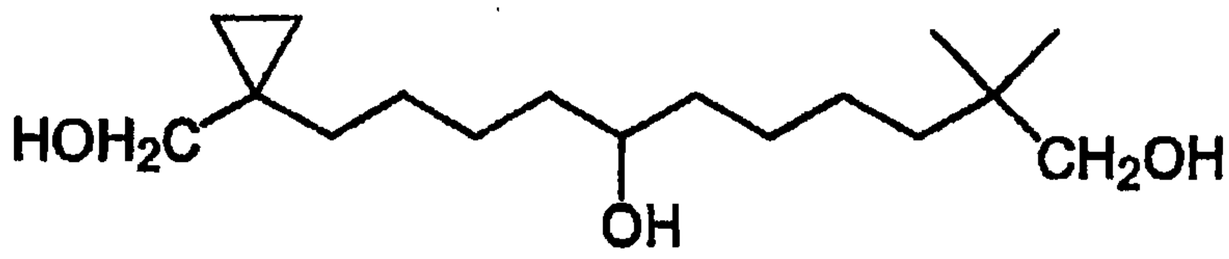

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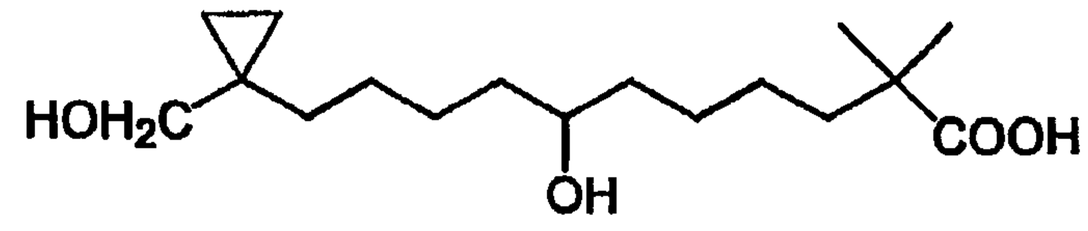

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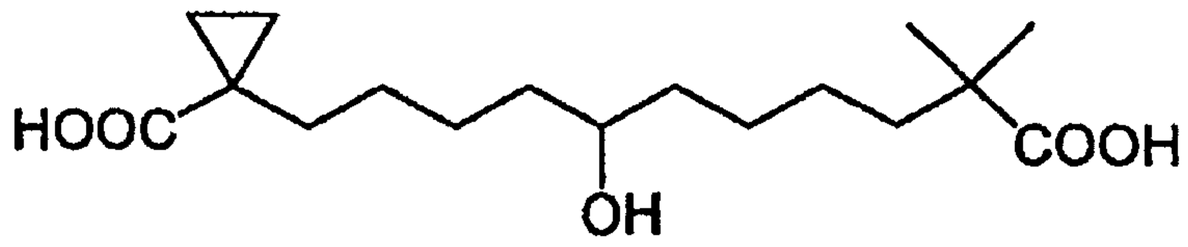
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COOH
OH

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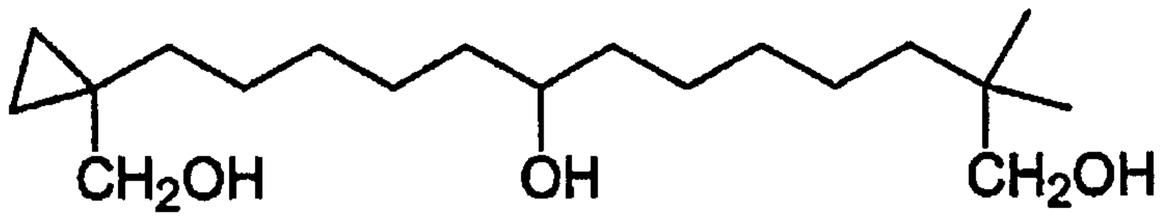
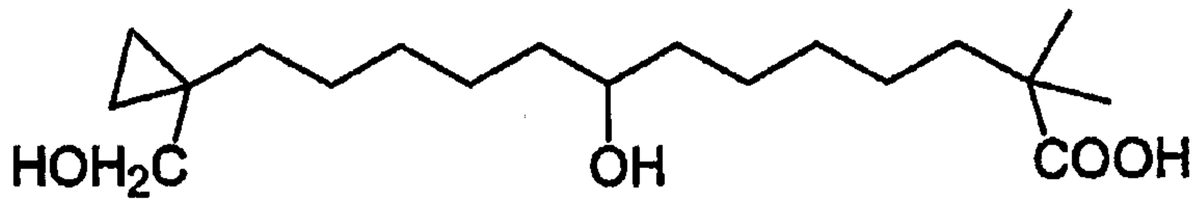

CH2OH
OH
CH2OH

,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OH
COOH

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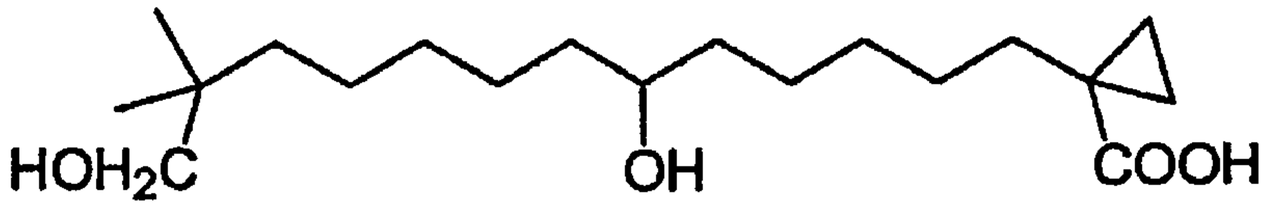
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OH
COOH

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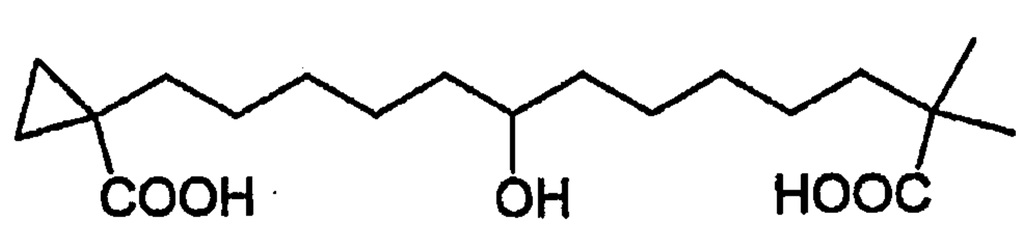
COOH
OH
HOOC

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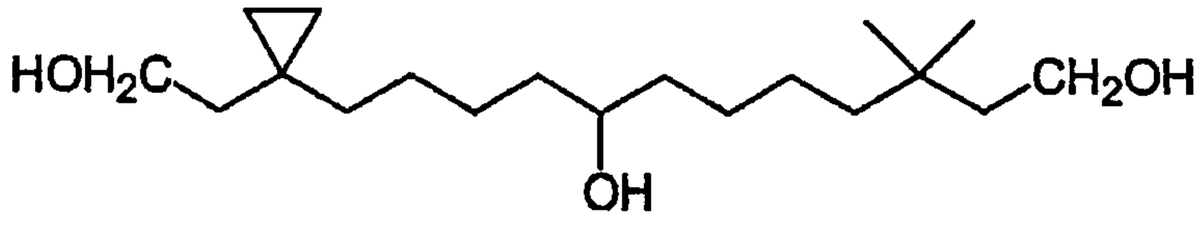
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CH2OH
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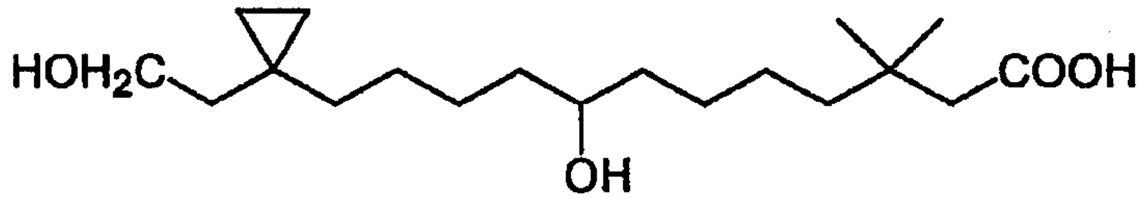
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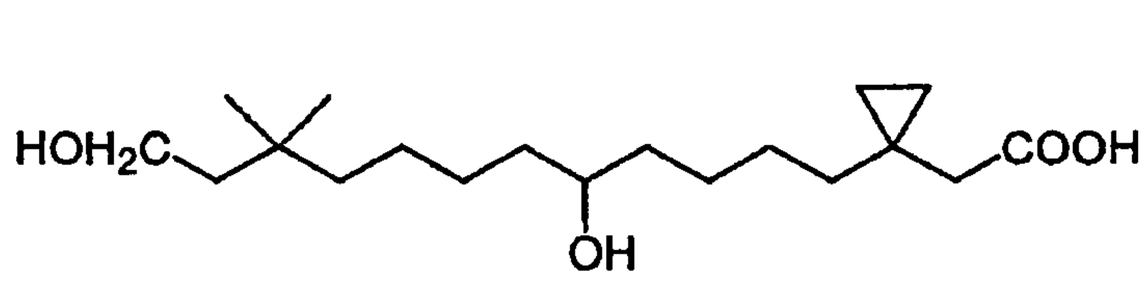
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COOH
OH

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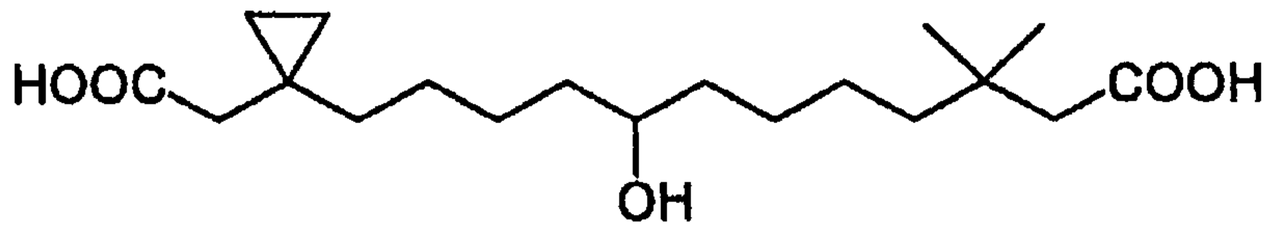

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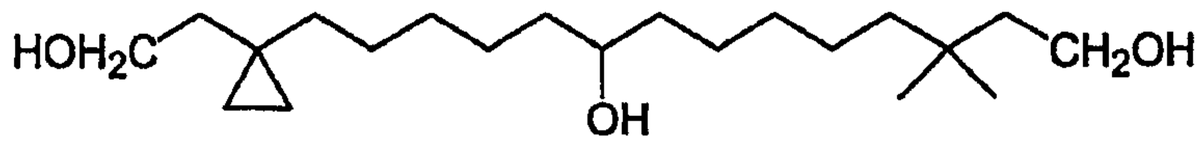

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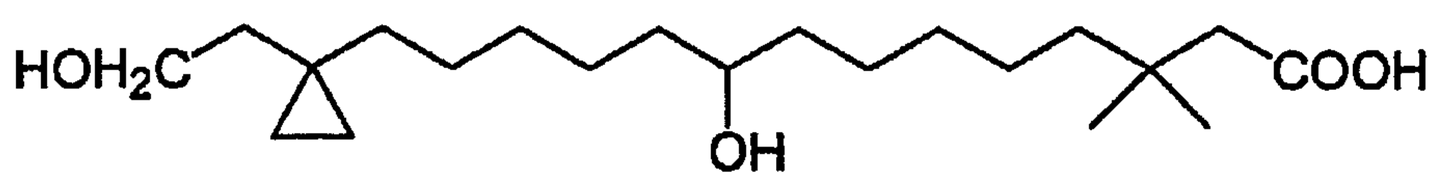

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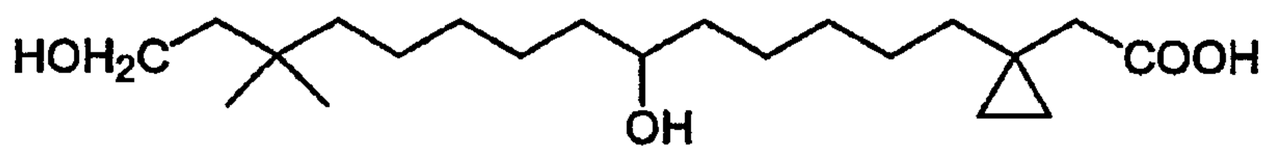

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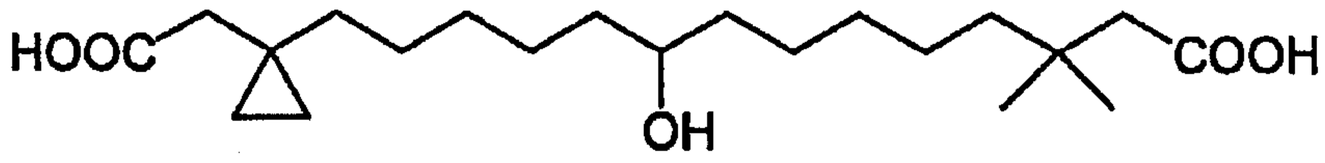

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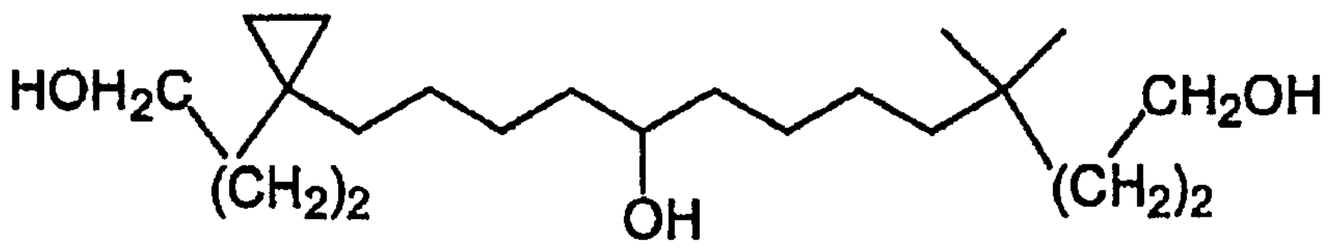

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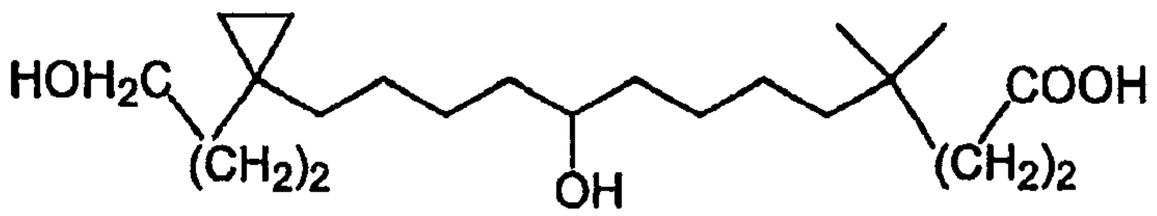

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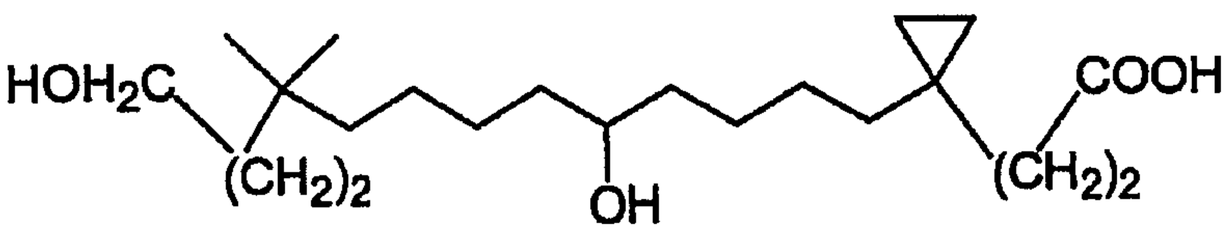

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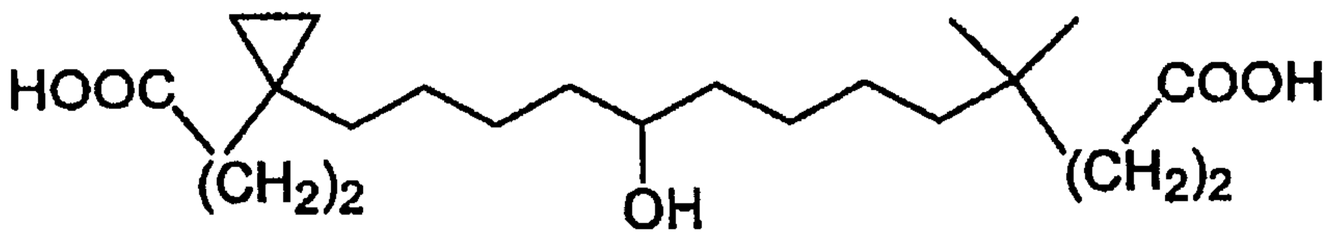
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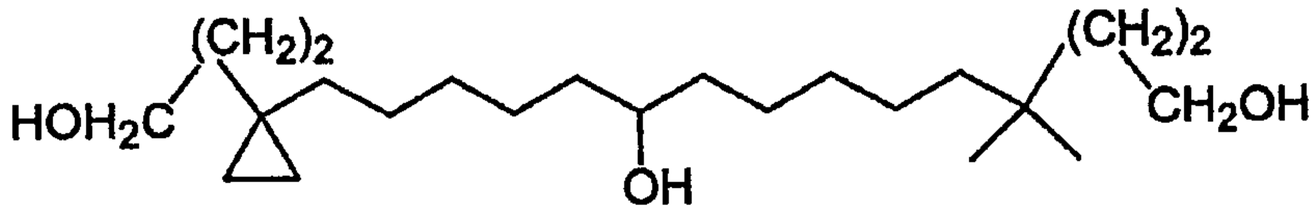
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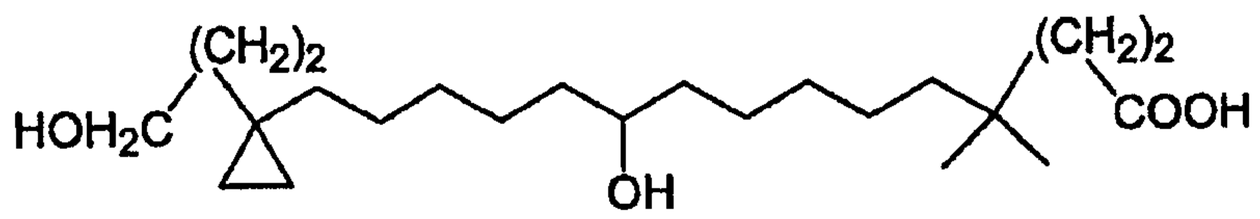
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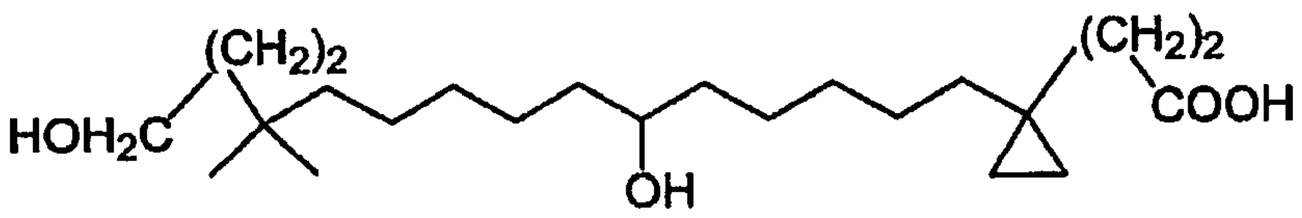
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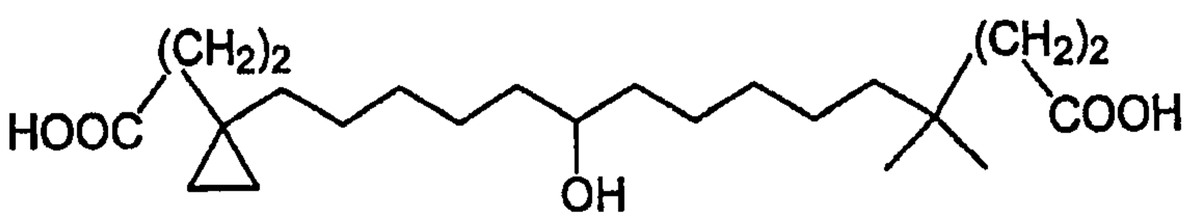
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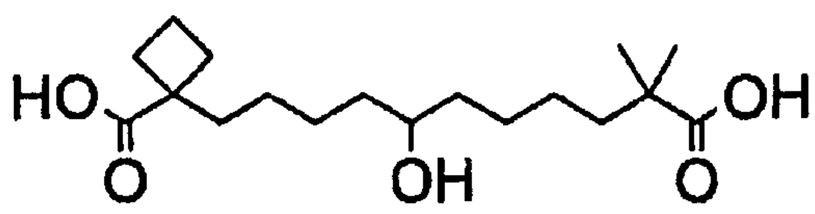
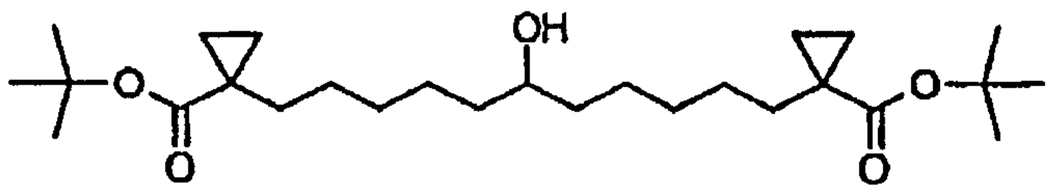
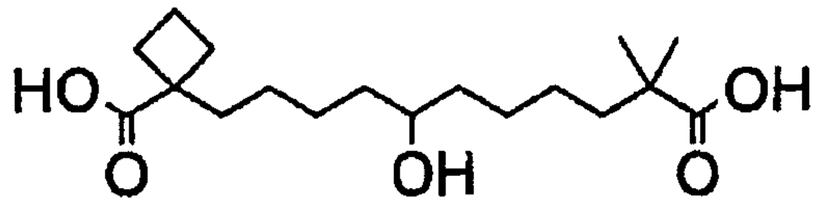

;or


;

or a pharmaceutically acceptable salt thereof.

42. A compound of structure:


;

or a pharmaceutically acceptable salt thereof.

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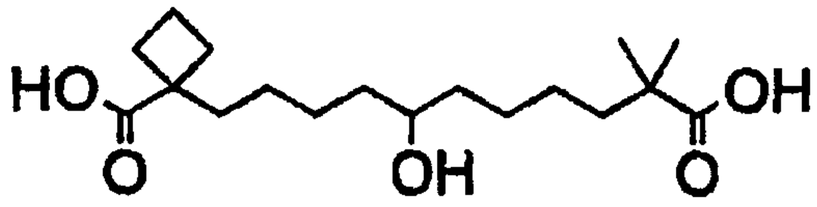
43. A compound of structure:



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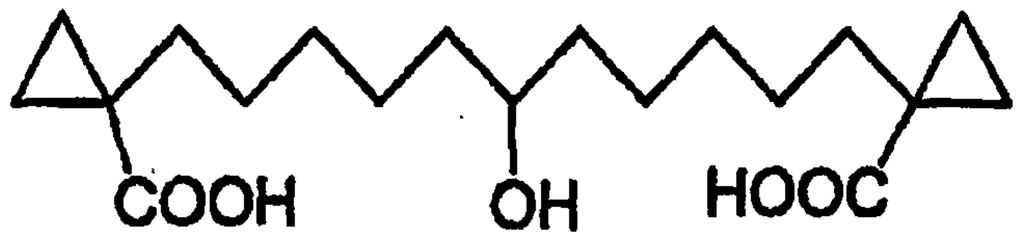
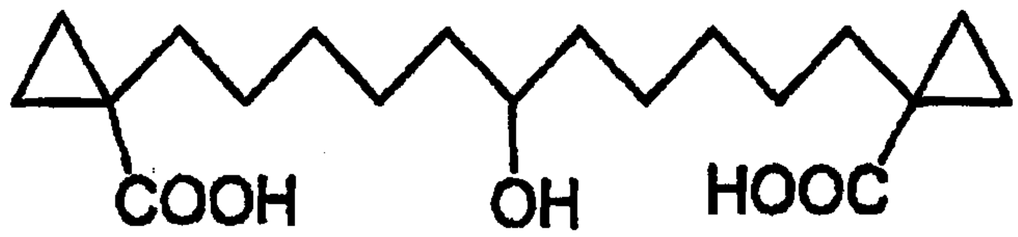


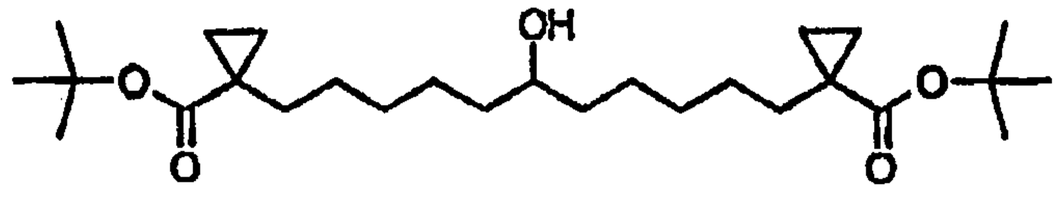
;

or a pharmaceutically acceptable salt thereof.

45. A compound of structure:



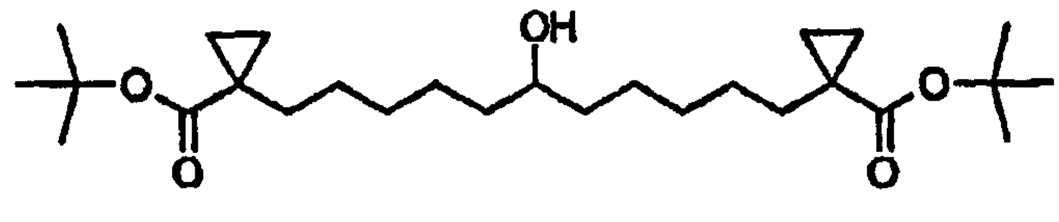
46. A compound of structure:



;

or a pharmaceutically acceptable salt thereof.

47. A compound of structure:



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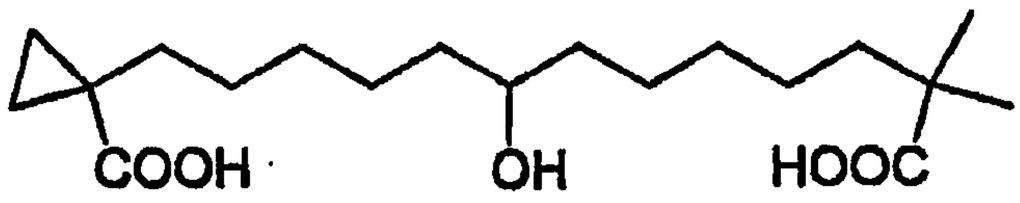
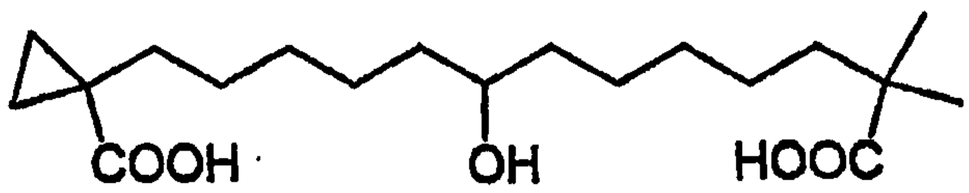
48. A compound of structure:

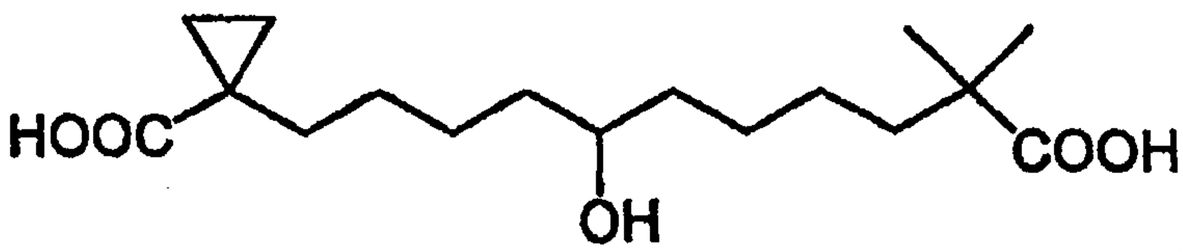


or a pharmaceutically acceptable salt thereof.

49. A compound of structure:

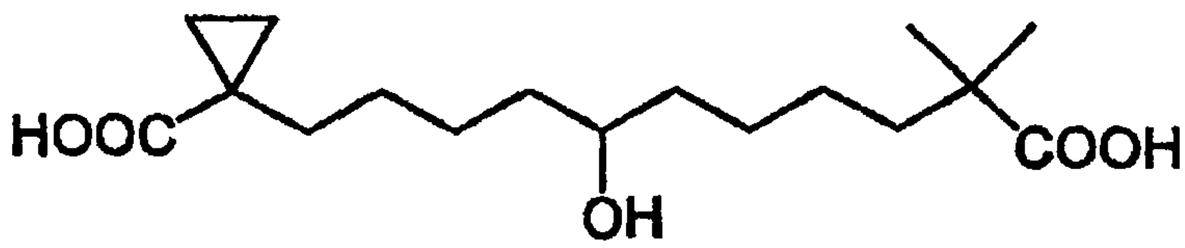


50. A compound of structure:

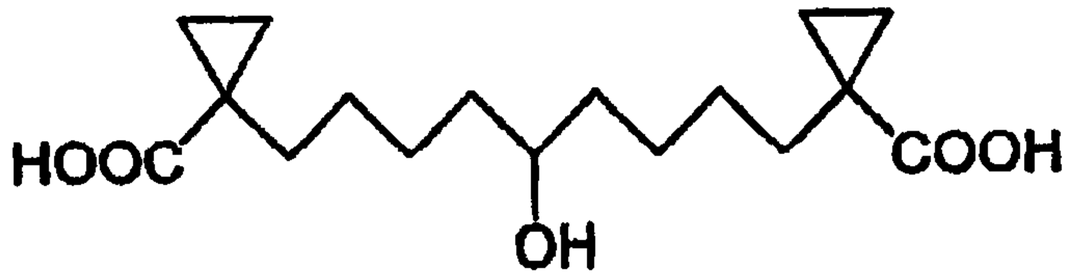


or a pharmaceutically acceptable salt thereof.

51. A compound of structure:



52. A compound of structure:



or a pharmaceutically acceptable salt thereof.

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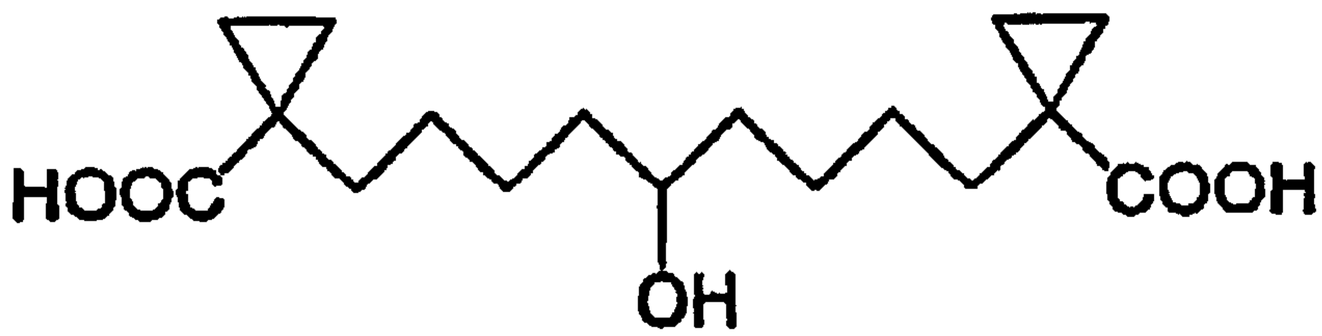
53. A compound of structure:



54. A pharmaceutical composition comprising a compound of any one of claims 1 to 21 and 32 to 40, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, a compound of claim 23, 24, 26, 28, 30, 41, 42, 44, 46, 48, 50 or 52, or a pharmaceutically acceptable salt thereof, or a compound of claim 22, 25, 27, 29, 31, 43, 45, 47, 49, 51 or 53, and a pharmaceutically acceptable vehicle, excipient, or diluent.

55. A pharmaceutical composition of claim 54 for use in the treatment or prevention of aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, obesity, oxysterol elimination in bile, pancreatitis, pancreatitius, Parkinson's disease, a peroxisome proliferator activated receptor associated disorder, phospholipid elimination in bile, renal disease, septicemia, Syndrome X, or thrombotic disorder, or for modulating C reactive protein, or for enhancing bile production, in a patient.

56. A pharmaceutical composition of claim 54 for use in the treatment or prevention of a cardiovascular disease in a patient.

57. A pharmaceutical composition of claim 54 for use in the treatment or prevention of a dyslipidemia in a patient.

58. A pharmaceutical composition of claim 54 for use in the treatment or prevention of a dyslipoproteinemia in a patient.

59. A pharmaceutical composition of claim 54 for use in the treatment or prevention of a disorder of glucose metabolism in a patient.

60. A pharmaceutical composition of claim 54 for use in the treatment or prevention of Alzheimer's disease in a patient.

61. A pharmaceutical composition of claim 54 for use in the treatment or prevention of Syndrome X in a patient.

62. A pharmaceutical composition of claim 54 for use in the treatment or prevention of septicemia in a patient.

63. A pharmaceutical composition of claim 54 for use in the treatment or prevention of a thrombotic disorder in a patient.

64. A pharmaceutical composition of claim 54 for use in the treatment or prevention of a peroxisome proliferator activated receptor associated disorder in a patient.

65. A pharmaceutical composition of claim 54 for use in the treatment or prevention of obesity in a patient.

66. A pharmaceutical composition of claim 54 for use in the treatment or prevention of pancreatitis in a patient.

67. A pharmaceutical composition of claim 54 for use in the treatment or prevention of hypertension in a patient.

68. A pharmaceutical composition of claim 54 for use in the treatment or prevention of renal disease in a patient.

69. A pharmaceutical composition of claim 54 for use in the treatment or prevention of cancer in a patient.

70. A pharmaceutical composition of claim 54 for use in the treatment or prevention of inflammation in a patient.

71. A pharmaceutical composition of claim 54 for use in the treatment or prevention of impotence in a patient.

72. A pharmaceutical composition of claim 54 for use in the treatment or prevention of a neurodegenerative disease or disorder in a patient.

73. A pharmaceutical composition of claim 54 for use in inhibiting hepatic fatty acid synthesis in a patient.

74. A pharmaceutical composition of claim 54 for use in inhibiting sterol synthesis in a patient.

75. A pharmaceutical composition of claim 54 for use in the treatment or prevention of metabolic syndrome disorders in a patient.

76. A pharmaceutical composition of claim 54 for use in increasing HDL levels in a patient.

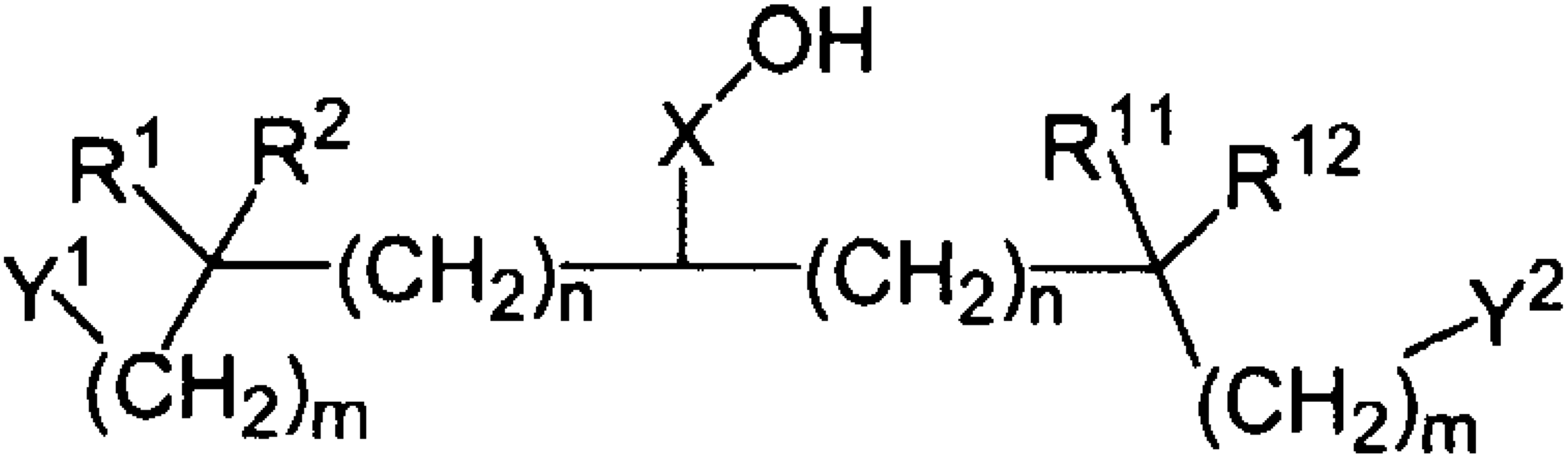
77. A pharmaceutical composition of claim 54 for use in lowering LDL levels in a patient.

78. A pharmaceutical composition comprising a compound of any one of claims 1 to 21 and 32 to 40, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, a compound of claim 23, 24, 26, 28, 30, 41, 42, 44, 46, 48, 50 or 52, or a pharmaceutically acceptable salt thereof, or a compound of claim 22, 25, 27, 29, 31, 43, 45, 47, 49, 51 or 53, and a pharmaceutically acceptable vehicle, excipient, or diluent for administration in combination with a statin.

79. Use of a compound of any one of claims 1 to 21 and 32 to 40, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, a compound of claim 23, 24, 26, 28, 30, 41, 42, 44, 46, 48, 50 or 52, or a pharmaceutically acceptable salt thereof, or a compound of claim 22, 25, 27, 29, 31, 43, 45, 47, 49, 51

or 53, in the manufacture of a medicament for the treatment or prevention of aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, obesity, oxysterol elimination in bile, pancreatitis, pancreatitius, Parkinson's disease, a peroxisome proliferator activated receptor associated disorder, phospholipid elimination in bile, renal disease, septicemia, SyndromeX, or thrombotic disorder, a neurodegenerative disease or disorder, or metabolic syndrome disorders, or for modulating C reactive protein, enhancing bile production, inhibiting hepatic fatty acid synthesis, inhibiting sterol synthesis, increasing HDL levels, or lowering LDL levels, in a patient.

80. Use of a compound of any one of claims 1 to 21 and 32 to 40, or a pharmaceutically acceptable salt, hydrate, solvate or a mixture thereof, a compound of claim 23, 24, 26, 28, 30, 41, 42, 44, 46, 48, 50 or 52, or a pharmaceutically acceptable salt thereof, or a compound of claim 22, 25, 27, 29, 31, 43, 45, 47, 49, 51 or 53, for the treatment or prevention of aging, Alzheimer's Disease, cancer, cardiovascular disease, diabetic nephropathy, diabetic retinopathy, a disorder of glucose metabolism, dyslipidemia, dyslipoproteinemia, hypertension, impotence, inflammation, insulin resistance, lipid elimination in bile, obesity, oxysterol elimination in bile, pancreatitis, pancreatitius, Parkinson's disease, a peroxisome proliferator activated receptor associated disorder, phospholipid elimination in bile, renal disease, septicemia, SyndromeX, or thrombotic disorder, a neurodegenerative disease or disorder, or metabolic syndrome disorders, or for modulating C reactive protein, enhancing bile production, inhibiting hepatic fatty acid synthesis, inhibiting sterol synthesis, increasing HDL levels, or lowering LDL levels, in a patient.



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