

[54] **NOVEL ESTERS AND DERIVATIVES**

[72] Inventors: **John B. Siddall**, Palo Alto, Calif.; **Jean Pierre Calame**, Locarno, Switzerland

[73] Assignee: **Zoecon Corporation**, Palo Alto, Calif.

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 800,266, Feb. 18, 1969, abandoned, which is a continuation-in-part of Ser. No. 618,351, Feb. 24, 1967, abandoned, which is a continuation-in-part of Ser. Nos. 579,490, Sept. 15, 1966, abandoned, and Ser. No. 590,195, Oct. 28, 1966, abandoned, and Ser. No. 592,324, Nov. 7, 1966, abandoned, and Ser. No. 594,664, Nov. 16, 1966, abandoned, and Ser. No. 605,566, Dec. 29, 1966, abandoned, and Ser. No. 605,578, Dec. 29, 1966, abandoned.

[52] U.S. Cl.**260/410.9 R**, 260/413, 260/468 P, 260/514 P, 260/294.3, 260/340.9, 260/345.7, 260/345.8, 260/347.3, 260/347.4, 260/348 A, 260/405, 260/408, 260/468 B, 260/468 R, 260/471 R, 260/473 C, 260/476 R, 260/482 R, 260/484 R, 260/486 R, 260/487, 260/488 H, 260/488 R,

260/493 R, 260/611 R, 260/612 D, 260/614 R, 260/617 R, 260/632 R, 260/633, 424/305, 424/312, 424/317, 424/318

[51] Int. Cl.**C07c 69/74**, C07c 61/16, A01n 9/24

[58] Field of Search.....260/410.9, 413, 408, 405, 468 P, 260/514 P

[56] **References Cited**

UNITED STATES PATENTS

3,413,351 11/1968 Eschenmoser et al.....260/586

Primary Examiner—Lewis Gotts

Assistant Examiner—Diana G. Rivers

Attorney—Donald W. Erickson

[57] **ABSTRACT**

Novel aliphatic hydrocarbon esters, acids and alcohols having a backbone of at least 12 carbon atoms, a lower alkyl group at C-3, C-7 and C-11 and unsaturation or saturation at C-2,3, C-6,7 and/or C-10,11 which are substituents with, for example, halo, hydroxy, methylene, oxido, dihalo-methylene, and the like, and the esters and ethers of said hydroxy substituent useful as arthropod maturation inhibitors.

13 Claims, No Drawings

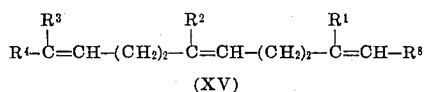
NOVEL ESTERS AND DERIVATIVES

This is a continuation-in-part of U.S. application Ser. No. 800,266, filed Feb. 18, 1969, which is a continuation-in-part of U.S. application Ser. No. 618,351, filed Feb. 24, 1967, which, in turn, is a continuation-in-part of the following U.S. applications: Ser. No. 579,490, filed Sept. 15, 1966; Ser. No. 590,195, filed Oct. 28, 1966; Ser. No. 592,324, filed Nov. 7, 1966; Ser. No. 594,664, filed Nov. 16, 1966; Ser. No. 605,566, filed Dec. 29, 1966; and Ser. No. 605,578, filed Dec. 29, 1966, each now abandoned.

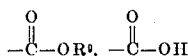
This invention relates to novel aliphatic hydrocarbon ester derivatives and to processes for their preparation.

More particularly, the present invention relates to novel substituted aliphatic hydrocarbon esters, substituted aliphatic hydrocarbon acids and substituted aliphatic hydrocarbon alcohols (and the ethers and esters of said alcohols) having a backbone chain of 12 to 17 carbon atoms and a lower alkyl group at positions C-3, C-7 and C-11. These substituted aliphatic hydrocarbons can be prepared according to several methods described hereinafter. One method is to first prepare a substituted aliphatic hydrocarbon ester and then convert the substituted ester into the acid or alcohol to obtain novel substituted aliphatic hydrocarbon acids and alcohols (the alcohol, thereafter, can be converted into the ether or ester). Alternatively, an unsubstituted aliphatic hydrocarbon ester is first converted into the corresponding acid or alcohol and thereafter the acid or alcohol is substituted according to the procedures described hereinafter.

The terms "aliphatic hydrocarbon ester," "aliphatic hydrocarbon acid," and "aliphatic hydrocarbon alcohol," as used herein, refers to compounds characterized by the following formula:

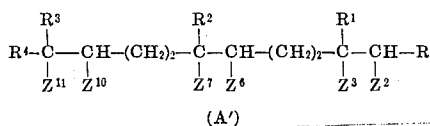


wherein each of R^1 , R^2 , R^3 and R^4 is a lower alkyl group and R^5 represents the group



and $-\text{CH}_2\text{OH}$, wherein R^6 is a lower alkyl group and the corresponding 2,3-dihydro; 6,7-dihydro; 10,11-dihydro; 2,3,6,7-tetrahydro; 6,7,10,11-tetrahydro and 2,3,10,11-tetrahydro compounds of the above formula.

The terms "substituted aliphatic hydrocarbon ester," "substituted aliphatic hydrocarbon acid" and "substituted aliphatic hydrocarbon alcohol" refer to compounds of formula XV above containing substituents, [for example, methylene, difluoromethylene, dichloromethylene, oxido, chloro, fluoro, bromo or hydroxy (ethers and esters thereof)], at one or more of positions C-2, C-3, C-6, C-7, C-10 and C-11 as described hereinafter, see, for example, formulas A', XVI through XXVIII and the examples.

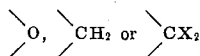


wherein,

each of R^1 , R^2 , R^3 and R^4 is lower alkyl;

Z^2 is hydrogen, hydroxy and ethers thereof, bromo, chloro or fluoro;

Z^3 is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z^2 , is a carbon-carbon double bond between C-2,3 or one of the groups

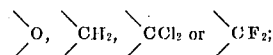


in which X is chloro or fluoro;

Z^6 is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro or fluoro;

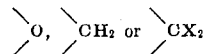
Z^7 is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z^6 , is a

carbon-carbon double bond between C-6,7 or one of the groups



Z^{10} is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro or fluoro;

Z^{11} is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z^{10} , is a carbon-carbon double bond between C-10,11 or one of the groups

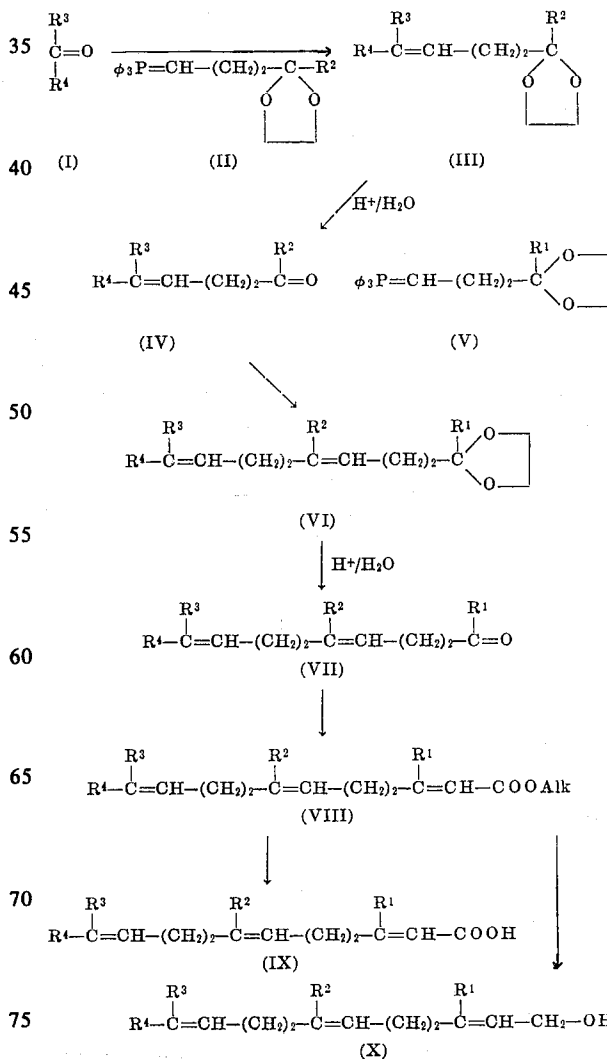


in which X is chloro or fluoro; and

R is the group $-\text{COOR}'$ or $-\text{CH}_2\text{OR}''$ in which R' is hydrogen or lower alkyl and R'' is hydrogen, lower alkyl or carboxylic acyl group; and the acid addition salts of the free acids, provided that when Z^3 is hydrogen — then Z^2 is hydrogen.

Included within the present invention are the alkali metal and alkaline earth metal salts of the substituted aliphatic hydrocarbon acids. The salts of these acids include sodium, potassium, calcium, magnesium, barium, and the like.

As indicated above, the novel substituted aliphatic hydrocarbon esters, acids and alcohols (including the esters and ethers of said alcohols) can be derived from the compounds of formula XV. The compounds of formula XV can be prepared according to a process outlined as follows wherein R^1 , R^2 , R^3 and R^4 are as defined above, Alk is a lower alkyl group and Φ is phenyl.



In the practice of the above process ($I \rightarrow X$), a dialkyl ketone (I) is reacted with an equal molar quantity, preferably an excess, of the Wittig reagent of Formula II in an organic solvent, e.g., dimethyl sulfoxide, at reflux temperatures to furnish the corresponding substituted Wittig reaction adduct of Formula III.

The Wittig reagent of Formula II can be prepared by conventional procedures, such as is described by Trippett, *Advances in Organic Chemistry*, Vol. 1, pp. 83-102, Trippett, *Quarterly Review*, Vol. 16-17, pp. 406-410; and Greenwald et al., *Journal of Organic Chemistry* 28, 1128 (1963) from the 4-ethylene ketal of a 1-halo-4-alkanone by treatment with triphenylphosphine followed by treatment with butyl or phenyl lithium.

The 4-ethylene ketal of the 1-halo-4-alkanone is obtained by subjecting the 4-keto compound to conventional ketalysis with ethylene glycol in benzene in the presence of an aryl sulfonic acid. The 1-halo-4-alkanone, particularly the 1-bromo derivative, can be prepared by known procedures such as that described in German Pat. No. 801,276 (Dec. 28, 1950), vide *Chemical Abstracts* 45, 2972h and by Jäger et al., *Arch. Pharm.* 293, 896 (1960), vide *Chemical Abstracts* 55, 3470g. Briefly, these procedures involve treating butyrolactone with the desired alkyl alkanoate to provide the corresponding α -acylbutyrolactone adduct. Treatment of the latter adduct with alkali metal halide, particularly sodium bromide, in aqueous sulfuric acid then provides the corresponding 1-bromo-4-alkanone. Thus butyrolactone when treated with ethyl acetate gives α -acetylbutyrolactone which is, in turn, converted to 1-bromo-4-pentanone.

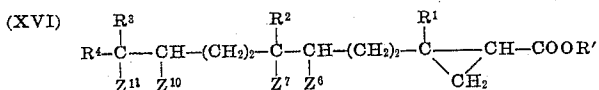
Hydrolysis of the Wittig reaction adduct (III) with aqueous acid affords the free ketone (IV).

By repeating the Wittig reaction just described on the thus formed ketone (IV) with the Wittig reagent (V) (prepared as described above), the corresponding diene adduct (VI) is obtained which is then hydrolyzed with aqueous acid to the dienone (VII).

The dienone of Formula VII is then converted into the trienoate of Formula VIII by treatment with a diethyl carboalkoxymethylphosphonate, such as diethyl carbomethoxymethylphosphonate (VIII; Alk is methyl), in the presence of an alkali metal hydride, e.g., sodium hydride.

The aliphatic hydrocarbon ester (trienoate) of Formula VIII can then be converted into the corresponding aliphatic hydrocarbon acid of Formula IX by treatment with an alkali metal salt, e.g., sodium carbonate, in aqueous alcohol, e.g., aqueous methanol or into the corresponding aliphatic hydrocarbon alcohol of Formula X by treatment with, for example, lithium aluminum hydride.

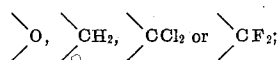
Typical of the substituted aliphatic hydrocarbon esters, acids and alcohols which can be obtained from the above prepared starting materials are those of the following formulas:



wherein R' is hydrogen or lower alkyl; each of R^1 , R^2 , R^3 and R^4 is lower alkyl;

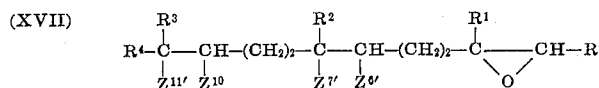
Z^6 is hydrogen, hydroxy, chloro, fluoro or bromo;

Z^7 is hydrogen, hydroxy, lower alkoxy, chloro, fluoro, or bromo, or when taken together with Z^6 , a carbon-carbon double bond or one of the groups

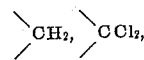


provided that when Z^6 is hydroxy, chloro, fluoro or bromo, Z^7 is other than hydrogen and when Z^7 is hydrogen, Z^6 is hydrogen;

Z^{10} is defined the same as Z^6 ; and Z^{11} is defined the same as Z^7 and Z^{11} together with Z^{10} is defined the same as Z^7 together with Z^6 .



wherein, R^1 , R^2 , R^3 and R^4 are defined the same as above; Z^6 is hydrogen, hydroxy, chloro, fluoro or bromo; Z^7 is hydrogen, hydroxy, lower alkoxy, chloro, fluoro, or bromo, or when taken together with Z^6 , a

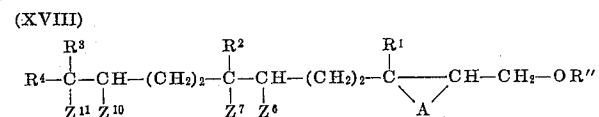


or

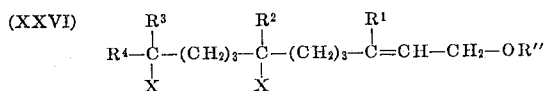
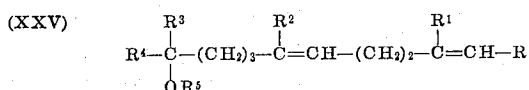
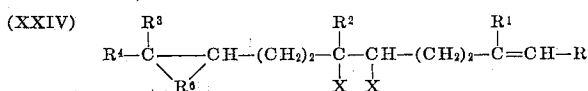
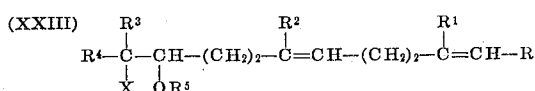
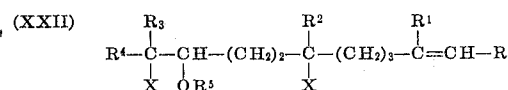
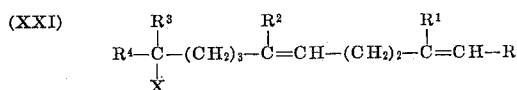
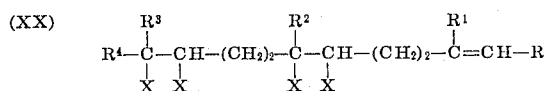
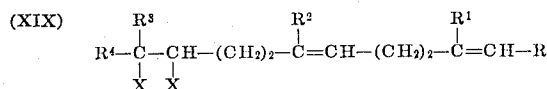


group, provided that when Z^6 is hydroxy, chloro, fluoro or bromo, Z^7 is other than hydrogen and when Z^7 is hydrogen, Z^6 is hydrogen;

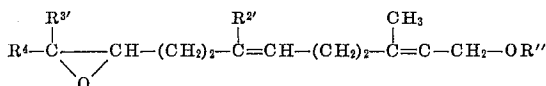
Z^{10} is defined the same as Z^6 ; Z^{11} is defined the same as Z^7 together with Z^{10} is defined the same as Z^7 together with Z^6 ; and R is the group $-COOR'$ or $-CH_2-OR''$, wherein R' is hydrogen or lower alkyl and R'' is hydrogen lower alkyl or a carboxylic acyl group.



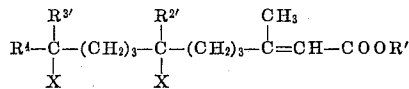
wherein R^1 , R^2 , R^3 , R^4 , Z^6 , Z^7 , Z^{10} and Z^{11} are as defined above in connection with Formula XVI; R'' is hydrogen, lower alkyl, or a carboxylic acyl group; and A is methylene, difluoromethylene, or dichloromethylene.



(XXVII)



(XXVIII)



wherein, in the above formulas XIX through XXVIII, each of R, R', R'', R¹, R², R³ and R⁴ is as defined above; R⁵ is hydrogen, lower alkyl or a carboxylic acyl group; R⁶ is oxa, methylene, difluoromethylene, or dichloromethylene; each of R^{2'} and R^{3'} is a lower alkyl of two to six carbon atoms;

and X is chloro, fluoro or bromo.

The term "lower alkyl," as used herein, refers to straight or branched chain saturated aliphatic hydrocarbons having a chain length of one to six carbon atoms, e.g., methyl, ethyl, propyl, i-propyl, s-butyl, i-butyl, and the like. The term "lower alkoxy," as used herein, refers to straight chain alkyloxy groups of one to six carbon atoms.

The carboxylic groups herein are derived from the corresponding carboxylic acids containing from 1 to 12 carbon atoms and possess straight, branched, cyclic or cyclic-aliphatic chain structure which may be saturated, unsaturated, or aromatic and optionally substituted by groups, such as hydroxy, alkoxy containing up to five carbon atoms, acyloxy containing up to six carbon atoms, nitro, amino, halogeno, and the like. Typical esters thus include formate, acetate, propionate, enanthate, benzoate, trimethylacetate, t-butyl acetate, phenoxyacetate, cyclopentylpropionate, aminoacetate, β-chloropropionate, adamantate, and the like, preferably a lower hydrocarbon carboxylic acyl group such as acetyl, propionyl, butyryl, and the like, containing up to about six carbon atoms.

The addition of a methylene group to an unsaturated position of the molecule can be performed selectively at C-2,3 by the reaction of an unsaturated compound with dimethylsulfoxonium methylide base [prepared in the manner of Corey et al., *Journal of the American Chemical Society* 87, 1353 (1965)] in dimethylsulfoxide. Addition of the fused methylene group at the C-6,7 and C-10,11 positions follows upon reaction of the unsaturated linkages with methylene iodide and a zinc-copper couple in the manner of Simmons and Smith, *J. Am. Chem. Soc.* 81, 4256 (1959). Preferably, the addition of the methylene group is conducted on an aliphatic hydrocarbon ester and thereafter the ester can be converted into the corresponding acid or alcohol by the procedures described hereinabove to obtain methylene substituted aliphatic hydrocarbon acids and methylene substituted aliphatic hydrocarbon alcohols. The thus obtained alcohol can then be etherified or esterified according to conventional etherification and esterification processes.

Similarly, the formation of the epoxide is selectively performed at the C-2,3 position by reaction with hydrogen peroxide in aqueous alkali medium, such as is usually provided by sodium hydroxide. Addition of the oxido group at the C-6,7 and C-10,11 positions is performed with m-chloroperbenzoic acid, preferably in methylene chloride or chloroform solution. The formation of an epoxide at C-2,3, C-6,7 and/or C-10,11 in the case of acids and alcohols is preferably accomplished via the appropriate or desired epoxidation of an aliphatic hydrocarbon ester and then conversion of the ester into the acid or alcohol. If a methylene substituent and epoxide are to be introduced on the same backbone, it is preferable to perform the methylene addition first and then carry out epoxidation.

A difluoromethylene group at positions C-6,7 and C-10,11 of an aliphatic hydrocarbon ester can be added by reacting the starting monoene, diene or triene with about 1.2 molar equivalents of trimethyltrifluoromethyl tin in the presence of

sodium iodide in benzene/monoglyme solvent at reflux over a period of a few hours. By varying the mole ratio of the two reactants and the temperature and time of reaction, the reaction can be favored toward one or the other 6,7 and 10,11 mono adducts and the 6,7;10,11 bis adduct. The C-2,3 position is not attacked except under forcing conditions. Thereafter, the ester group can, if desired, be converted into the corresponding acid or alcohol by the procedures described above.

In the case of adding difluoromethylene to an aliphatic hydrocarbon alcohol, introduction at any one of positions C-2,3; C-6,7; and C-10,11 can be accomplished by using about 1.2 molar equivalents of trimethyltrifluoromethyl tin and sodium iodide in monoglyme and refluxing for about 2 hours. Similarly, the bis adducts at C-2,3;6,7, C-2,3;10,11 and C-6,7;10,11 can be prepared by following the above procedure with the exception of using about 2.5 molar equivalents of trimethyltrifluoromethyl tin and sodium iodide and refluxing for about 3 hours. Similarly, the tris adduct can be obtained by using about 5 to 10 molar equivalents of the reagents and refluxing for about 5 to 15 hours. The mono, bis and tris adducts are separable by preparative gas-liquid chromatography.

A fused dichloromethylene group is introduced into an aliphatic hydrocarbon ester by reacting the C-6 or C-10 monoene; C-2,6, C-2,10 or C-6,10 diene; or C-2,6,10 triene thereof with phenyldichlorobromomethyl mercury in benzene at reflux for from one to five hours. The relative yield of the C-6,7 and C-10,11 mono adducts and the C-6,7;10,11 bis adduct varies with the amount of mercury reagent and the reaction conditions employed. Generally, about or slightly more than one molar equivalent provides the mono adducts predominantly, the bis adduct being favored by use of about 2.5 molar equivalents. The mono and bis adducts are separable by gas-liquid chromatography. These adducts can be converted into the correspondingly substituted aliphatic hydrocarbon acids and alcohol via the procedure described above. In the case of aliphatic hydrocarbon alcohol starting materials, dichloromethylene can be added at C-2,3 in addition to the formation of bis adducts (C-2,3;6,7, C-2,3;10,11, C-6,7;10,11) by following the methods described above for aliphatic hydrocarbon esters and thereafter separating the adducts by gas-liquid chromatography. In addition, by using about four to six molar equivalents of the mercury reagent and refluxing for about 5 hours, the tris adduct can be obtained from corresponding 2,6,10- triene starting material.

A hydroxy, lower alkoxy, chloro, fluoro or bromo group at one or more positions on the backbone as indicated by formulas XVI through XXVIII can be introduced via a number of methods.

At the C-2,3-position, a monohydroxy substituent is introduced by treating a 2,3-oxido substituted aliphatic hydrocarbon ester with a mole or less of lithium aluminum hydride under mild conditions such as at temperatures of from 0° C to about 30° C for a few minutes, e.g., about 15-30 minutes to furnish the corresponding 1,3-diol and the corresponding 2,3-oxido-1-ol. For the preparation of 3-OH derivatives of aliphatic hydrocarbon esters and acids, a ketone of formula VII above is subjected to Reformatsky reaction (see for example, U.S. Pat. No. 3,031,481).

Etherification is thereafter conducted by methods known per se. For example, the hydroxy group can be treated with sodium hydride followed by an alkyl halide, such as ethyl bromide, to form the desired (lower)alkoxy group. 2-Halotetrahydropyran and 2-halotetrahydrofuran are utilized for the corresponding tetrahydropyran-2-yl and tetrahydrofuran-2-yl ethers. Acylation is likewise accomplished by known chemical processes, such as through the use of an acid anhydride in the presence of acid catalyst, for example, p-toluenesulfonic acid.

A 2,3-dihydroxy substitution can be accomplished by treating a 2,3-oxido substituted aliphatic hydrocarbon ester with 0.1 to 0.001 N perchloric acid in aqueous solution at room temperature for about 16 hours. A 2-hydroxy-3-lower alkoxy

(straight chain) can be formed by similar perchloric acid treatment in a lower straight chain alcohol solvent medium. Alternatively, the 2,3-oxido starting material can be an aliphatic hydrocarbon acid or alcohol to furnish the corresponding C-2 and C-3 substituted compounds.

A 2-hydroxy-3-chloro, fluoro or bromo substitution can be similarly accomplished by treating a 2,3-oxido substituted aliphatic hydrocarbon ester/acid or alcohol with HCl, HF or HBr, respectively.

Each of the C-6,7 and C-10,11 positions can be similarly substituted. Alternatively, monohydroxy substitution at C-7 and/or C-11 can be carried out by treating the unsaturated aliphatic hydrocarbon with aqueous formic acid as described more fully hereinafter. Thereafter, etherification or esterification can be carried out by the methods described above.

Monohalo (chloro, fluoro or bromo) substitution or introduction can be accomplished by treating an unsaturated aliphatic hydrocarbon ester or acid with hydrogen halide. Selective introduction at C-11 is obtained by treatment of the unsaturated compound with the appropriate hydrogen halide in carbon tetrachloride or other halogenated hydrocarbon solvents of low dielectric constant. Introduction at C-7 and C-7,11 is favored by performing the reaction in diethyl ether or benzene. This halo introduction can be performed using as the starting material either a 6 or 10 monene, 2,10-diene, 2,6-diene, 6,10 -diene or 2,6,10-triene unsaturated aliphatic hydrocarbon ester, acid, or alcohol.

Dihalo (Cl, F or Br) introduction at C-10,11 or C-6,7 or tetrahalo introduction at C-6,7,10,11 can be accomplished by treating an unsaturated aliphatic hydrocarbon ester, acid or alcohol with chlorine, fluorine or bromine in a chlorinated hydrocarbon solvent. A mixture of the dihalo and tetrahalo products is obtained which is separable by chromatography. The starting material can be either a monene, diene or triene. The 2-ene is unaffected by the reaction except in the case of aliphatic hydrocarbon alcohols in which case halo substitution at C-2 and C-3 also takes place.

The bishydroxy derivatives ($Z^6=Z^7$ =hydroxy and/or $Z^{10}=Z^{11}$ =hydroxy) are prepared from the precursor epoxide (introduced as described above) with aqueous acid as set forth above. Similarly, the procedure given above in the insertion of the 6(10)-hydroxy-7(11)-alkoxy and 6(10)-hydroxy-7(11)-halo substituents analogously apply.

In the preparation of the 6(10)-bromo- and 6(10)-chloro-7(11)-hydroxy compounds, the starting unsaturated compound is treated with the appropriate quantity of N-bromo- or N-chlorosuccinimide in aqueous organic solvent, such as dioxane. The corresponding 7(11)-alkoxy compounds are similarly prepared in the presence of dry alkanol solvent. Use of hydrogen fluoride starting with the corresponding oxido compounds affords some of the 6(10)-fluoro-7(11)-hydroxy derivatives. Treatment thereof with acidified alkanol solution affords the corresponding (lower) alkoxy compounds.

In the practice of the above described elaborations on the compounds hereof, relative sensitivities of various groups to certain reaction conditions dictates the preference for a general pattern of reaction sequence. Thus, in accordance herewith, the methyleneation reaction is usually performed initially on the triene. As mentioned, this can be done selectively.

The remaining sites of elaboration are generally epoxidized as the next step. This is particularly true for epoxidations at C-2,3 position for which it is preferred not to have present a halo substituent on the backbone chain. However, since the acidic conditions required for the addition of hydrogen halides cleave the epoxide, it is preferred to insert the oxide after such reactions are performed unless, of course, the epoxide is required for the insertion of the hydroxy(alkoxy)-halo bis-substituents, and the like.

With the exception of the above proviso for the oxido group, the fused halomethylene groups are preferably introduced after the fused methylene and oxido groups are present since these reactions are compatible with these groups.

After all desired elaboration is complete, hydrogenation of any of the unsubstituted double bonds is, if desired, carried out. Halogenation in the instance of introducing a tertiary halo atom is preferably conducted on the desired olefin isolated after hydrogenation.

Certain exceptions to the above general and preferred sequence exist; however, upon slight modification of the reactions according to the purposes desired in the preparation of particular compounds embraced by the present invention, chemical obstacles are overcome. These modifications are, as a whole, obvious to one skilled in the art and/or apparent by the preparative procedures set forth in the examples contained hereinafter.

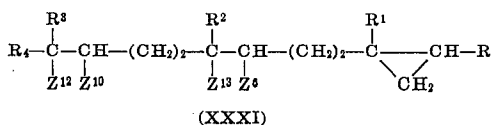
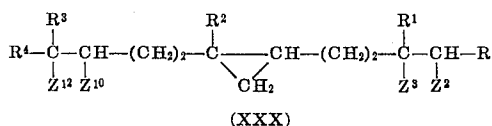
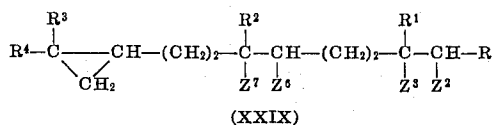
Separation of the various geometric isomers can be performed at any appropriate or convenient point in the overall process. An advantageous and particular synthetically valuable point at which isomers can be separated by chromatography and the like is at the conclusion of each step of the backbone synthesis, that is, after preparing each of the compounds represented by formulas (VIII), (IX), and (X). Another advantageous point includes that just after the selective addition of the methylene group at C-2,3.

The novel substituted aliphatic hydrocarbon esters, acids and alcohols (including the esters and ethers of said alcohols) of the present invention are arthropod maturation inhibitors. They possess the ability to inhibit the maturation of members of the phylum Arthropoda, particularly, insects, in the passage from metamorphic stage to the next metamorphic stage. Thus, in the case of insects passing from the embryo stage to the larva stage, thence to the pupa stage, and thence to the adult stage, contact with an effective amount of a compound of the present invention, at any of the first three stages, inhibits passage to the next developmental stage with the insect either repeating passage through its present stage or dying. Moreover, these compounds exhibit ovidical properties with insects and are accordingly useful in combating them. These compounds are very potent and thus can be used at extremely low levels, for example, from 10^{-6} to 10^{-8} g. and are thus advantageously administered over large areas in quantities suitable for the estimated insect population. Generally the substances are liquids and for the purposes herein described, they can be utilized in conjunction with liquid or solid carriers. Typical insects against which these compounds are effective include mealworm, housefly, bollweevil, cornborer, mosquito, cockroach, moth, and the like.

Although not intending to be limited by any theoretical explanation, it appears that the effectiveness of these derivatives can be traced to their ability to mimic the activity of certain so-called "juvenile hormone" substances, such as those described in U.S. Pat. Ser. No. 2,981,655 and Law et al. Proc. Nat. Acad. Sci. 55, 576 (1966). Because of the potency of the compounds of the present invention, they can be employed at extremely low concentrations, as noted above, to obtain reproducible and predetermined levels of activity. Juvenile hormone substances have been referred to as growth hormone also. Juvenile hormone was identified as methyl 10,11-oxido-7-ethyl-3,11-trimethyltrideca-2,6-dienoate using an extract of cecropia moths by Roeller et al., Angew. Chem. internat. Edit. 6, 179 (Feb., 1967) and Chemical & Engineering News, 48-49 (Apr. 10, 1967). A second juvenile hormone from the same source has been identified as methyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate by Meyer et al., "The Two Juvenile Hormones from the Cecropia Silk Moth," Zoology (Proc. N.A.S.) 60, 853 (1968). In addition to the natural juvenile hormones and the unidentified mixture of Law et al. above, some synthetic terpenoids have been reported to exhibit juvenile hormone activity — Bowers et al., Life Sciences (Oxford) 4, 2323 (1965) — methyl 10,11-oxido-3,7,11-trimethyldodeca-2,6-dienoate; Williams et al., Journal of Insect Physiology 11, 569 (1965); BioScience 18, No. 8, 791 (Aug., 1968); Williams, Scientific American 217, No. 1, 13 (July, 1967); Science 154, 248 (Oct. 14, 1966); Romanuk et al., Proc. Nat. Acad. Sci. 57, 349 (Feb., 1967) — 7,11-dichloro of esters of farnesoic acid — Canadian Pat. No.

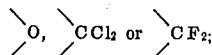
795,805 (1968); Masner et al., Nature 219, 395 (July 27, 1968); U.S. Pat. No. 3,429,970 and 3,453,362 — farnesene derivatives.

The compounds embraced by the terms "substituted aliphatic hydrocarbon ester," "substituted aliphatic hydrocarbon acid," "substituted aliphatic hydrocarbon alcohol," formulas A', XVI through XXVIII and the examples are represented by the following formulas in which R, R¹, R², R³, R⁴, Z², Z³, Z⁶, Z⁷ and Z¹⁰ are as defined hereinabove.



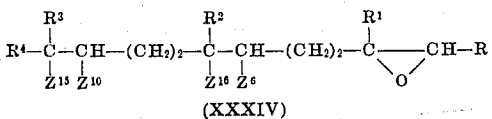
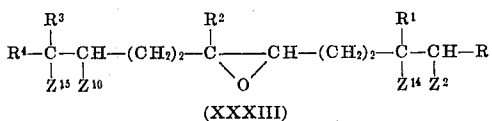
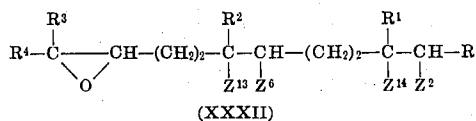
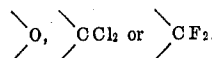
in which,

Z¹² is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z¹⁰, is a carbon-carbon double bond between C-10,11 or one of the groups



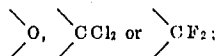
and

Z¹³ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z⁶, is a carbon-carbon double bond between C-6,7 or one of the groups

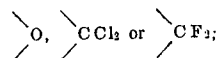


in which,

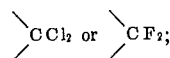
Z¹⁵ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z⁶, is a carbon-carbon double bond between C-6,7 or one of the groups



Z¹⁴ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z², is a carbon-carbon double bond between C-2,3 or one of the groups

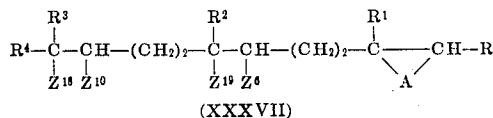
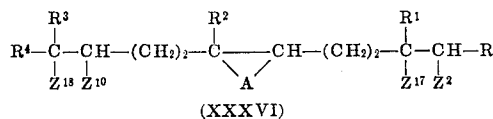
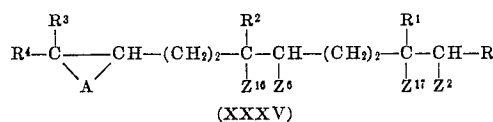
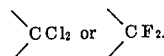


Z¹⁵ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z¹⁰, is a carbon-carbon double bond between C-10,11 or one of the groups

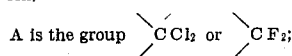


and

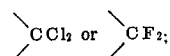
Z¹⁶ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z⁶, is a carbon-carbon double bond between C-6,7 or one of the groups



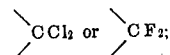
in which,



Z¹⁶ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z⁶, is a carbon-carbon double bond between C-6,7 or one of the groups

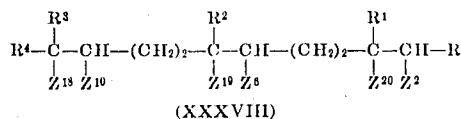


Z¹⁷ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z², is a carbon-carbon double bond between C-2,3 or one of the groups



Z¹⁸ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z¹⁰, is a carbon-carbon double bond between C-10,11; and

Z¹⁹ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z⁶, is a carbon-carbon double bond between C-6,7.

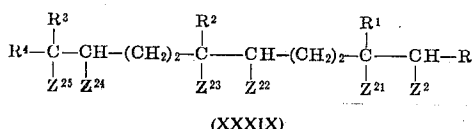


in which,

Z¹⁸ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z¹⁹, is a carbon-carbon double bond between C-10,11;

Z¹⁹ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z¹⁸, is a carbon-carbon double bond between C-6,7; and

Z²⁰ is hydrogen, hydroxy and esters and ethers thereof, bromo, chloro, fluoro, or, when taken together with Z², is a carbon-carbon double bond between C-2,3, provided that at least one of Z⁶, Z¹⁰, Z¹⁸, Z¹⁹ and Z²⁰ is bromo, chloro or fluoro.



in which,

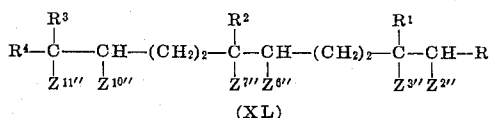
Z²¹ is hydrogen, hydroxy and esters and ethers thereof, or, when taken together with Z², is a carbon-carbon double bond between C-2,3;

Z²² is hydrogen, or hydroxy and esters and ethers thereof;

Z²³ is hydrogen, hydroxy and esters and ethers thereof, or, when taken together with Z²², is a carbon-carbon double bond between C-6,7;

Z²⁴ is hydrogen or hydroxy and esters and ethers thereof; and

Z²⁵ is hydrogen, hydroxy and esters and ethers thereof, or, when taken together with Z²⁴, is a carbon-carbon double bond, provided that at least one of Z²¹, Z²², Z²³, Z²⁴ and Z²⁵ is hydroxy or the ester or ether thereof.



in which,

Z^{2''} is hydrogen; Z^{3''} is hydrogen, or, when taken together with Z^{2''}, is a carbon-carbon double bond between C-2,3; Z^{6''} is hydrogen; Z^{7''} is hydrogen, or, when taken together with Z^{6''}, is a carbon-carbon double bond between C-6,7; Z^{10''} is hydrogen; and Z^{11''} is hydrogen, or, when taken together with Z^{10''}, is a carbon-carbon double bond between C-10,11, provided that in formula XL at least one of R¹, R² or R³ is lower alkyl of at least two carbon atoms.

The term "hydroxy and esters and ethers thereof," as used herein, refers to free hydroxyl and esters and ethers which are hydrolyzable to free hydroxyl. Typical esters are carboxylic esters of up to 12 carbon atoms which are saturated or unsaturated and of straight chain aliphatic, branched chain aliphatic, and cyclic or cyclic aliphatic structure, such as acetate, propionate, butyrate, valerate, caproate, enanthate, pelargonate, acrylate, undecanoate, phenoxycetate, benzoate, phenylacetate, diethylacetate, trimethylacetate, trichloroacetate, t-butylacetate, trimethylhexanoate, methylneopentylacetate, cyclohexylacetate, cyclopentylpropionate, adamantanoate, methoxyacetate, acetoxyacetate, aminoacetate, diethylaminoacetate, β-chloropropionate, 2-chloro-4-nitrobenzoate, piperidinoacetate, and the like, preferably a lower hydrocarbon carboxylic ester containing up to six carbon atoms. Typical ethers are formed by etherification of the hydroxy group by tetrahydrofuran-2-yl, tetrahydropyran-2-yl or by a monovalent hydrocarbon group of up to eight carbon atoms which can be of straight, branched, cyclic or cyclic aliphatic structure, such as alkyl, alkenyl, cycloalkyl, or aralkyl, e.g., methyl, ethyl, propyl, butyl, pentyl, butenyl, phenethyl, benzyl, cyclopentyl, cyclohexyl, and the like.

The presence of at least one and optionally two double bonds in the foregoing compounds permits the existence of geometric isomerism in the configuration of these compounds. This isomerism occurs with regard to the double bond

bridging the C-2,3 carbon atoms, the C-6,7 atoms, and C-10,11 atoms. Obviously, isomerism at the C-10,11 carbon atoms occurs only when R³ and R⁴ are different alkyl groups.

Thus, the isomers are the cis and trans of the monoene series and the cis,cis; cis,trans; trans,cis; and trans,trans of the diene series; each of which isomers in each series being included within the scope of this invention. Preferably, the isomerism relative to the double bond between C-2 and C-3 is trans. Each of these isomers are separable from the reaction mixture by which they are prepared by virtue of their different physical properties via conventional techniques, such as chromatography, including thin-layer and gas-liquid chromatography, and fractional distillation.

The following examples will serve to further typify the nature of this invention. In some instances, the various isomeric forms are specified; however, in any of the reaction steps, the carbon-carbon double bonds can be cis or trans independent of the other or, isomeric mixtures can be employed.

EXAMPLE 1

Part A

To a solution of 20.9 g. of the ethylene ketal of 1-bromo-4-pentanone (obtained by treating 1-bromo-4-pentanone with ethylene glycol in benzene in the presence of p-toluene-sulfonic acid) in 100 ml. of benzene is added 20 g. of triphenylphosphine. This mixture is heated at reflux temperature for 2 hours and then filtered. The solid material thus collected is washed with benzene, dried in vacuo, and added to 6.49 g. of butyl lithium in 50 ml. of dimethylsulfoxide. This mixture is stirred until an orange solution is obtained and 3.8 g. of methyl ethyl ketone is then added. This mixture is stirred at about 25° C for about 8 hours, poured into water, and this mixture is extracted with ether. The ethereal extracts are concentrated and the residue thus obtained is added to a 0.1 N solution of hydrochloric acid in aqueous acetone and stirred for about 15 hours. The mixture is then poured into ice water and extracted with ethyl acetate. After washing these extracts with water and drying them over sodium sulfate, they are evaporated to yield a mixture of the cis and trans isomer of 6-methyl-5-octen-2-one which is separated by preparative gas-liquid chromatography into the individual isomers.

Part B

To a solution of 20.9 g. of the ethylene ketal of 1-bromo-4-pentanone in 100 ml. of benzene is added 20 g. of triphenylphosphine. This mixture is heated at reflux temperature for 2 hours and then filtered. The solid material thus collected is washed with benzene, dried in vacuo, and added to 6.49 g. of butyl lithium in 50 ml. of dimethylsulfoxide. This mixture is stirred until an orange solution is obtained and 5.5 g. of trans 6-methyl-5-octen-2-one (the ketone obtained in Part A) is then added. This mixture is stirred at about 25° C for about 8 hours, poured into water, and this mixture is extracted with ether. The ethereal extracts are concentrated and the residue thus obtained is added to a 0.1 N solution of hydrochloric acid in aqueous acetone and stirred for about 15 hours. The mixture is then poured into ice water and extracted with ethyl acetate. After washing these extracts with water and drying them over sodium sulfate, they are evaporated to furnish a mixture of the trans, trans and cis, trans isomers of 6,10-dimethyldodeca-5,9-dien-2-one which is separated by preparative gas-liquid chromatography to the individual isomers.

By repeating the above procedure with the exception of using cis 6-methyl-5-octen-2-one in place of trans 6-methyl-5-octen-2-one, there is obtained a mixture of the cis, cis and trans, cis isomers of 6,10-dimethyldodeca-5,9-dien-2-one which is separated as described above.

Similarly, in the above procedure, instead of using either the trans or cis isomers of 6-methyl-5-octen-2-one as the starting material, there can be used a mixture of the isomers obtained

in Part A in which case a mixture of the four isomers is obtained which can then be separated by preparative gas-liquid chromatography into the four isomers.

Part C

A mixture of 11.2 g. of diethyl carbomethoxy methylphosphonate in 100 ml. of diglyme is treated with 2.4 g. of sodium hydride. This mixture is stirred until the evolution of gas ceases and 7.5 g. of trans, trans 6,10-dimethyldeca-5,9-dien-2-one is then slowly added with stirring, maintaining a temperature below 30° C. The mixture is stirred for about 15 minutes and then diluted with water and extracted with ether. These ethereal extracts are washed well with water, dried over sodium sulfate and evaporated to remove the solvent to furnish a mixture of the trans,trans,trans and cis,trans,trans isomers of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate which is separated by preparative gas-liquid chromatography.

The above procedure is repeated with the exception of using cis,trans 6,10-dimethyldeca-5,9-dien-2-one as the starting material in place of the trans,trans isomer and there is obtained a mixture of the cis,cis,trans and trans,cis,trans isomers of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate.

Similarly, in the above procedure, in place of using either the trans,trans or cis,trans isomer of 6,10-dimethyldeca-5,9-dien-2-one as the starting material, there can be used as the starting material a mixture of isomers obtained in Part B and thereafter separating the individual isomers by preparative gas-liquid chromatography.

In the examples which follow, in some instances the isomeric forms are not specified; however, in each of the procedures set forth in the following examples, reference to the compound or compounds named is inclusive of each isomer or isomeric mixtures thereof. In other words, the following examples are illustrative of procedures which are applicable to compounds embracing individual isomers or isomeric mixtures of the type set forth hereinabove.

EXAMPLE 2

By repeating the process of Example 1 with the exceptions that in Part A thereof, methyl ethyl ketone is replaced with the ketones listed in column I and the ketone thus obtained is used in place of 6-methyl-5-octen-2-one in Part B, there is obtained the acid esters listed in column II.

I	II
acetone	methyl 3,7,11-trimethyldodeca-2,6,10-trienoate
methyl n-propyl ketone	methyl 3,7,11-trimethyltrideca-2,6,10-trienoate
diethyl ketone	methyl 3,7-dimethyl-11-ethyltrideca-2,6,10-trienoate
methyl i-propyl ketone	methyl 3,7,11,12-tetramethyltrideca-2,6,10-trienoate
methyl n-butyl ketone	methyl 3,7,11-trimethylpentadeca-2,6,10-trienoate
ethyl n-propyl ketone	methyl 3,7-dimethyl-11-ethyltetradeca-2,6,10-trienoate
methyl t-butyl ketone	methyl 3,7,11,12,12-pentamethyltrideca-2,6,10-trienoate
methyl i-butyl ketone	methyl 3,7,11,13-tetramethyltetradeca-2,6,10-trienoate
methyl s-butyl ketone	methyl 3,7,11,12-tetramethyltetradeca-2,6,10-trienoate
ethyl i-propyl ketone	methyl 3,7,12-trimethyl-11-ethyltrideca-2,6,10-trienoate
methyl n-amyl ketone	methyl 3,7,11-trimethylhexadeca-2,6,10-trienoate
ethyl n-butyl ketone	methyl 3,7-dimethyl-11-ethylpentadeca-2,6,10-trienoate
3-ethyl-2-pentanone	methyl 3,7,11-trimethyl-12-ethyltetradeca-2,6,10-trienoate
diisopropyl ketone	methyl 3,7,12-trimethyl-11-(i-propyl)-trideca-2,6,10-trienoate
methyl n-hexyl ketone	methyl 3,7,11-trimethylheptadeca-2,6,10-trienoate
5-ethyl-3-heptanone	methyl 3,7-dimethyl-11,13-diethyltetradeca-2,6,10-trienoate

4-decanone

di-n-amyl ketone

5

di-n-hexyl ketone

methyl 3,7-dimethyl-11-(n-propyl)-heptadeca-2,6,10-trienoate
methyl 3,7-dimethyl-11-(n-amyl)-hexadeca-2,6,10-trienoate
methyl 3,7-dimethyl-11-(n-hexyl)-heptadeca-2,6,10-trienoate

EXAMPLE 3

The process of Example 1 is repeated with the exception that in Part A thereof, 1-bromo-4-pentanone is replaced with the 1-bromo-4-ketones listed in Column III to furnish the acid esters listed in Column IV.

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III
1-bromo-4-hexanone
1-bromo-4-heptanone

1-bromo-4-octanone

1-bromo-4-nonanone

1-bromo-5-methyl 4-hexanone

1-bromo-6-methyl 4-heptanone

1-bromo-5,5-dimethyl 4-hexanone

IV
methyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate
methyl 3,11-dimethyl-7-(n-propyl)-trideca-2,6,10-trienoate
methyl 3,11-dimethyl-7-(n-butyl)-trideca-2,6,10-trienoate
methyl 3,11-dimethyl-7-(n-amyl)-trideca-2,6,10-trienoate
methyl 3,11-dimethyl-7-(i-propyl)-trideca-2,6,10-trienoate
methyl 3,11-dimethyl-7-(i-butyl)-trideca-2,6,10-trienoate
methyl 3,11-dimethyl-7-(t-butyl)-trideca-2,6,10-trienoate

Similarly, by repeating the procedure of Example 2 using the 1-bromo-4-ketones listed in Column III in place of 1-bromo-4-pentanone, there is obtained

methyl 3,11-dimethyl-7-ethyldodeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(n-propyl)-dodeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(n-butyl)-dodeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(n-amyl)-dodeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(i-propyl)-dodeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(i-butyl)-dodeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(t-butyl)-dodeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-ethyltetradeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(n-propyl)-tetradeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(n-butyl)-tetradeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(n-amyl)-tetradeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(i-propyl)-tetradeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(i-butyl)-tetradeca-2,6,10-trienoate,
methyl 3,11-dimethyl-7-(t-butyl)-tetradeca-2,6,10-trienoate,
methyl 3-methyl-7,11-diethyltrideca-2,6,10-trienoate,
methyl 3-methyl-7-(n-propyl)-11-ethyltrideca-2,6,10-trienoate,
methyl 3-methyl-7-(n-butyl)-11-ethyltrideca-2,6,10-trienoate,
methyl 3-methyl-7-(n-amyl)-11-ethyltrideca-2,6,10-trienoate,
methyl 3-methyl-7-(i-propyl)-11-ethyltrideca-2,6,10-trienoate,
methyl 3-methyl-7-(i-butyl)-11-ethyltrideca-2,6,10-trienoate,
methyl 3-methyl-7-(t-butyl)-11-ethyltrideca-2,6,10-trienoate,
methyl 7-ethyl-3,11,12-trimethyltrideca-2,6,10-trienoate,
methyl 7-(n-propyl)-3,11,12-trimethyltrideca-2,6,10-trienoate,
methyl 7-(n-butyl)-3,11,12-trimethyltrideca-2,6,10-trienoate,

methyl 7-(n-amyl)-3,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 7-(i-propyl)-3,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 7-(t-butyl)-3,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 7-ethyl-3,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 7-(n-butyl)-3,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 7-(n-amyl)-3,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 7-(i-propyl)-3,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 7-(t-butyl)-3,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 3-methyl-7,11-diethyltetradeca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 7-(n-butyl)-3-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 7-(n-amyl)-3-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 7-(i-propyl)-3-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 7-(t-butyl)-3-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 7-ethyl-3,11,12,12-tetramethyltrideca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3,11,12,12-tetramethyltrideca-2,6,10-trienoate,
 methyl 7-(n-butyl)-3,11,12,12-tetramethyltrideca-2,6,10-trienoate,
 methyl 7-(n-amyl)-3,11,12,12-tetramethyltrideca-2,6,10-trienoate,
 methyl 7-(i-propyl)-3,11,12,12-tetramethyltrideca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3,11,12,12-tetramethyltrideca-2,6,10-trienoate, and
 methyl 7-(t-butyl)-3,11,12,12-tetramethyltrideca-2,6,10-trienoate, respectively.

EXAMPLE 4

The process of Example 1 is repeated with the exception that in Part B, 1-bromo-4-pentanone is replaced with the 1-bromo-4-ketones listed in Column III above furnishing the following acid esters:

methyl 7,11-dimethyl-3-ethyltrideca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(n-propyl)-trideca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(n-butyl)-trideca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(n-amyl)-trideca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(i-propyl)-trideca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(i-butyl)-trideca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(t-butyl)-trideca-2,6,10-trienoate.
 Similarly, by repeating the procedure of Example 2 with the exception that the 1-bromo-4-ketones listed in Column III are used in place of 1-bromo-4-pentanone in Part B of Example 1, there is obtained
 methyl 7,11-dimethyl-3-ethyldodeca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(n-propyl)-dodeca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(n-butyl)-dodeca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(n-amyl)-dodeca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(i-propyl)-dodeca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-(i-butyl)-dodeca-2,6,10-trienoate,

methyl 7,11-dimethyl-3-(t-butyl)-dodeca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-ethyltetradeca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7,11-dimethyltetradeca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7,11-dimethyltetradeca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7,11-dimethyltetradeca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7,11-dimethyltetradeca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7,11-dimethyltetradeca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7,11-dimethyltetradeca-2,6,10-trienoate,
 methyl 3,11-diethyl-7-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7-methyl-11-ethyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-methyl-11-ethyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7-methyl-11-ethyltrideca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-methyl-11-ethyltrideca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-methyl-11-ethyltrideca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-methyl-11-ethyltrideca-2,6,10-trienoate,
 methyl 3-ethyl-7,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7,11,12-trimethyltrideca-2,6,10-trienoate,
 methyl 7,11-dimethyl-3-ethylpentadeca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7,11-dimethylpentadeca-2,6,10-trienoate,
 methyl 3,11-diethyl-7-methyltetradeca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-methyl-11-ethyltetradeca-2,6,10-trienoate,
 methyl 3-ethyl-7,11,12,12-tetramethyltrideca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7,11,12,12-tetramethyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7,11,12,12-tetramethyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7,11,12,12-tetramethyltrideca-2,6,10-trienoate,

methyl 3-(n-propyl)-7-methyl-11-(n-amyl)-hexadeca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-methyl-11-(n-amyl)-hexadeca-2,6,10-trienoate,
 methyl 3,11-[di(n-amyl)]-7-methylhexadeca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-methyl-11-(n-amyl)-hexadeca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-methyl-11-(n-amyl)-hexadeca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-methyl-11-(n-amyl)-hexadeca-2,6,10-trienoate,
 methyl 3-ethyl-7-methyl-11-(n-hexyl)-heptadeca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7-methyl-11-(n-hexyl)-heptadeca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-methyl-11-(n-hexyl)-heptadeca-2,6,10-trienoate,
 methyl 3-(n-amyl)-8-methyl-11-(n-hexyl)-heptadeca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-methyl-11-(n-hexyl)-heptadeca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-methyl-11-(n-hexyl)-heptadeca-2,6,10-trienoate, and
 methyl 3-(t-butyl)-7-methyl-11-(n-hexyl)-heptadeca-2,6,10-trienoate, respectively.

Likewise, by repeating the procedure of Example 3 with the exception that the 1-bromo-4-ketones listed in Column III are used in place of 1-bromo-4-pentanone in Part B of Example 1, there is obtained

methyl 3,7-diethyl-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7-ethyl-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-ethyl-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7-ethyl-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-ethyl-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-ethyl-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-ethyl-11-methyltrideca-2,6,10-trienoate,
 methyl 3-ethyl-7-(n-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3,7-[di(n-propyl)]-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-(n-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7-(n-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-(n-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-(n-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-(n-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-ethyl-7-(n-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7-(n-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3,7-[di(n-butyl)]-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7-(n-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-(n-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-(n-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-(n-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-ethyl-7-(n-amyl)-11-methyltrideca-2,6,10-trienoate,

methyl 3-(n-propyl)-7-(n-amyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-(n-amyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3,7-[di(n-amyl)]-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-(n-amyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-(n-amyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-(n-amyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-ethyl-7-(i-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7-(i-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-(i-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7-(i-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3,7-[di(i-propyl)]-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-(i-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-(i-propyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-ethyl-7-(i-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7-(i-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-(i-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7-(i-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-(i-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3,7-[di(i-butyl)]-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(t-butyl)-7-(i-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-ethyl-7-(t-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-propyl)-7-(t-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-butyl)-7-(t-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(n-amyl)-7-(t-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-propyl)-7-(t-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3-(i-butyl)-7-(t-butyl)-11-methyltrideca-2,6,10-trienoate,
 methyl 3,7-[di(t-butyl)]-11-methyltrideca-2,6,10-trienoate, respectively, and similarly,
 methyl 3,7-diethyl-11-methyldodeca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3-ethyl-11-methyldodeca-2,6,10-trienoate,
 methyl 7-(n-butyl)-3-ethyl-11-methyldodeca-2,6,10-trienoate,
 methyl 7-(n-amyl)-3-ethyl-11-methyldodeca-2,6,10-trienoate,
 methyl 7-(i-propyl)-3-ethyl-11-methyldodeca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3-ethyl-11-methyldodeca-2,6,10-trienoate,
 methyl 7-(t-butyl)-3-ethyl-11-methyldodeca-2,6,10-trienoate,
 methyl 3,7-diethyl-11-methyltetradeca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3-ethyl-11-methyltetradeca-2,6,10-trienoate,
 methyl 7-(n-butyl)-3-ethyl-11-methyltetradeca-2,6,10-trienoate,
 methyl 7-(n-amyl)-3-ethyl-11-methyltetradeca-2,6,10-trienoate,

methyl 7-(i-propyl)-3-ethyl-11-methyltetradeca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3-ethyl-11-methyltetradeca-2,6,10-trienoate,
 methyl 7-(t-butyl)-3-ethyl-11-methyltetradeca-2,6,10-trienoate,
 methyl 3,7,11-triethyltrideca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3,11-diethyltrideca-2,6,10-trienoate,
 methyl 7-(n-butyl)-3,11-diethyltrideca-2,6,10-trienoate,
 methyl 7-(n-amyl)-3,11-diethyltrideca-2,6,10-trienoate,
 methyl 7-(i-propyl)-3,11-diethyltrideca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3,11-diethyltrideca-2,6,10-trienoate,
 methyl 7-(t-butyl)-3,11-diethyltrideca-2,6,10-trienoate,
 methyl 3,7-diethyl-11-methylpentadeca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3-ethyl-11-methylpentadeca-2,6,10-trienoate,
 methyl 7-(n-butyl)-3-ethyl-11-methylpentadeca-2,6,10-trienoate,
 methyl 7-(n-amyl)-3-ethyl-11-methylpentadeca-2,6,10-trienoate,
 methyl 7-(i-propyl)-3-ethyl-11-methylpentadeca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3-ethyl-11-methylpentadeca-2,6,10-trienoate,
 methyl 7-(t-butyl)-3-ethyl-11-methylpentadeca-2,6,10-trienoate,
 methyl 3,7,11-triethyltetradeca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3,11-diethyltetradeca-2,6,10-trienoate,
 methyl 7-(n-butyl)-3,11-diethyltetradeca-2,6,10-trienoate,
 methyl 7-(n-amyl)-3,11-diethyltetradeca-2,6,10-trienoate,
 methyl 7-(i-propyl)-3,11-diethyltetradeca-2,6,10-trienoate,
 methyl 7-(i-butyl)-3,11-diethyltetradeca-2,6,10-trienoate,
 methyl 7-(t-butyl)-3,11-diethyltetradeca-2,6,10-trienoate,
 methyl 3,7-diethyl-11,12,12-trimethyltrideca-2,6,10-trienoate,
 methyl 7-(n-propyl)-3-ethyl-11,12,12-trimethyltrideca-2,6,10-trienoate, and the like.

EXAMPLE 5

The procedure of Example 1 is repeated with the exception that in Part C, diethyl carbomethoxy methyl phosphonate is replaced with other dialkyl carboalkoxy methyl phosphonates, e.g. diethyl carbethoxy methyl phosphonate, diethyl n-propoxycarbonyl methyl phosphonate, dimethyl n-butoxycarbonyl methyl phosphonate, and the like, to furnish the corresponding alkyl 3,7,11-trimethyltrideca-2,6,10-trienoate, e.g. ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate, n-propyl 3,7,11-trimethyltrideca-2,6,10-trienoate, n-butyl 3,7,11-trimethyltrideca-1,6,10-trienoate, and the like.

Similarly, by repeating the procedure of Examples 2, 3 and 4 with the exception that diethyl carbomethoxy methyl phosphonate is replaced with diethyl carbethoxy methyl phosphonate, diethyl n-propoxycarbonyl methyl phosphonate and dimethyl n-butoxycarbonyl methyl phosphonate, the corresponding ethyl 2,6,10-trienoates, n-propyl 2,6,10-trienoates and n-butyl 2,6,10-trienoates are obtained. For example,

ethyl 3,7,11-trimethyldodeca-2,6,10-trienoate,
 n-propyl 3,7,11-trimethyldodeca-2,6,10-trienoate,
 n-butyl 3,7,11-trimethyldodeca-2,6,10-trienoate,
 ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate,
 n-propyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, n-butyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate,
 ethyl 3,11-dimethyl-7-ethyldodeca-2,6,10-trienoate,
 n-propyl 3,11-dimethyl-7-ethyldodeca-2,6,10-trienoate, n-butyl 3,11-dimethyl-7-ethyldodeca-2,6,10-trienoate,
 ethyl 3-ethyl-7,11-dimethyltrideca-2,6,10-trienoate,
 n-propyl 3-ethyl-7,11-dimethyltrideca-2,6,10-trienoate, n-butyl 3-ethyl-7,11-dimethyltrideca-2,6,10-trienoate,
 ethyl 3-ethyl-7,11-dimethyltrideca-2,6,10-trienoate,
 n-propyl 3-ethyl-7,11-dimethyltrideca-2,6,10-trienoate, n-butyl 3-ethyl-7,11-dimethyltrideca-2,6,10-trienoate,
 ethyl 3,7-diethyl-11-methyltrideca-2,6,10-trienoate,

n-propyl 3,7-diethyl-11-methyltrideca-2,6,10-trienoate, n-butyl 3,7-diethyl-11-methyltrideca-2,6,10-trienoate, and the like.

EXAMPLE 6

A mixture of 1 g. of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate, 60 ml. of methanol, 0.1 g. of sodium carbonate, and 6 ml. of water is heated as reflux for 2 hours. The mixture is then cooled, diluted with water and extracted with ether. The ethereal extracts are washed with water, dried over sodium sulfate and evaporated to remove the solvent. The residue is subjected to fractional vacuum distillation to yield 3,7,11-trimethyltrideca-2,6,10-trienoic acid.

By repeating the procedure of this example with the exception of substituting the other acid esters, preferably the methyl esters or ethyl esters obtained by the above procedures (Examples 2, 3, 4 and 5) for methyl 3,7,11-trimethyltrideca-2,6,10-trienoate, there is obtained the corresponding free acids, e.g. 3,7,11-trimethyldodeca-2,6,10-trienoic acid, 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoic acid, 3,7-diethyl-11-methyltrideca-2,6,10-trienoic acid, 3,11-dimethyl-7-ethyldodeca-2,6,10-trienoic acid, 7,11-dimethyl-3-ethyltrideca-2,6,10-trienoic acid, 7,11-dimethyl-3-ethyldodeca-2,6,10-trienoic acid, and the like.

EXAMPLE 7

A suspension of 0.5 g. of 5 percent palladium-on-carbon catalyst in 50 ml. of benzene is hydrogenated for 30 minutes. A solution of 2 g. of 6,10-dimethyldodeca-5,9-dien-2-one in 100 ml. of benzene is added and hydrogenated with agitation until the theoretical amount of hydrogen has been absorbed. The catalyst is thereafter removed by filtration and the solution is evaporated to yield 6,10-dimethyldodec-5-en-2-one, 6,10-dimethyldodec-9-en-2-one and 6,10-dimethyldodecan-2-one which are separated and purified by preparative gas-liquid chromatography.

EXAMPLE 8

By repeating the procedure of Part A of Example 1 using, for example, the ketones listed in Column V in lieu of methyl ethyl ketone and using the ketone thus obtained for the procedure of Part B of Example 1, there are obtained the respective products listed in Column VI which are hydrogenated using the procedure of Example 7 to afford 6,10-dimethylundec-5-en-2-one, 6,10-dimethylundec-9-en-2-one, and 6,10-dimethylundecan-2-one; 6-methyl-10-ethyldodec-5-en-2-one, 6-methyl-10-ethyldodec-9-en-2-one, and 6-methyl-10-ethyldodecan-2-one; 6,10,11-trimethyldodec-5-en-2-one, 6,10,11-trimethyldodec-9-en-2-one, and 6,10,11-trimethyldodecan-2-one; 6-methyl-10-ethyltridec-5-en-2-one, 6-methyl-10-ethyltridec-9-en-2-one, and 6-methyl-10-ethyltridecan-2-one; and 6,10,11,11-tetramethyldodec-5-en-2-one, 6,10,11,11-tetramethyldodec-9-en-2-one, and 6,10,11,11-tetramethyldodecan-2-one, respectively.

V	VI
acetone	6,10-dimethylundeca-5,9-dien-2-one
diethyl ketone	6-methyl-10-ethyldodeca-5,9-dien-2-one
methyl i-propyl ketone	6,10,11-trimethyldodeca-5,9-dien-2-one
ethyl n-propyl ketone	6-methyl-10-ethyltrideca-5,9-dien-2-one
methyl t-butyl ketone	6,10,11,11-tetramethyldodeca-5,9-dien-2-one

By repeating the procedure of Part C of Example 1 using diethyl carbethoxymethyl phosphonate in place of diethyl carbomethoxymethyl phosphonate and using the mono-unsaturated and saturated 2-ketones prepared in this example in place of 6,10-dimethyldodeca-5,9-dien-2-one, the following ethyl esters are obtained:

ethyl 3,7,11-trimethyldodeca-2,6-dienoate,
 ethyl 3,7,11-trimethyldodeca-2,10-dienoate,
 ethyl 3,7,11-trimethyldodec-2-enoate,

ethyl 3,7-dimethyl-11-ethyltrideca-2,6-dienoate,
ethyl 3,7-dimethyl-11-ethyltrideca-2,10-dienoate,
ethyl 3,7-dimethyl-11-ethyltridec-2-enoate,
ethyl 3,7,11,12-tetramethyltrideca-2,6-dienoate,
ethyl 3,7,11,12-tetramethyltrideca-2,10-dienoate,
ethyl 3,7,11,12-tetramethyltridec-2-enoate,
ethyl 3,7-dimethyl-11-ethyltetradeca-2,6-dienoate,
ethyl 3,7-dimethyl-11-ethyltetradec-2-enoate,
ethyl 3,7,11,12,12-pentamethyltrideca-2,6-dienoate,
ethyl 3,7,11,12,12-pentamethyltrideca-2,10-dienoate, and
ethyl 3,7,11,12,12-pentamethyltridec-2-enoate, respective-
ly.

EXAMPLE 9

By repeating the procedure of Part A of Example 1 using the 1-bromo-4-alkanones listed in Column VII in place of 1-bromo-4-pentanone, the corresponding ketones listed in Column VIII are obtained which are used in Part B of Example 1 to afford the diunsaturated ketones listed in Column IX. The diunsaturated ketones are hydrogenated using the procedure of Example 7 to yield 6-ethyl-10-methyldodec-5-en-2-one, 6-ethyl-10-methyldodec-9-en-2-one, and 6-ethyl-10-methyldodecan-2-one; 6-(n-propyl)-10-methyldodec-5-en-2-one, 6-(n-propyl)-10-methyldodec-9-en-2-one, and 6-(n-propyl)-10-methyldodecan-2-one; 6-(i-propyl)-10-methyldodec-5-en-2-one, 6-(i-propyl)-10-methyldodec-9-en-2-one, and 6-(i-propyl)-10-methyldodecan-2-one; and 6-(t-butyl)-10-methyldodec-5-en-2-one, 6-(t-butyl)-10-methyldodec-9-en-2-one, and 6-(t-butyl)-10-methyldodecan-2-one, respectively.

VII	VIII	IX
1-bromo-4-hexanone	7-methylnon-6-en-3-one	6-ethyl-10-methyldodeca-5,9-dien-2-one
1-bromo-4-heptanone	8-methyldec-7-en-4-one	6-(n-propyl)-10-methyldodeca-5,9-dien-2-one
1-bromo-5-methyl-4-hexanone	2,7-dimethylnon-6-en-3-one	6-(i-propyl)-10-methyldodeca-5,9-dien-2-one
1-bromo-5,5-dimethyl-4-hexanone	2,2,7-trimethylnon-6-en-3-one	6-(t-butyl)-10-methyldodeca-5,9-dien-2-one

By repeating the procedure of Part C of Example 1 using diethyl carbethoxymethyl phosphonate in place of diethyl carbomethoxymethyl phosphonate and using the mono-unsaturated and saturated 2-ketones prepared in this example in place of 6,10-dimethyldodeca-5,9-dien-2-one, the following ethyl esters are obtained:

ethyl 3,11-dimethyl-7-ethyltrideca-2,6-dienoate,
ethyl 3,11-dimethyl-7-ethyltrideca-2,10-dienoate,
ethyl 3,11-dimethyl-7-ethyltridec-2-enoate,
ethyl 3,11-dimethyl-7-(n-propyl)-trideca-2,6-dienoate,
ethyl 3,11-dimethyl-7-(n-propyl)-trideca-2,10-dienoate,
ethyl 3,11-dimethyl-7-(n-propyl)-tridec-2-enoate,
ethyl 3,11-dimethyl-7-(i-propyl)-trideca-2,6-dienoate,
ethyl 3,11-dimethyl-7-(i-propyl)-trideca-2,10-dienoate,
ethyl 3,11-dimethyl-7-(i-propyl)-tridec-2-enoate,
ethyl 3,11-dimethyl-7-(t-butyl)-trideca-2,6-dienoate,
ethyl 3,11-dimethyl-7-(t-butyl)-trideca-2,10-dienoate, and
ethyl 3,11-dimethyl-7-(t-butyl)-tridec-2-enoate, respective-
ly.

EXAMPLE 10

By using the ketones listed in Column VIII in place of 6-methyl-5-octen-2-one and the ethylene ketal of the 1-bromo-4-alkanones listed in Column VII in place of the ethylene ketal of 1-bromo-4-pentanone in Part B of Example 1, there is obtained

7-ethyl-11-methyltrideca-6,10-dien-3-one,
8-(n-propyl)-12-methyltetradeca-7,11-dien-4-one,
2,11-dimethyl-7-(i-propyl)-trideca-6,10-dien-3-one,
and

2,2,11-trimethyl-7-(t-butyl)-trideca-6,10-dien-3-one, respectively, which are hydrogenated using the procedure of Example 7 to yield

7-ethyl-11-methyltridec-6-en-3-one,
7-ethyl-11-methyltridec-10-en-3-one, and
7-ethyl-11-methyltridecan-3-one;
8-(n-propyl)-12-methyltetradec-7-en-4-one,
8-(n-propyl)-12-methyltetradec-11-en-4-one, and
8-(n-propyl)-12-methyltetradecan-4-one;
2,11-dimethyl-7-(i-propyl)-tridec-6-en-3-one,
2,11-dimethyl-7-(i-propyl)-tridec-10-en-3-one, and
2,11-dimethyl-7-(i-propyl)-tridecan-3-one; and
2,2,11-trimethyl-7-(t-butyl)-tridec-6-en-3-one,
2,2,11-trimethyl-7-(t-butyl)-tridec-10-en-3-one, and
2,2,11-trimethyl-7-(t-butyl)-tridecan-3-one,
respectively.

The thus-obtained mono-unsaturated ketones and saturated ketones are subjected to the procedure of Part C of Example 1 using diethyl carbethoxymethyl phosphonate to obtain the following ethyl esters:

ethyl 3,7-diethyl-11-methyltrideca-2,6-dienoate,
ethyl 3,7-diethyl-11-methyltrideca-2,10-dienoate,
ethyl 3,7-diethyl-11-methyltridec-2-enoate,
ethyl 3,7-(n-propyl)-11-methyltrideca-2,6-dienoate,
ethyl 3,7-(n-propyl)-11-methyltrideca-2,10-dienoate,
ethyl 3,7-(n-propyl)-11-methyltridec-2-enoate,
ethyl 3,7-di(i-propyl)-11-methyltrideca-2,6-dienoate,
ethyl 3,7-di(i-propyl)-11-methyltrideca-2,10-dienoate,
ethyl 3,7-di(i-propyl)-11-methyltridec-2-enoate,
ethyl 3,7-di(t-butyl)-11-methyltrideca-2,6-dienoate,
ethyl 3,7-di(t-butyl)-11-methyltrideca-2,10-dienoate, and
ethyl 3,7-di(t-butyl)-11-methyltridec-2-enoate, respective-
ly.

EXAMPLE 11

The process of Part A of Example 1 is repeated using acetone in place of methyl ethyl ketone and the ethylene ketal of the 1-bromo-4-alkanones listed in Column VII in place of 1-bromo-4-pentanone to afford the compounds listed in Column X which are used in place of 6-methyl-5-octen-2-one in Part B of Example 1 to afford the compounds listed in Column XI.

X	XI
7-methyloct-6-en-3-one	6-ethyl-10-methylundeca-5,9-dien-2-one
8-methylnon-7-en-4-one	6-(n-propyl)-10-methylundeca-5,9-dien-2-one
2,7-dimethyloct-6-en-3-one	6-(i-propyl)-10-methylundeca-5,9-dien-2-one
2,2,7-trimethyloct-6-en-3-one	6-(t-butyl)-10-methylundeca-5,9-dien-2-one

The compounds listed in Column XI are hydrogenated according to the procedure of Example 7 to yield 6-ethyl-10-methylundec-5-en-2-one, 6-ethyl-10-methylundec-9-en-2-one and 6-ethyl-10-methylundecan-2-one; 6-(n-propyl)-10-methylundec-5-en-2-one, 6-(n-propyl)-10-methylundec-9-en-2-one and 6-(n-propyl)-10-methylundecan-2-one; 6-(i-propyl)-10-methylundec-5-en-2-one, 6-(i-propyl)-10-methylundec-9-en-2-one and 6-(i-propyl)-10-methylundecan-2-one; and 6-(t-butyl)-10-methylundec-5-en-2-one, 6-(t-butyl)-10-methylundec-9-en-2-one and 6-(t-butyl)-10-methylundecan-2-one, respectively.

The thus-obtained mono-unsaturated and saturated ketones are treated with diethyl carbethoxymethylphosphonate using the procedure of Example 1 (Part C) to afford:

ethyl 3,11-dimethyl-7-ethylundeca-2,6-dienoate,
ethyl 3,11-dimethyl-7-ethylundeca-2,10-dienoate,
ethyl 3,11-dimethyl-7-ethylundec-2-enoate,
ethyl 3,11-dimethyl-7-(n-propyl)-undeca-2,6-dienoate,
ethyl 3,11-dimethyl-7-(n-propyl)-undeca-2,10-dienoate,
ethyl 3,11-dimethyl-7-(n-propyl)-undec-2-enoate,
ethyl 3,11-dimethyl-7-(i-propyl)-undeca-2,6-dienoate,
ethyl 3,11-dimethyl-7-(i-propyl)-undeca-2,10-dienoate,
ethyl 3,11-dimethyl-7-(i-propyl)-undec-2-enoate,
ethyl 3,11-dimethyl-7-(t-butyl)-undeca-2,6-dienoate,
ethyl 3,11-dimethyl-7-(t-butyl)-undeca-2,10-dienoate, and
ethyl 3,11-dimethyl-7-(t-butyl)-undec-2-enoate, respective-
ly.

ethyl 3,11-dimethyl-7-(*t*-butyl)-dodeca-2,6-dienoate,
ethyl 3,11-dimethyl-7-(*t*-butyl)-dodeca-2,10-dienoate,
and
ethyl 3,11-dimethyl-7-(*t*-butyl)-dodec-2-enoate, respective-
ly.

EXAMPLE 12

The mono-unsaturated ketones listed in Column X are substituted in place of 6-methyl-5-octen-2-one and the ethylene ketal of the 1-bromo-4-hexanone is used in place of the ethylene ketal of 1-bromo-4-pentanone in the process of Example 1 (Part B) to give 7-ethyl-11-methyldodeca-6,10-dien-3-one, 7-(*n*-propyl)-11-methyldodeca-6,10-dien-3-one, 7-(*i*-propyl)-11-methyldodeca-6,10-dien-3-one and 7-(*t*-butyl)-11-methyldodeca-6,10-dien-3-one, respectively, which are hydrogenated using the procedure of Example 7 to yield 7-ethyl-11-methyldodec-6-en-3-one, 7-ethyl-11-methyldodec-10-en-3-one and 7-ethyl-11-methyldodecan-3-one; 7-(*n*-propyl)-11-methyldodec-6-en-3-one, 7-(*n*-propyl)-11-methyldodec-10-en-3-one and 7-(*n*-propyl)-11-methyldodecan-3-one; 7-(*i*-propyl)-11-methyldodec-6-en-3-one, 7-(*i*-propyl)-11-methyldodec-10-en-3-one and 7-(*i*-propyl)-11-methyldodecan-3-one; and 7-(*t*-butyl)-11-methyldodec-6-en-3-one, 7-(*t*-butyl)-11-methyldodec-10-en-3-one and 7-(*t*-butyl)-11-methyldodecan-3-one, respectively.

The thus-obtained mono-unsaturated and saturated 3-ketones are treated with diethyl carbethoxymethylphosphonate using the procedure of Example 1 (Part C) to give:

ethyl 3,7-diethyl-11-methyldodeca-2,6-dienoate,
ethyl 3,7-diethyl-11-methyldodeca-2,10-dienoate,
ethyl 3,7-diethyl-11-methyldodec-2-enoate,
ethyl 3-ethyl-7-(*n*-propyl)-11-methyldodeca-2,6-dienoate,
ethyl 3-ethyl-7-(*n*-propyl)-11-methyldodeca-2,10-dienoate,
ethyl 3-ethyl-7-(*n*-propyl)-11-methyldodec-2-enoate,
ethyl 3-ethyl-7-(*i*-propyl)-11-methyldodeca-2,6-dienoate,
ethyl 3-ethyl-7-(*i*-propyl)-11-methyldodeca-2,10-dienoate,
ethyl 3-ethyl-7-(*i*-propyl)-11-methyldodec-2-enoate,
ethyl 3-ethyl-7-(*t*-butyl)-11-methyldodeca-2,6-dienoate,
ethyl 3-ethyl-7-(*t*-butyl)-11-methyldodeca-2,10-dienoate,
and
ethyl 3-ethyl-7-(*t*-butyl)-11-methyldodec-2-enoate, respectively.

By repeating the procedure of this example using the ethylene ketal of the other 1-bromo-4-alkanones listed in Column VII in place of the ethylene ketal of 1-bromo-4-hexanone, the corresponding 3-(*n*-propyl)-, 3-(*i*-propyl)-, and 3-(*t*-butyl)-ethyl esters of the 3-ethyl esters enumerated in the preceding paragraph are obtained, for example, ethyl 3-(*n*-propyl)-7-ethyl-11-methyldodeca-2,6-dienoate, ethyl 3-(*n*-propyl)-7-ethyl-11-methyldodeca-2,10-dienoate and ethyl 3-(*n*-propyl)-7-ethyl-11-methyldodec-2-enoate.

EXAMPLE 13

The procedure of Example 1 (Part A) is repeated using diethyl ketone in place of methyl ethyl ketone and 1-bromo-4-hexanone in place of 1-bromo-4-pentanone to give 7-ethyl-non-6-en-3-one. By repeating this procedure using ethyl *i*-propyl ketone, ethyl *n*-propyl ketone, ethyl *t*-butyl ketone, ethyl *n*-butyl ketone, and di-*i*-propyl ketone in place of diethyl ketone, there is obtained 7-(*i*-propyl)-non-6-en-3-one, 7-ethyldec-6-en-3-one, 7-(*t*-butyl)-non-6-en-3-one, 7-ethylundec-6-en-3-one, and 7-(*i*-propyl)-8-methylnon-6-en-3-one, respectively.

The process of Example 1 (Part B) is repeated using the thus-obtained alk-6-en-3-one's in place of 6-methyl-5-octen-2-one and the ethylene ketal of 1-bromohexan-4-one in place of the ethylene ketal of 1-bromopentan-4-one to afford 7,11-diethyltrideca-6,10-dien-3-one, 11-(*i*-propyl)-7-ethyltrideca-6,10-dien-3-one, 7,11-diethyltetradeca-6,10-dien-3-one, 11-(*t*-butyl)-7-ethyltrideca-6,10-dien-3-one, 7,11-diethylpentadeca-6,10-dien-3-one and 7-ethyl-11-(*i*-propyl)-12-methyltrideca-6,10-dien-3-one, respectively, which are

hydrogenated using the procedure of Example 7 to yield 7,11-diethyltridec-6-en-3-one, 7,11-diethyltridec-10-en-3-one and 7,11-diethyltridecan-3-one; 11-(*i*-propyl)-7-ethyltridec-6-en-3-one, 11-(*i*-propyl)-7-ethyltridec-10-en-3-one and 11-(*i*-propyl)-7-ethyltridecan-3-one; 7,11-diethyltetradec-6-en-3-one, 7,11-diethyltetradec-10-en-3-one and 7,11-diethyltetradecan-3-one; 11-(*t*-butyl)-7-ethyltridec-6-en-3-one, 11-(*t*-butyl)-7-ethyltridec-10-en-3-one and 11-(*t*-butyl)-7-ethyltridecan-3-one; 7,11-diethylpentadec-6-en-3-one, 7,11-diethylpentadec-10-en-3-one and 7,11-diethylpentadecan-3-one; and 7-ethyl-11-(*i*-propyl)-12-methyltridec-6-en-3-one, 7-ethyl-11-(*i*-propyl)-12-methyltridec-10-en-3-one and 7-ethyl-11-(*i*-propyl)-12-methyltridecan-3-one, respectively, each of which are treated with diethyl carbethoxymethylphosphonate using the procedure of Example 1 (Part C) to afford:

ethyl 3,7,11-triethyltrideca-2,6-dienoate,
ethyl 3,7,11-triethyltrideca-2,10-dienoate,
ethyl 3,7,11-triethyltridec-2-enoate,
ethyl 3,7,11-triethyl-12-methyltrideca-2,6-dienoate,
ethyl 3,7,11-triethyl-12-methyltrideca-2,10-dienoate,
ethyl 3,7,11-triethyl-12-methyltridec-2-enoate,
ethyl 3,7,11-triethyltetradeca-2,6-dienoate,
ethyl 3,7,11-triethyltetradeca-2,10-dienoate,
ethyl 3,7,11-triethyltetradec-2-enoate,
ethyl 3,7,11-triethyl-12,12-dimethyltrideca-2,6-dienoate,
ethyl 3,7,11-triethyl-12,12-dimethyltrideca-2,10-dienoate,
ethyl 3,7,11-triethyl-12,12-dimethyltridec-2-enoate,
ethyl 3,7,11-triethylpentadeca-2,6-dienoate,
ethyl 3,7,11-triethylpentadeca-2,10-dienoate,
ethyl 3,7,11-triethylpentadec-2-enoate,
ethyl 3,7-diethyl-11-(*i*-propyl)-12-methyltrideca-2,6-dienoate,
ethyl 3,7-diethyl-11-(*i*-propyl)-12-methyltrideca-2,10-dienoate, and
ethyl 3,7-diethyl-11-(*i*-propyl)-12-methyltridec-2-enoate, respectively.

EXAMPLE 14

Each of 6,10-dimethyldodec-5-en-2-one, 6,10-dimethyldodec-9-en-2-one and 6,10-dimethyldodecan-2-one is treated with diethyl carbethoxymethylphosphonate using the procedure of Example 1 (Part C) to yield ethyl 3,7,11-trimethyltrideca-2,6-dienoate, ethyl 3,7,11-trimethyltrideca-2,10-dienoate and ethyl 3,7,11-trimethyltridec-2-enoate, respectively.

EXAMPLE 15

A solution of 20.9 g. of the ethylene ketal of methyl 3-bromopropyl ketone (obtained by treating the ketone with ethylene glycol in benzene in the presence of *p*-toluenesulfonic acid) in 100 ml. of benzene is treated with 20 g. of triphenylphosphine. This mixture is heated at reflux temperatures for 2 hours and then filtered. The solid material thus collected is washed with benzene, dried in vacuo and added to 6.49 g. of butyl lithium in 50 ml. of dimethylsulfoxide. This mixture is stirred until a red solution is obtained and 7.2 g. of 6-hydroxy-6-methylheptan-2-one are then added. This mixture is stirred at about 25° C for 8 hours, poured into water, and this mixture is extracted with ether. The ethereal extracts are concentrated and the residue thus obtained is added to a 0.1 N solution of hydrochloric acid in aqueous acetone and stirred for 15 hours. The mixture is then poured into ice water and extracted with ethyl acetate. After washing these extracts with water and drying them over sodium sulfate, they are evaporated to yield a mixture of *cis* and *trans* 10-hydroxy-10-methylundec-5-en-2-one which may be separated by fractional vacuum distillation or by preparative gas-liquid chromatography.

A mixture of 11.2 g. of diethyl carbethoxymethylphosphonate in 100 ml. of diglyme is treated with 2.4 g. of sodium hydride. This mixture is stirred until the evolution

of gas ceases and 7.5 g. of trans 10-hydroxy-10-methylundec-5-en-2-one are then slowly added with stirring, maintaining a temperature below 30° C. The mixture is stirred for 15 minutes and then diluted with water and extracted with ether. These ethereal extracts are washed well with water, dried over sodium sulfate and evaporated to remove the solvent. The residue is subjected to fractional vacuum distillation to yield cis, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate and trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate.

By employing the cis isomer of 10-hydroxy-10-methylundec-5-en-2-one in the foregoing procedure, there is obtained cis, cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate and trans, cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate.

EXAMPLE 16

A solution of 20.9 g. of the ethylene ketal of methyl 3-bromopropyl ketone (obtained by treating the ketone with ethylene glycol in benzene in the presence of p-toluenesulfonic acid) in 100 ml. of benzene is treated with 20 g. of triphenylphosphine. This mixture is heated at reflux temperatures for 2 hours and then filtered. The solid material thus collected is washed with benzene, dried in vacuo, and added to 6.49 g. of butyl lithium in 50 ml. of dimethylsulfoxide. This mixture is stirred until a red solution is obtained and 7.2 g. of 6-hydroxy-6-methylheptan-2-one are then added. This mixture is stirred at about 25° C for 8 hours, poured into water, and this mixture is extracted with ether. The ether extracts are combined, washed with water to neutrality, dried over sodium sulfate and reduced to dryness under vacuum. The residue, containing 2-ethylenedioxy-6,10-dimethyl-10-hydroxyundec-2-ene, is added to 100 ml. of dry methanol containing 500 mg. of activated 5percent palladium-on-charcoal catalyst. The mixture is hydrogenated at room temperature until 1.05 equivalents of hydrogen have been taken up; then the mixture is filtered over a bed of Celite diatomaceous earth. The filtrate is added to 250 ml. of benzene, washed with several portions of water, dried over sodium sulfate and evaporated to dryness under vacuum. The residue, containing the desired 2-ethylenedioxy-6,10-dimethylundecan-10-ol, is added to a 0.1 N solution of hydrochloric acid in aqueous acetone and stirred for 15 hours. The mixture is then poured into ice water and extracted with ethyl acetate. After washing these extracts with water and drying them over sodium sulfate, they are evaporated to yield 10-hydroxy-6,10-dimethylundecan-2-one which may be separated by fractional vacuum distillation or by preparative gas-liquid chromatography.

A mixture of 11.2 g. of diethyl carbethoxymethylphosphonate in 100 ml. of diglyme is treated with 2.4 g. of sodium hydride. This mixture is stirred until the evolution of gas ceases and 7.5 g. of 10-hydroxy-6,10-dimethylundecan-2-one are then slowly added with stirring, maintaining a temperature below 30° C. The mixture is stirred for 15 minutes and then diluted with water and extracted with ether. These ethereal extracts are washed well with water, dried over sodium sulfate and evaporated to remove the solvent. The residue is subjected to fractional vacuum distillation to yield cis ethyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate and trans ethyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate.

EXAMPLE 17

To a solution of 28.2 g. of trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate and 250 ml. of dry ethyl acetate, 500 mg. of (4 percent) activated palladium-on-barium sulfate are added. The resulting mixture is hydrogenated at room temperature until 0.11 moles of gaseous hydrogen have been taken up. The mixture is filtered over a bed of diatomaceous earth, and the filtrate is added to 500 ml. of benzene, washed with 4 150 ml. portions of water, dried over sodium sulfate and evaporated to dryness under reduced pressure to predominately yield the desired trans ethyl 3,7,11-

trimethyl-11-hydroxydodec-2-enoate which is purified by preparative scale gas-liquid chromatography.

Similarly, trans ethyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate is prepared from trans, cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate.

EXAMPLE 18

By the procedure described in Example 17 the compounds listed under II are prepared from the respective compounds listed under I.

I	II
cis, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid	cis 3,7,11-trimethyl-11-hydroxydodec-2-enoic acid
cis, cis 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid	cis 3,7,11-trimethyl-11-hydroxydodec-2-enoic acid
trans, cis 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid	trans 3,7,11-trimethyl-11-hydroxydodec-2-enoic acid
trans, trans methyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate	trans methyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate
trans, cis methyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate	trans methyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate
trans, cis propyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate	trans propyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate
cis, cis isopropyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate	cis isopropyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate
cis, trans hexyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate	cis hexyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate
trans, trans 3,7,11-trimethyl-11-acetoxydodeca-2,6-dienoic acid	trans 3,7,11-trimethyl-11-acetoxydodec-2-enoic acid
cis, trans 3,7,11-trimethyl-11-trimethylacetox-2,6-dienoic acid	cis 3,7,11-trimethyl-11-trimethylacetox-2-enoic acid
trans, cis 3,7,11-trimethyl-11-benzoxydodeca-2,6-dienoic acid	trans 3,7,11-trimethyl-11-benzoxydodec-2-enoic acid
trans, trans 3,7,11-trimethyl-11-ethoxydodeca-2,6-dienoic acid	trans 3,7,11-trimethyl-11-ethoxydodec-2-enoic acid
cis, cis 3,7,11-trimethyl-11-butoxydodeca-2,6-dienoic acid	cis 3,7,11-trimethyl-11-butoxydodec-2-enoic acid
cis, trans 3,7,11-trimethyl-11-phenylethoxydodeca-2,6-dienoic acid	cis 3,7,11-trimethyl-11-phenylethoxydodec-2-enoic acid
trans, cis 3,7,11-trimethyl-11-ethoxydodeca-2,6-dienoic acid	trans 3,7,11-trimethyl-11-ethoxydodec-2-enoic acid
trans, trans methyl 3,7,11-trimethyl-11-methoxydodeca-2,6-dienoate	trans methyl 3,7,11-trimethyl-11-methoxydodec-2-enoate
cis, cis ethyl 3,7,11-trimethyl-11-ethoxydodeca-2,6-dienoate	cis ethyl 3,7,11-trimethyl-11-ethoxydodec-2-enoate
cis, trans ethyl 3,7,11-trimethyl-11-ethoxydodeca-2,6-dienoate	cis ethyl 3,7,11-trimethyl-11-ethoxydodec-2-enoate
trans, cis ethyl 3,7,11-trimethyl-11-ethoxydodeca-2,6-dienoate	trans ethyl 3,7,11-trimethyl-11-ethoxydodec-2-enoate
trans, trans ethyl 3,7,11-trimethyl-11-ethoxydodeca-2,6-dienoate	trans ethyl 3,7,11-trimethyl-11-ethoxydodec-2-enoate
trans, trans butyl 3,7,11-trimethyl-11-(tetrahydropyran-2-yloxy)dodeca-2,6-dienoate	trans butyl 3,7,11-trimethyl-11-(tetrahydropyran-2-yloxy)dodec-2-enoate
cis, trans hexyl 3,7,11-trimethyl-11-(tetrahydrofuran-2-yloxy)dodeca-2,6-dienoate	cis hexyl 3,7,11-trimethyl-11-(tetrahydrofuran-2-yloxy)dodec-2-enoate
trans, trans hexyl 3,7,11-trimethyl-11-propoxydodeca-2,6-dienoate	trans hexyl 3,7,11-trimethyl-11-propoxydodec-2-enoate
cis, cis octyl 3,7,11-trimethyl-11-phenylethoxydodeca-2,6-dienoate	cis octyl 3,7,11-trimethyl-11-phenylethoxydodec-2-enoate
trans, trans ethyl 3,7,11-trimethyl-11-acetoxydodeca-2,6-dienoate	trans ethyl 3,7,11-trimethyl-11-acetoxydodec-2-enoate
cis, trans ethyl 3,7,11-trimethyl-11-caproxydodeca-2,6-dienoate	cis ethyl 3,7,11-trimethyl-11-caproxydodec-2-enoate

EXAMPLE 19

To a solution of 20.9 g. of the ethylene ketal of 1-bromohexan-4-one (obtained by treating 1-bromo-4-hexanone with ethylene glycol in benzene in the presence of p-toluenesulfonic acid) in 100 ml. of benzene is added 20 g. of triphenylphosphine. This mixture is heated at reflux temperature for 2 hours and then filtered. The solid material thus collected is washed with benzene, dried in vacuo and added to 6.49 g. of butyl lithium in 50 ml. of dimethylsulfoxide. This mixture is stirred until an orange solution is obtained and 3.8 g. of ethyl methyl ketone is then added. This mixture is stirred at about 25° C for about 8 hours, poured into water and this mixture is extracted with ether. The ethereal extracts are concentrated and the residue thus obtained is added to a 0.1 N solution of hydrochloric acid in aqueous acetone and stirred for about 15 hours. The mixture is then poured into ice water and extracted with ethyl acetate. After washing these extracts with water and drying them over sodium sulfate, they are evaporated to yield a mixture of the cis and trans isomer of 7-methylnon-6-en-3-one which is separated by preparative gas-liquid chromatography into the individual isomers.

To a solution of 20.9 g. of the ethylene ketal of 1-bromopentan-4-one in 100 ml. of benzene is added 20 g. of triphenylphosphine. This mixture is heated at reflux temperature for 2 hours and then filtered. The solid material thus collected is washed with benzene, dried in vacuo and added to 6.49 g. of butyl lithium in 50 ml. of dimethylsulfoxide. This mixture is stirred until an orange solution is obtained and 5.5 g. of cis 7-methylnon-6-en-3-one (the ketone obtained in Paragraph 1) is then added. This mixture is stirred at about 25° C for about 8 hours, poured into water and this mixture is extracted with ether. The ethereal extracts are concentrated and the residue thus obtained is added to a 0.1 N solution of hydrochloric acid in aqueous acetone and stirred for about 15 hours. The mixture is then poured into ice water and extracted with ethyl acetate. After washing these extracts with water and drying them over sodium sulfate, they are evaporated to furnish a mixture of the trans, cis and cis, cis isomers of 6-ethyl-10-methyldodeca-5,9-dien-2-one which is separated by preparative gas-liquid chromatography to the individual isomers.

By repeating the above procedure with the exception of using trans 7-methylnon-6-en-3-one in place of cis 7-methylnon-6-en-3-one, there is obtained a mixture of the cis, trans and trans, trans isomers of 6-ethyl-10-methyldodeca-5,9-dien-2-one which is separated as described above.

Similarly, in the above procedure, instead of using either the trans or cis isomer of 7-methylnon-6-en-3-one as the starting material, there can be used a mixture of the isomers obtained in Paragraph 1 hereof in which case a mixture of the four isomers is obtained which can then be separated by preparative gas-liquid chromatography into the four isomers.

A mixture of 11.2 g. of diethyl carbethoxymethylphosphonate in 100 ml. of diglyme is treated with 2.4 g. of sodium hydride. This mixture is stirred until the evolution of gas ceases and 7.5 g. of trans, cis 6-ethyl-10-methyldodeca-5,9-dien-2-one is then slowly added with stirring, maintaining a temperature below 30° C. The mixture is stirred for about 15 minutes and then diluted with water and extracted with ether. These ethereal extracts are washed well with water, dried over sodium sulfate, and evaporated to remove the solvent to furnish a mixture of the trans,trans,cis and cis,trans,cis isomers of ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate which is separated by preparative gas-liquid chromatography.

The above procedure is repeated three times with the exception of using cis, cis 6-ethyl-10-methyldodeca-5,9-dien-2-one as the starting material the first time; trans, trans 6-ethyl-10-methyldodeca-5,9-dien-2-one the second time; and cis, trans 6-ethyl-10-methyldodeca-5,9-dien-2-one the third time to obtain the cis,cis,trans and cis,cis,cis; the trans,trans,trans and trans,trans,cis; and the cis,trans,trans and cis,trans,cis of

ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, respectively. The isomers are separated by preparative gas-liquid chromatography.

EXAMPLE 20

2 grams of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate in 50 ml. of anhydrous ether is added over a 30-minute period to a stirred suspension of 2 g. of lithium aluminum hydride in 50 ml. of anhydrous ether at -20° C under nitrogen. This mixture is stirred at -20° C for 15 hours and then cautiously treated with about 10 ml. of ethyl acetate and then about 4 ml. of water. The mixture is then filtered and the solid thus collected is washed well with ether. The ether solution is dried over sodium sulfate and evaporated to yield 3,7,11-trimethyltrideca-2,6,10-trien-1-ol.

The procedure of this example is repeated with the exception that methyl 3,7,11-trimethyltrideca-2,6,10-trienoate is replaced with the esters preferably the methyl esters, described hereinabove, for example, those Examples 1 through 4 to furnish the corresponding free alcohol at C-1, for example, 3,7,11-trimethyldodeca-2,6,10-trien-1-ol 3,11-dimethyl-7-ethyltrideca-2,6,10-trien-1, 3,7-diethyl-11-methyltrideca-2,6,10-trien-1-ol, 3,11-dimethyl-7-ethyldodeca-2,6,10-trien-1-ol, 7,11-dimethyl-3-ethyltrideca-2,6,10-trien-1-ol, 7,11-dimethyl-3-ethylododeca-2,6,10-trien-1-ol, and the like.

Similarly, the C-1 alcohol corresponding to the 2,6-diene, 1,10-diene and 2-ene esters of Examples 8 through 17 are obtained by treatment with lithium aluminum hydride using the procedure of this example, for example,

3,7,11-trimethyldodeca-2,6-dien-1-ol,
3,7-dimethyl-11-ethyltrideca-2,10-dien-1-ol,
3,11-dimethyl-7-ethyltrideca-2,10-dien-1-ol,
3,7-diethyl-11-methyltrideca-2,10-dien-1-ol,
3,11-dimethyl-7-ethyldodeca-2,10-dien-1-ol,
3,7-diethyl-11-methyldodec-2-en-1-ol,
3,7,11-triethyltrideca-2,10-dien-1-ol,
3,7,11-trimethyltrideca-2,10-dien-1-ol, and
3,7,11-trimethyldodeca-2,6-dien-1,11-diol are obtained from

ethyl 3,7,11-trimethyldodeca-2,6-dienoate,
ethyl 3,7-dimethyl-11-ethyltrideca-2,10-dienoate,
ethyl 3,11-dimethyl-7-ethyltrideca-2,10-dienoate,
ethyl 3,7-diethyl-11-methyltrideca-2,10-dienoate,
ethyl 3,11-dimethyl-7-ethyldodeca-2,10-dienoate,
ethyl 3,7-diethyl-11-methyldodec-1-enoate,
ethyl 3,7,11-triethyltrideca-2,10-dienoate,
ethyl 3,7,11-trimethyltrideca-2,10-dienoate, and
ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate, respectively.

EXAMPLE 21

A mixture of 1 g. of 3,7,11-trimethyltrideca-2,6,10-trien-1-ol, 4 ml. of pyridine and 2 ml. of acetic anhydride is allowed to stand at room temperature for 15 hours. The mixture is then poured into water and stirred. The mixture is extracted with methylene chloride and the organic extracts are dried and evaporated to yield 1-acetoxy-3,7,11-trimethyltrideca-2,6,10-triene.

By repeating the above process using as the starting material, other C-1 alcohols prepared hereinabove, the corresponding acetate is obtained, e.g. 1-acetoxy-3,7,11-trimethyldodeca-2,6,10-triene, 1-acetoxy-3,11-dimethyl-7-ethyltrideca-2,6,10-triene, 1-acetoxy-3,7-diethyl-11-methyltrideca-2,6,10-triene, 1-acetoxy-3,11-dimethyl-7-ethyldodeca-2,6,10-triene, 1-acetoxy-7,11-dimethyl-3-ethyltrideca-2,6,10-triene, 1-acetoxy-7,11-dimethyl-13-ethyldodeca-2,6,10-triene, and the like.

Similarly, by using other carboxylic acid anhydrides in the process of this example in place of acetic anhydride, for example, propionic anhydride, n-butyric anhydride, n-caproic anhydride, and the like, the corresponding 1-acylates are obtained, e.g. 1-propionate, 1-butyrate, and the like.

EXAMPLE 22

28 grams of 3,7,11-trimethyltrideca-2,6,10-trien-1-ol is added to a suspension of 3.0 g. of sodium hydride in 110 ml. of benzene, this mixture is stirred until the evolution of hydrogen ceases and then 47 g. of ethyl iodide is added with stirring. The mixture is refluxed for 2 hours and then washed with water. Evaporation of solvent in vacuo furnishes the ethyl ether of 3,7,11-trimethyltrideca-2,6,10-trien-1-ol which is purified by chromatography.

Through the use of other alkyl halides, such as methyl iodide, propyl bromide, and the like, in place of ethyl iodide, the corresponding methyl ether, propyl ether, and the like, are obtained.

By repeating the process of this example with the exception of substituting other C-1 alcohols in place of 3,7,11-trimethyltrideca-2,6,10-trien-1-ol, e.g. 3,7,11-trimethyldodeca-2,6,10-trien-1-ol, 3,11-dimethyl-7-ethyltrideca-2,6,10-trien-1-ol, 3,7-diethyl-11-methyltrideca-2,6,10-trien-1-ol, and the like, the corresponding ether, methyl ether, propyl ether, and the like, are obtained.

EXAMPLE 23

a solution of 1.2 g. of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate in 5 ml. of dimethylsulfoxide is added to a solution of 1 equivalent of dimethylsulfoxonium methylide in dimethylsulfoxide [prepared by the procedure of Corey et al., J. Am. Chem. Soc. 87, 1353 (1965)]. The mixture is stirred under nitrogen and at room temperature for about 20 hours and then at 50° C for about 7 hours. 50 ml. of water is then added and the resulting mixture extracted 4 times with 50 ml. of ethyl acetate. The combined extracts are washed with water and saturated aqueous sodium chloride solution, dried and evaporated to furnish methyl 2,3-methylene-3,7,11-trimethyltrideca-6,10-dienoate which is purified by silica chromatography.

By using as the starting material in the process of this example, other 2,6,10-trienoates described herein (see Examples 1-5, for example), there are obtained the corresponding 2,3-methylene-6,10-dienoates, e.g., methyl 2,3-methylene-3,7,11-trimethyldodeca-6,10-dienoate, methyl 2,3-methylene-3,11-dimethyl-7-ethyltrideca-6,10-dienoate, ethyl 2,3-methylene-3,7,11-trimethyldodeca-6,10-dienoate, ethyl 2,3-methylene-3,11-dimethyl-7-ethyltrideca-6,10-dienoate, ethyl 2,3-methylene-3,11-dimethyl-7-ethyldodeca-6,10-dienoate, ethyl 2,3-methylene-3,7,11-trimethyltrideca-6,10-dienoate, ethyl 2,3-methylene-3-ethyl-7,11-dimethyltrideca-6,10-dienoate, ethyl 2,3-methylene-3-ethyl-7,11-dimethyl-dodeca-6,10-dienoate, ethyl 2,3-methylene-3,7-diethyl-11-methyltrideca-6,10-dienoate, and the like.

By using as the starting material in the process of this example, the ethyl esters of Examples 8-17 and 19 and the esters of Example 18, the corresponding 2,3-methylene esters are obtained. For example,

ethyl 2,3-methylene-3,7,11-trimethyldodec-6-enoate,
ethyl 2,3-methylene-3,7-dimethyl-11-ethyltridec-10-enoate,
ethyl 2,3-methylene-3,11-dimethyl-7-ethyltridec-10-enoate,
ethyl 2,3-methylene-3,7-diethyl-11-methyltridec-10-enoate,
ethyl 2,3-methylene-3,11-dimethyl-7-ethyldodec-10-enoate,
ethyl 2,3-methylene-3,7-diethyl-11-methyldodec-10-enoate,
ethyl 2,3-methylene-3,7-diethyl-11-methyldodecanoate,
ethyl 2,3-methylene-3,7,11-triethyltridec-10-enoate,
ethyl 2,3-methylene-3,7,11-trimethyltridec-10-enoate,
ethyl 2,3-methylene-11-hydroxy-3,7,11-trimethyldodec-6-enoate,
ethyl 2,3-methylene-3,7,11-trimethyldodecanoate,
ethyl 2,3-methylene-7-ethyl-3,11-dimethyltridecanoate,
and

ethyl 2,3-methylene-3,7,11-trimethyldodec-10-enoate are obtained from the corresponding ethyl 2,6-dienoate, ethyl 2,10-dienoate and ethyl 2-enoate.

By subjecting the thus-prepared 2,3-methylene-2,6-dienoates to the procedures of Examples 6, 20, 21 and 22, the corresponding free acids, free alcohols, esters and ethers, respectively, are obtained, e.g., 2,3-methylene-3,7,11-trimethyltrideca-6,10-dienoic acid, 2,3-methylene-3,7,11-trimethyltrideca-6,10-dien-1-ol, 1-acetoxy-2,3-methylene-3,7,11-trimethyltrideca-6,10-diene, 1-ethoxy-2,3-methylene-3,7,11-trimethyltrideca-6,10-diene, and the like.

EXAMPLE 24

A mixture of 7 g. of methylene iodide and 3 g. of zinc-copper couple in 15 ml. of anhydrous ether is heated at reflux under nitrogen for 3 hours. The mixture is then cooled and 2 g. of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate added. This mixture is allowed to stand at room temperature for 20 hours and is then poured into 200 ml. of 2 percent aqueous sodium carbonate and extracted twice with 100 ml. portions of ether. The extracts are dried over sodium sulfate and evaporated under reduced pressure. The oily residue is held at 0.01 mm. to remove any unreacted methylene iodide and then purified by gas-liquid chromatography to obtain methyl 6,7-methylene-3,7,11-trimethyltrideca-2,10-dienoate, methyl 10,11-methylene-3,7,11-trimethyltrideca-2,6-dienoate, methyl 6,7;10,11-(bis)methylene-3,7,11-trimethyltridec-2-enoate.

By using the 2,3-methylene compounds of Example 23 as the starting material in the above process, there is obtained methyl 2,3;6,7;10,11-(tris)methylene-3,7,11-trimethyltridecanoate, methyl 2,3;6,7-(bis)methylene-3,7,11-trimethyltridec-11-enoate, and methyl 2,3;10,11-(bis)methylene-3,7,11-trimethyltridec-6-enoate, ethyl 2,3;6,7-(bis)methylene-3,7,11-trimethyldodecanoate, ethyl 2,3;10,11-(bis)methylene-3,7-dimethyl-11-ethyltridecanoate, ethyl 2,3;10,11-(bis)methylene-3,11-dimethyl-7-ethyltridecanoate, ethyl 2,3;10,11-(bis)methylene-3,11-dimethyl-7-ethyldodecanoate, ethyl 2,3;10,11-(bis)methylene-3,7-diethyl-11-methyldodecanoate, ethyl 2,3;10,11-(bis)methylene-3,7,11-trimethyldodecanoate, and the like.

By repeating the procedure of this example using other alkyl esters described herein (e.g. Examples 1-5, 8-15 and 19), the corresponding methylene and (bis)methylene compounds are obtained. For example,

ethyl 10,11-methylene-3,7,11-trimethyldodeca-2,6-dienoate,
ethyl 6,7;10,11-bismethylene-3,7,11-trimethyldodec-2-enoate, and
ethyl 6,7-methylene-3,7,11-trimethyldodeca-2,10-dienoate;
ethyl 10,11-methylene-3,11-dimethyl-7-ethyltrideca-2,6-dienoate,
ethyl 6,7-methylene-3,11-dimethyl-7-ethyltrideca-2,10-dienoate, and
ethyl 6,7;10,11-bismethylene-3,11-dimethyl-7-ethyltridec-2-enoate;
ethyl 10,11-methylene-3,11-dimethyl-7-ethyldodeca-2,6-dienoate,
ethyl 6,7-methylene-3,11-dimethyl-7-ethyldodeca-2,10-dienoate, and
ethyl 6,7;10,11-bismethylene-3,11-dimethyl-7-ethyldodec-2-enoate;
ethyl 10,11-methylene-3,7-dimethyl-11-ethyltrideca-2,6-dienoate,
ethyl 6,7-methylene-3,7-dimethyl-11-ethyltrideca-2,10-dienoate, and
ethyl 6,7;10,11-bismethylene-3,7-dimethyl-11-ethyltridec-2-enoate;
ethyl 10,11-methylene-3,7,11-trimethyltrideca-2,6-dienoate,
ethyl 6,7-methylene-3,7,11-trimethyltrideca-2,10-dienoate,
and

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ethyl 6,7;10,11-bismethylene-3,7,11-trimethyltridec-2-enoate are obtained from

ethyl 3,7,11-trimethyldodeca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,7-dimethyl-11-ethyltrideca-2,6,10-trienoate, and ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate, respectively.

The corresponding acids can be obtained using the procedure of Example 6 and the corresponding saturated derivatives can be obtained by hydrogenation using the procedure of, for example, Example 7.

EXAMPLE 25

To a mixture of 2 g. of 3,11-dimethyl-7-ethyltrideca-2,6,10-trien-1-ol in 150 ml. of methylene chloride at 0° C, there is slowly added 1.0 molar equivalent of m-chloroperbenzoic acid in 100 ml. of methylene chloride. The resulting mixture is then allowed to stand for 15 minutes at 0° C and then washed with 2 percent aqueous sodium sulfite solution, with 5 percent aqueous sodium bicarbonate solution and with water, dried over sodium sulfate and evaporated to an oil which contains a mixture of the 10,11-epoxide, 6,7-epoxide and a small amount of the 6,7;10,11-(bis)epoxide of 3,11-dimethyl-7-ethyltrideca-2,6,10-trien-1-ol. This mixture is then purified and separated into the individual epoxides by chromatography on silica, i.e., 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dien-1-ol, 6,7-oxido-3,11-dimethyl-7-ethyltrideca-2,10-dien-1-ol, and 6,7;10,11-(bis)oxido-3,11-dimethyl-7-ethyltridec-2-en-1-ol.

By repeating the process of this example with the exception of using as the starting material other 2,6,10-trienes described herein, e.g., 1-acetoxy-3,11-dimethyl-7-ethyltrideca-2,6,10-triene, methyl ether of 3,11-dimethyl-7-ethyltrideca-2,6,10-triene-1-ol, methyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, methyl 3,7,11-trimethyltrideca-2,6,10-trienoate, methyl 3,7,11-trimethyldodeca-2,6,10-trienoate, methyl 3,7-diethyl-11-methyltrideca-2,6,10-trienoate, 3,7,11-trimethyltrideca-2,6,10-trienoic acid, 3,7,11-trimethyldodeca-2,6,10-trienoic acid, 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoic acid, 3,7-diethyl-11-methyltrideca-2,6,10-trienoic acid, 3,7-diethyl-11-methyltrideca-2,6,10-trien-1-ol, 3,7,11-trimethyltrideca-2,6,10-trien-1-ol, and the like, in place of 3,11-dimethyl-7-ethyltrideca-2,6,10-trien-1-ol, the corresponding 10,11-epoxides, 6,7-epoxides and a small amount of the 6,7;10,11-(bis)epoxides are obtained, e.g.,

1-acetoxy-10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-diene, methyl ether of 3,11-dimethyl-7-ethyl-10,11-oxidotrideca-2,6-dien-1-ol, methyl 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, methyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate, methyl 10,11-oxido-3,7,11-trimethyldodeca-2,6-dienoate, methyl 10,11-oxido-3,7-diethyl-11-methyltrideca-2,6-dienoate, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoic acid, 10,11-oxido-3,7,11-trimethyldodeca-2,6-dienoic acid, 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dienoic acid, 10,11-oxido-3,7-diethyl-11-methyltrideca-2,6-dienoic acid, 10,11-oxido-3,7-diethyl-11-methyltrideca-2,6-dien-1-ol, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dien-1-ol, and the like, and the corresponding 6,7-epoxide and 6,7;10,11(bis)epoxide.

By use of the procedure of this example, there is obtained, ethyl 10,11-oxido-3,7,11-trimethyldodeca-2,6-dienoate, ethyl 6,7-oxido-3,7,11-trimethyldodeca-2,10-dienoate, and ethyl 6,7;10,11-bisoxido-3,7,11-trimethyldodec-2-enoate; ethyl 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, ethyl 6,7-oxido-3,11-dimethyl-7-ethyltrideca-2,10-dienoate, and

ethyl 6,7;10,11-bisoxido-3,11-dimethyl-7-ethyltridec-2-enoate; ethyl 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, ethyl 6,7-oxido-3,11-dimethyl-7-ethyltrideca-2,10-dienoate, and ethyl 6,7;10,11-bisoxido-3,11-dimethyl-7-ethyltridec-2-enoate; ethyl 10,11-oxido-3,7-dimethyl-11-ethyltrideca-2,6-dienoate, ethyl 6,7-oxido-3,7-dimethyl-11-ethyltrideca-2,10-dienoate, and ethyl 6,7;10,11-bisoxido-3,7-dimethyl-11-ethyltridec-2-enoate; and ethyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate, ethyl 6,7-oxido-3,7,11-trimethyltrideca-2,10-dienoate, and ethyl 6,7;10,11-bisoxido-3,7,11-trimethyltridec-2-enoate from

ethyl 3,7,11-trimethyldodeca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,7-dimethyl-11-ethyltrideca-2,6,10-trienoate, and

ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate, respectively. By use of the procedure of this example, the 2,3-methylenes, 6,7-methylenes, 10,11-methylenes, 2,3;6,7-bis-methylenes and 2,3;10,11-bismethylenes of Examples 23 and 24 having unsaturation at C-6,7, C-10,11 or C-6,7;10,11 are converted into the corresponding mono and/or bis-epoxide. For example,

ethyl 2,3-methylene-10,11-oxido-3,7,11-trimethyldodeca-6-enoate, ethyl 2,3-methylene-6,7-oxido-3,7,11-trimethyldodec-10-enoate, and ethyl 2,3-methylene-6,7;10,11-bisoxido-3,7,11-trimethyldodecanoate; ethyl 2,3-methylene-10,11-oxido-3,7,11-trimethyltridec-6-enoate, ethyl 2,3-methylene-6,7-oxido-3,7,11-trimethyltridec-10-enoate, and ethyl 2,3-methylene-6,7;10,11-bisoxido-3,7,11-trimethyltridecanoate; ethyl 2,3-methylene-10,11-oxido-3,11-dimethyl-7-ethyltridec-6-enoate, ethyl 2,3-methylene-6,7-oxido-3,11-dimethyl-7-ethyltridec-10-enoate, and ethyl 2,3-methylene-6,7;10,11-bisoxido-3,11-dimethyl-7-ethyltridecanoate; ethyl 10,11-methylene-6,7-oxido-3,11-dimethyl-7-ethyltridec-2-enoate; ethyl 6,7-methylene-10,11-oxido-3,11-dimethyl-7-ethyltridec-2-enoate; and ethyl 2,3;6,7-bismethylene-10,11-oxido-3,11-dimethyl-7-ethyltridecanoate

are obtained from ethyl 2,3-methylene-3,7,11-trimethyldodeca-6,10-dienoate; ethyl 2,3-methylene-3,7,11-trimethyltrideca-6,10-dienoate; ethyl 2,3-methylene-3,11-dimethyl-7-ethyltrideca-6,10-dienoate;

ethyl 10,11-methylene-3,11-dimethyl-7-ethyltrideca-2,6-dienoate; ethyl 6,7-methylene-13,11-dimethyl-7-ethyltrideca-2,10-dienoate; and ethyl 2,3;6,7-bismethylene-3,11-dimethyl-7-ethyltridec-10-enoate, respectively.

Hydrogenation of the above prepared epoxide unsaturated derivatives according to the procedure of Example 7 affords the corresponding epoxide saturated at one or more positions on the backbone chain.

Thus, for example, ethyl 3,11-dimethyl-7-ethyl-10,11-oxidotrideca-2,6-dienoate when subjected to hydrogenation yields ethyl 3,11-dimethyl-7-ethyl-10,11-oxidotridec-2-enoate, ethyl 3,11-dimethyl-7-ethyl-10,11-oxidotridec-6-

enoate and ethyl 3,11-dimethyl-7-ethyl-10,11-oxidotridecanoate.

EXAMPLE 26

Anhydrous hydrogen chloride is introduced into 100 ml. of ether at 0° C until a saturated solution is obtained. 1 gram of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate is added and the resulting mixture is then allowed to stand at 0° C for 4 days. The mixture is then evaporated under reduced pressure to an oil which is purified by silica chromatography to furnish methyl 7,11-dichloro-3,7,11-trimethyltridec-2-enoate.

Through the use of other 2,6,10-triunsaturated compounds described herein as the starting material in the above process, the corresponding 7,11-dichloro derivatives are obtained, e.g., methyl 7,11-dichloro-3,7,11-trimethyltridec-2-enoate, methyl 7,11-dichloro-3,11-trimethyltridec-2-enoic acid, 7,11-dichloro-3,7,11-trimethyltridec-2-enoic acid, 7,11-dichloro-3,11-dimethyl-7-ethyltridec-2-enoic acid, and the like.

By use of the above procedure, there is prepared ethyl 7,11-dichloro-3,7,11-trimethyltridec-2-enoate, ethyl 7,11-dichloro-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 3,11-dichloro-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 7,11-dichloro-3,7-dimethyl-11-ethyltridec-2-enoate, and ethyl 7,11-dichloro-3,7,11-trimethyltridec-2-enoate from ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,7-dimethyl-11-ethyltrideca-2,6,10-trienoate, and ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate, respectively.

Similarly, by using the 2,3-methylene-6,10-dienoates of Example 23 as the starting material in the procedure of this example, the corresponding 7,11-dichloro compounds are obtained. For example, ethyl 7,11-dichloro-2,3-methylene-3,11-dimethyl-7-ethyltridecanoate and ethyl 7,11-dichloro-2,3-methylene-3,7,11-trimethyltridecanoate from ethyl 2,3-methylene-3,11-dimethyl-7-ethyltrideca-6,10-dienoate and ethyl 2,3-methylene-3,7,11-trimethyltrideca-6,10-dienoate, respectively.

7,11-Dichloro compounds having saturation at C-2,3 are prepared from the corresponding 6,10-diene compound or by hydrogenation of 7,11-dichloro-2-ene compounds using the procedure of Example 7.

EXAMPLE 27

Chlorine gas is bubbled into 200 ml. of carbon tetrachloride at 0° C until a 0.5 molar solution is obtained. 25 grams of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate is added and the mixture is then stirred and allowed to stand at 0° C for 24 hours. The mixture is then evaporated to furnish an oil containing methyl 10,11-dichloro-3,7,11-trimethyltrideca-2,6-dienoate, methyl 6,7-dichloro-3,7,11-trimethyltrideca-2,10-dienoate and methyl 6,7,10,11-tetrachloro-3,7,11-trimethyltridec-2-enoate which are purified and separated by gas-liquid chromatography or alternatively purification and separation can be made by 2 distillations through a spinning band fractionation column.

The above process is repeated with the exception of using as the starting material other 2,6,10-triunsaturated compounds described herein in place of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate, e.g. methyl 3,7,11-trimethyltrideca-2,6,10-trienoate, methyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, 3,7,11-trimethyltrideca-2,6,10-trienoic acid, 3,7,11-trimethyltrideca-2,6,10-trienoic acid, 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoic acid, 3,7,11-trimethyltrideca-2,6,10-trien-1-ol, 3,7,11-trimethyltrideca-2,6,10-trien-1-ol, 3,11-dimethyl-7-ethyltrideca-2,6,10-trien-1-ol, 1-acetoxy-3,7,11-trimethyltrideca-2,6,10-trien, 1-acetoxy-3,7,11-trimethyltrideca-2,6,10-triene, 1-acetoxy-3,11-dimethyl-7-ethyltrideca-2,6,10-trien, 1-acetoxy-3,11-dimethyl-7-ethyltrideca-2,6,10-triene, 1-methoxy-3,7,11-trimethyltrideca-2,6,10-triene, 1-methoxy-3,7,11-trimethyltrideca-2,6,10-

trien, 1-methoxy-3,11-dimethyl-7-ethyltrideca-2,6,10-triene, and the like, and there are obtained the corresponding 10,11-dichloro derivatives, 6,7-dichloro derivatives and 6,7,10,11-tetrachloro derivatives, e.g. methyl 10,11-dichloro-3,7,11-trimethyltrideca-2,6-dienoate, methyl 6,7-dichloro-3,7,11-trimethyltrideca-2,10-dienoate, methyl 6,7,10,11-tetrachloro-3,7,11-trimethyltridec-2-enoate, and the like. The C-1 alcohol, 1-acetoxy and 1-methoxy compounds also furnish C-2,3 dichloro derivatives which can be separated by chromatography.

By repeating the above procedure using ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,7-dimethyl-11-ethyltrideca-2,6,10-trienoate and ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate, respectively, as the starting material, the corresponding ethyl 10,11-dichloro-2,6-dienoate, ethyl 6,7-dichloro-2,10-dienoate and ethyl 6,7,10,11-tetrachloro-2-enoate derivatives are obtained.

By repeating the procedure outlined in this example except for substituting bromine for chlorine, a mixture of the corresponding brominated compounds is prepared and separated by chromatography.

Use of a mixed halogen reagent, such as chlorine-fluorine in this procedure provides the corresponding mixed dihalo compounds.

In like manner, the corresponding 6,7-dibromo; 10,11-dibromo; and 6,7,10,11-tetrabromo derivatives of starting compounds ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate and ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate are prepared.

EXAMPLE 28

Ethyl 3,7,11-trimethyl-10,11-oxidododeca-2,6-dienoate is prepared as described in Example 25 and is thereafter treated by the procedure of Example 27 to afford ethyl 3,7,11-trimethyl-6,7-dichloro-10,11-oxidododec-2-enoate. By repeating this procedure with those compounds not containing the α , β -unsaturated carbonyl system, the corresponding 6,7-dichloro-10,11-oxido derivative is separated from the final reaction mixture by chromatography from the presence of some of the corresponding 2,3,6,7-tetrachloro-10,11-oxido compound.

Similarly obtained are ethyl 3,7,11-trimethyl-6,7-dichloro-10,11-oxidotridec-2-enoate and ethyl 3,11-dimethyl-6,7-dichloro-7ethyl-10,11-oxidotridec-2-enoate as well as the corresponding methyl esters thereof.

EXAMPLE 29

The process of Example 27 is repeated with the exception that methyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate is employed as the starting material in place of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate and there is obtained methyl 6,7-dichloro-10,11,13,7,11-trimethyltridec-2-enoate which can be purified by chromatography or fractional distillation.

By substituting other 10,11-oxido-2,6-diunsaturated compounds described herein as the starting material in this example, e.g. methyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate, methyl 10,11-oxido-7-ethyl-3,11-dimethyltrideca-2,6-dienoate, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dien-1-ol, 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dien-1-ol, 10,11-oxido-1-acetoxy-3,7,11-trimethyltrideca-2,6-diene, 10,11-oxido-1-acetoxy-3,7,11-trimethyltrideca-2,6-diene, 10,11-oxido-1-acetoxy-3,11-dimethyl-7-ethyltrideca-2,6-diene, 10,11-oxido-1-methoxy-3,7,11-trimethyltrideca-2,6-diene, 10,11-oxido-1-methoxy-3,7,11-trimethyltrideca-2,6-diene, 10,11-oxido-1-methoxy-3,11-dimethyl-7-ethyltrideca-2,6-diene, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoic acid, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoic acid, 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dienoic acid,

and the like, the corresponding 6,7-dichloro-10,11-oxido compounds are obtained, e.g. methyl 6,7-dichloro-10,11-oxido-3,7,11-trimethyldodeca-2-enoate, methyl 6,7-dichloro-10,11-oxido-7-ethyl-3,11-dimethyltrideca-2-enoate, 6,7-dichloro-10,11-oxido-3,7,11-trimethyltridec-2-en-1-ol, 6,7-dichloro-10,11-oxido-3,7,11-trimethyldodec-2-en-1-ol, and the like.

EXAMPLE 30

Anhydrous hydrogen chloride is bubbled into 100 ml. of carbon tetrachloride at 0° C until a saturated solution is obtained. 1 gram of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate is added and the resulting mixture is then allowed to stand at 0° C for 4 days. Then the mixture is evaporated under reduced pressure to an oil which is purified by column chromatography to furnish methyl 11-chloro-3,7,11-trimethyltrideca-2,6-dienoate. β The process of this example is repeated with the exception of substituting other 2,6,10-trienoates prepared hereinabove, e.g. those of Examples 2-5, for the starting material and there is obtained the corresponding 11-chloro-2,6-dienoate, for example methyl 11-chloro-3,7,11-trimethyldodeca-2,6-dienoate, methyl 11-chloro-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, methyl 11-chloro-3,7-diethyl-11-methyltrideca-2,6-dienoate, and the like, ethyl 11-chloro-3,7,11-trimethyltrideca-2,6-dienoate, ethyl 11-chloro-3,7,11-trimethyldodeca-2,6-dienoate, and the like.

By repeating the process of this example with the exception of substituting the corresponding 2,6,10-trienoic acids prepared hereinabove, (see, for example, Example 6) as the starting material in place of the 2,6,10-trienoate employed above, the corresponding 11-chloro-2,6-dienoic acids are obtained, e.g. 11-chloro-3,7,11-trimethyltrideca-2,6-dienoic acid, 11-chloro-3,7,11-trimethyldodeca-2,6-dienoic acid, 11-chloro-3,11-dimethyl-7-ethyltrideca-2,6-dienoic acid, 11-chloro-3,7-diethyl-11-methyltrideca-2,6-dienoic acid, 11-chloro-3,11-dimethyl-7-ethyltrideca-2,6-dienoic acid, 11-chloro-7,11-dimethyl-3-ethyltrideca-2,6-dienoic acid, 11-chloro-7,11-dimethyl-3-ethyltrideca-2,6-dienoic acid, and the like.

EXAMPLE 31

Into a solution of 5 g. of methyl 10,11-oxido-3,7,11-trimethyltridecanoate (obtained by hydrogenation of the corresponding $\Delta^{2,6}$ -10,11-epoxide on 5 percent Pd/C) in 100 ml. of CCl_4 is slowly bubbled hydrogen fluoride at 0° C with stirring. When about 1 chemical equivalent has been added, the mixture is allowed to stand for 6 hours, washed with water and evaporated to an oil which is chromatographed on silica to give methyl 10-hydroxy-11-fluoro-3,7,11-trimethyltridecanoate and methyl 10-fluoro-11-hydroxy-3,7,11-trimethyltridecanoate.

By substituting in the above process as the starting material methyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate, there is obtained the corresponding 10-hydroxy-11-fluoro and 10-fluoro-11-hydroxy derivatives containing a fluoro atom at position C-7.

The process of this example is repeated with the exceptions that 0.1 N hydrogen fluoride in anhydrous methanol is used as the reagent and reaction medium and the reaction is run for 3 days at room temperature and there is obtained the corresponding substitution product 10-fluoro-11-methoxy derivative. Use of other lower monohydric alcohols as the reaction medium provides the corresponding alkoxy derivatives.

To 5 grams of methyl 10-hydroxy-11-fluoro-3,7,11-trimethyltridecanoate in 100 ml. of anhydrous ether, is added 1 chemical equivalent of diazomethane. 1 drop of boron/trifluoride is then added and the reaction mixture is allowed to stand at 0° C for 1 hour and then at room temperature for 2 additional hours. Thereafter, the mixture is washed with water, evaporated and chromatographed to give methyl 10-methoxy-11-fluoro-3,7,11-trimethyltridecanoate.

By use of other diazoalkanes, such as diazoethane, the corresponding alkoxy derivatives are prepared, such as the 10-ethoxy compounds.

EXAMPLE 32

A. To a solution of 2 g. of methyl 7,11-dichloro-3,7,11-trimethyltrideca-2-enoate in anhydrous ether (50 ml.) at 0° C is added with stirring lithium aluminum hydride (0.36 g.). After 1 hour, acetic acid (2.4 ml.) is added. The mixture is washed with ice water and the ether phase dried and evaporated to give 7,11-dichloro-3,7,11-trimethyltridec-2-en-1-ol.

By using other 7,11-dichloro esters (see Example 26, for example), the corresponding C-1 alcohols are obtained.

By the procedure of Example 21, the above C-1 alcohols are converted into the corresponding acylates, e.g. acetates.

By the procedure set forth in paragraph 4 of Example 31, the above C-1 alcohols are converted to the corresponding ether.

B. Likewise, the alkyl 11-monochloro 2,6-dienoates, e.g. methyl 11-chloro-3,7,11-trimethyltrideca-2,6-dienoate, and the like (see Example 30), are converted by the processes of Part A above to the corresponding 11-chloro-1-hydroxy, 11-chloro-1-acyloxy and 11-chloro-1-alkoxy derivatives.

EXAMPLE 33

The procedure of Example 30 is repeated using other C-10,11 unsaturated compounds described herein such as those of Examples 8-14, 23 and 24 to obtain the corresponding 11-chloro-derivatives, e.g. ethyl 11-chloro-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, ethyl 11-chloro-2,3-methylene-3,7,11-trimethyldodec-6-enoate, ethyl 11-chloro-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 11-chloro-2,3,6,7-bismethylene-3,7,11-trimethyldodecanoate, and the like.

EXAMPLE 34

1 gram of trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate in 8 ml. of pyridine and 2 ml. of triethylamine is treated with 1 ml. of acetyl chloride. This mixture is allowed to stand for 15 hours at about 25° C and is then poured into ice water and extracted with methylene chloride. These extracts are washed well with water, dried over sodium sulfate and evaporated to yield trans, trans ethyl 3,7,11-trimethyl-11-acetoxydodeca-2,6-dienoate.

Use of other acid chlorides, such as trimethylacetyl chloride, benzoyl chloride, phenylacetyl chloride, and the like, yields the corresponding esters.

EXAMPLE 35

A. Into a mixture of 2 g. of methyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate in 150 ml. of ether, there is introduced a slow stream of hydrogen chloride for 1 hour at 0° C. The mixture is then allowed to stand at 0° C for 18 hours. Then the mixture is washed with 5 percent aqueous sodium bicarbonate solution, dried over sodium sulfate and evaporated to an oil containing methyl 11-chloro-10-hydroxy-3,7,11-trimethyltrideca-2,6-dienoate and methyl 7,11-dichloro-10-hydroxy-3,7,11-trimethyltridec-2-enoate which are purified and separated by preparative silica chromatography.

B. The process of Part A above is repeated with the exception of using as the starting material methyl 6,7-oxido-3,7,11-trimethyltrideca-2,10-dienoate and there is obtained methyl 7-chloro-6-hydroxy-3,7,11-trimethyltrideca-2,10-dienoate and methyl 7,11-dichloro-6-hydroxy-3,7,11-trimethyltridec-2-enoate.

C. By repeating the process of Example 34 with the exception of using methyl 11-chloro-10-hydroxy-3,7,11-trimethyltrideca-2,6-dienoate or methyl 7,11-dichloro-10-hydroxy-3,7,11-trimethyltridec-2-enoate as the starting material, the corresponding 10-acylates are obtained, e.g. methyl 11-chloro-10-acetoxy-3,7,11-trimethyltrideca-2,6-dienoate,

methyl 7,11-dichloro-10-acetoxy-3,7,11-trimethyltridec-2-enoate, and the like.

D. Similarly, by repeating the process of Part A of this example with the exception of using other 10,11-oxido-2,6-diunsaturated compounds described herein (e.g. see Example 25) as the starting material in place of methyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate, for example, methyl 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoate, methyl 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoic acid, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dienoic acid, 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dienoic acid, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dien-1-ol, 10,11-oxido-3,7,11-trimethyltrideca-2,6-dien-1-ol, 10,11-oxido-1-acetoxy-3,7,11-trimethyltrideca-2,6-diene, 10,11-oxido-1-acetoxy-3,7,11-trimethyltrideca-2,6-diene, 10,11-oxido-1-acetoxy-3,11-dimethyl-7-ethyltrideca-2,6-diene, 10,11-oxido-1-methoxy-3,7,11-trimethyltrideca-2,6-diene, 10,11-oxido-1-methoxy-3,7,11-trimethyltrideca-2,6-diene, 10,11-oxido-1-methoxy-3,11-dimethyl-7-ethyltrideca-2,6-diene, and the like, the corresponding 11-chloro-10-hydroxy-2,6-diunsaturated and 7,11-dichloro-10-hydroxy-2-monounsaturated compounds are obtained, e.g. methyl 11-chloro-10-hydroxy-3,7,11-trimethyltrideca-2,6-dienoate, methyl 7,11-dichloro-10-hydroxy-3,7,11-trimethyltridec-2-enoate; 11-chloro-10-hydroxy-3,7,11-trimethyltrideca-2,6-dienoic acid, 7,11-dichloro-10-hydroxy-3,7,11-trimethyltridec-2-enoic acid; 11-chloro-3,7,11-trimethyltrideca-2,6-diene-1,10-diol, 7,11-dichloro-3,7,11-trimethyltridec-2-ene-1,10-diol; 1-acetoxy-11-chloro-3,7,11-trimethyltrideca-2,6-dien-10-ol, 1-acetoxy-7,11-dichloro-3,7,11-trimethyltridec-2-en-10-ol; 11-chloro-1-methoxy-3,7,11-trimethyltrideca-2,6-dien-10-ol, 7,11-dichloro-1-methoxy-3,7,11-trimethyltridec-2-en-10-ol, and the like.

By use of the procedure of Example 7, the foregoing unsaturated compounds are converted into the corresponding 2,3-dihydro, 6,7-dihydro and 2,3,6,7-tetrahydro derivatives.

EXAMPLE 36

A. 6 grams of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate is dissolved in 250 ml. of dioxane and 150 ml. of water. The solution is cooled to 10° C and treated with 4 g. of N-bromosuccinimide, added in portions with stirring. The mixture is stirred at about 25° C for 15 hours and then diluted with water, treated with sodium bisulfite, and extracted with ether. These ethereal extracts are washed with water, dried over sodium sulfate and evaporated to yield methyl 3,7,11-trimethyl-10-bromo-11-hydroxytrideca-2,6-dienoate and a small amount of methyl 3,7,11-trimethyl-6-bromo-7-hydroxytrideca-2,10-dienoate and methyl 3,7,11-trimethyl-6,10-dibromo-7-dihydroxytridec-2-enoate which are purified via chromatography on silica.

A solution of 2.8 g. of the 10-bromo-11-hydroxy compound in 50 ml. of ethanol is stirred for 2 hours at 20° C with a suspension of 5.5 g. of Raney nickel in 5 ml. of ethanol. The mixture is then filtered through Celite diatomaceous earth and the filtrate is evaporated to yield methyl 3,7,11-trimethyl-11-hydroxytrideca-2,6-dienoate which is purified via chromatography on silica.

Through the above process, there is prepared methyl 3,7,11-trimethyl-11-hydroxytrideca-2,6-dienoate, methyl 3,11-dimethyl-7-ethyl-11-hydroxytrideca-2,6-dienoate, and the like from the corresponding 2,7,10-trienoates.

Similarly, by the use of N-chlorosuccinimide in place of N-bromosuccinimide, the corresponding 10-chloro-11-hydroxy, 6-chloro-7-hydroxy and 6,10-dichloro-7,11-dihydroxy derivatives are obtained, e.g. methyl 3,7,11-trimethyl-10-chloro-11-hydroxytrideca-2,6-dienoate, and the like.

By repeating the above process using ethyl 2,3-methylene-3,7,11-trimethyltrideca-2,6-dienoate and N-chlorosuccinimide, there is obtained ethyl 10-chloro-11-hydroxy-2,3-

methylene-3,7,11-trimethyltridec-6-enoate, ethyl 6-chloro-7-hydroxy-2,3-methylene-3,7,11-trimethyltridec-10-enoate, ethyl 6,10-dichloro-7,11-dihydroxy-2,3-methylene-3,7,11-trimethyltridecanoate, ethyl 11-hydroxy-2,3-methylene-3,7,11-trimethyltridec-6-enoate, ethyl 7-hydroxy-2,3-methylene-3,7,11-trimethyltridec-10-enoate and ethyl 7,11-dihydroxy-2,3-methylene-3,7,11-trimethyltridecanoate.

B. The 11-hydroxy compounds obtained in Part A are subjected to the process of Example 6 and the corresponding 2,6-dienoic acids are obtained, e.g. 3,7,11-trimethyl-11-hydroxytrideca-2,6-dienoic acid, 3,7,11-trimethyl-11-hydroxytrideca-2,6-dienoic acid, and the like.

C. Through the procedure of Example 20, the 11-hydroxy-2,6-dienoates of Part A are converted into the corresponding C-1 alcohols, e.g. 3,7,11-trimethyltrideca-2,6-diene-1,11-diol, 3,7,11-trimethyltrideca-2,6-diene-1,11-diol, 3,11-dimethyl-7-ethyltrideca-2,6-diene-1,11-diol, and the like.

D. The process of Part A is repeated using 2,6,10-triene C-1 alcohols, e.g. 3,7,11-trimethyltrideca-2,6,10-trien-1-ol, and the like, as the starting material and the corresponding 10-bromo-11-hydroxy, 6-bromo-7-hydroxy, 6,10-dibromo-7,11-dihydroxy derivatives which can be treated with Raney nickel to remove the bromine atom and thus obtain the 1,11-diol; 1,7-diol; and 1,7,11-triol. In a similar manner, the 1-alkoxy and 1-acyloxy derivatives can be prepared.

EXAMPLE 37

To a solution of 2.5 g. of 3,7,11-trimethyltrideca-2,6,10-trien-1-ol in 100 ml. of methylene chloride at 0° C is added 1 molar equivalent of m-chloroperbenzoic acid in methylene chloride (50 ml.). After 30 minutes, the solution is washed with aqueous sodium sulfite, aqueous potassium bicarbonate, water and then dried and evaporated to give an oil which is subjected to silica chromatography to furnish 2,3-oxido-3,7,11-trimethyltrideca-6,10-dien-1-ol.

By esterification and etherification via procedures of Examples 21 and 22, respectively, the corresponding acylates and alkyl ethers of the above 2,3-oxido alcohol are obtained.

Similarly, the above 2,3-epoxides can be subjected to the procedure of Example 20 to prepare the corresponding 1,3-diol from the 2,3-oxido C-1 alcohols and 1-alkoxy-3-ol from the 2,3-oxido C-1 ethers.

EXAMPLE 38

The process of Example 25 is repeated using 2.5 molar equivalents of m-chloroperbenzoic acid to furnish 6,7;10,11-(bis)oxido-3,11-dimethyl-7-ethyltridec-2-en-1-ol and a small amount of 6,7-oxido-3,11-dimethyl-7-ethyltrideca-2,10-dien-1-ol and 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dien-1-ol which are purified and separated by silica chromatography. In a similar manner, other 2,6,10-triunsaturated compounds described herein are converted into the corresponding 6,7;10,11-(bis)-epoxides, 6,7-epoxides and 10,11-epoxides.

EXAMPLE 39

By following the procedure of Example 22, methyl 3,7,11-trimethyl-21,-ethoxytrideca-2,6-dienoate and methyl 3,11-dimethyl-7-ethyl-11-ethoxytrideca-2,6-dienoate are prepared from the corresponding free 11-hydroxy compounds. The thus-obtained 11-alkoxy derivatives are subjected to the procedures of Examples 6 and 20 furnishing 3,7,11-trimethyl-11-ethoxytrideca-2,6-dienoic acid, 3,11-dimethyl-7-ethyl-11-ethoxytrideca-2,6-dienoic acid, 3,7,11-trimethyl-11-ethoxytrideca-2,6-dien-1-ol and 3,11-dimethyl-7-ethyl-11-ethoxytrideca-2,6-dien-1-ol, respectively. By using the thus-obtained C-1 alcohols as the starting material in the process of Example 22, 3,7,11-trimethyl-1,11-diethoxytrideca-2,6-diene and 3,11-dimethyl-7-ethyl-1,11-diethoxytrideca-2,6-diene are obtained. Similarly, the C-1 alcohols are converted into the corresponding esters by the procedure of Example 21, that is, 3,7,11-trimethyl-11-ethoxy-1-acetoxytrideca-2,6-diene and 3,11-dimethyl-7-ethyl-11-ethoxy-1-acetoxytrideca-2,6-diene, and the like, are obtained.

EXAMPLE 40

Into a mixture of 2 g. of ethyl 3,7,11-trimethyl-10,11-oxido-2,6-dienoate in 150 ml. of ether, there is introduced a slow stream of hydrogen chloride for 1 hour at 0° C. The mixture is then allowed to stand at 0° C for 18 hours. Then the mixture is washed with a 5 percent aqueous sodium bicarbonate solution, dried over sodium sulfate and evaporated to an oil containing a mixture of ethyl 3,7,11-trimethyl-10-hydroxy-11-chlorododeca-2,6-dienoate, ethyl 3,7,11-trimethyl-10-chloro-11-hydroxydodeca-2,6-dienoate, ethyl 3,7,11-trimethyl-7,11-dichloro-10-hydroxydodec-2-enoate and ethyl 3,7,11-trimethyl-7,10-dichloro-11-hydroxydodec-2-enoate which are purified and separated by preparative silica chromatography.

EXAMPLE 41

The process of Example 25 is repeated with the exception that about 4.2 molar equivalents of M-chloro perbenzoic acid is employed, and there is obtained 2,3;6,7;10,11-(tris) oxido-3,11-dimethyl-7-ethyltridec-1-ol and minor amounts of the corresponding 6,7;10-(bis)-epoxide, and 10,11-epoxide which are separated and purified by silica chromatography.

In a similar manner other 2,6,10-triunsaturated compounds described herein (for example, see Examples 20-22) are converted into the corresponding tris, bis and mono epoxides.

EXAMPLE 42

The procedure of examples 30 and 32 is repeated with the exception of substituting hydrogen bromide in place of hydrogen chloride and the corresponding 11-bromo derivatives are obtained, e.g. methyl 11-bromo-3,7,11-trimethyltrideca-2,6-dienoate, 11-bromo-3,7,11-trimethyltrideca-2,6-dienoic acid, 11-bromo-3,7,11-trimethyltrideca-2,6-dien-1-ol, and the like.

EXAMPLE 43

The procedure of Example 27 is repeated with the exception of using bromine in place of chlorine and the corresponding 10,11-dibromo, 6,7-dibromo, and 6,7,10,11-tetrabromo derivatives are obtained, e.g. methyl 10,11-dibromo-3,7,11-trimethyltrideca-2,6-dienoate, methyl 6,7-dibromo-3,7,11-trimethyltrideca-2,10-dienoate, methyl 6,7,10,11-tetrabromo-3,7,11-trimethyltrideca-2-enoate, and the like.

EXAMPLE 44

The procedure of Example 26 is repeated with the exception that hydrogen bromide is employed in the place of hydrogen chloride and the corresponding 7,11-dibromo derivatives are obtained, e.g. methyl 7,11-dibromo-3,7,11-trimethyltridec-2-enoate, methyl 7,11-dibromo-3,7,11-trimethyldec-2-enoate, methyl 7,11-dibromo-3,11-dimethyl-7-ethyltridec-2-enoate, and the like.

EXAMPLE 45

Chlorine is bubbled slowly into CCl₄ at -10° C containing 2 grams of 3,7,11-trimethyltrideca-2,6,10-trien-1-ol until no more chlorine is consumed. The solution is evaporated at 0° C under reduced pressure to furnish 2,3,6,7,10,11-hexachloro-3,7,11-trimethyltridecan-1-ol.

Similarly, the tetrachloro derivatives can be prepared by introducing a smaller amount of chlorine. The reaction product which is an oil contains a mixture of tetrachloro and dichloro derivatives which are separated by column chromatography.

EXAMPLE 46

To a mixture of 5 g. of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate in 100 ml. of fluorotrichloromethane is slowly added anhydrous fluorine for 1 hour at a bout -78° C. After stirring the mixture at this temperature for about 16 hours, the resultant mixture is evaporated and chromatographed on silica furnishing methyl 6,7-difluoro-3,7,11-trimethyltrideca-2,10-dienoate, methyl 10,11-difluoro-3,7,11-

trimethyltrideca-2,6-dienoate and methyl 6,7,10,11-tetrafluoro-3,7,11-trimethyltridec-2-enoate.

In a similar manner, other 2,6,10-triunsaturated compounds described herein are converted into the corresponding 6,7-difluoro, 10,11-difluoro and 6,7,10,11-tetrafluoro derivatives, e.g., methyl 6,7-difluoro-3,7,11-trimethyldodeca-2,10-dienoate, methyl 10,11-difluoro 3,7,11-trimethyldodec-2,6-dienoate, methyl 6,7,10,11-tetrafluoro-3,7,11-trimethyltrideca-2-enoate, and the like.

By use of the procedure of this example, the 6,7-difluoro-, 10,11-difluoro-, and 6,7,10,11-tetrafluoro- derivatives of other aliphatic hydrocarbon esters are obtained.

EXAMPLE 47

A. 30 grams of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienoic acid are added to a mixture of 300 ml. of 98 percent formic acid, 200 ml. of water, 1.5 g. of sodium formate and p.5 g. of cetylpyridinium chloride. This mixture is then stirred vigorously at 30° C for 4 days and then partitioned between water and ethyl acetate. The ethyl acetate solution is washed with water, dried over sodium sulfate and evaporated under vacuum to yield trans, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid and trans 3,7,11-trimethyl-7,11-dihydroxydodeca-2-enoic acid.

20 grams of trans, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid in 100 ml. of ether are added to a solution of 6 g. of diazoethane in 150 ml. of ether. This mixture is allowed to stand at 0° C for 1 hour and the excess diazoethane is destroyed by the careful addition of acetic acid until the solution is colorless. The ether is evaporated under vacuum to yield trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate.

In a similar fashion there is obtained:
cis, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate;
trans, cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate;
and cis, cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate.

B. 10 grams of trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate in 250 ml. of anhydrous ether is added over a 30 minute period to a suspension of 10 g. of lithium aluminum hydride at -20° C stirred under nitrogen. This mixture is stirred at -20° C for 15 hours and then cautiously treated with acetic anhydride and then water. After removing the solid by filtration and washing it well with ether, the organic solution is dried over sodium sulfate and evaporated to yield trans, trans 3,7,11-trimethyldodeca-2,6-diene-1,11-diol.

In a similar fashion, there is obtained:
cis, trans 3,7,11-trimethyldodeca-2,6-diene-1,11-diol;
trans, cis 3,7,11-trimethyldodeca-2,6-diene-1,11-diol; and
cis, cis 3,7,11-trimethyldodeca-2,6-diene-1,11-diol.

EXAMPLE 48

A. To a solution of 28.2 g. of trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate in 250 ml. of dry ethyl acetate are added 500 mg. of (4 percent) activated palladium-on-barium sulfate. The resulting mixture is hydrogenated at room temperature until a 10 percent molar excess of gaseous hydrogen has been consumed. The mixture is filtered over diatomaceous earth, and the filtrate is added to 500 ml. of benzene, washed with 4 150 ml. portions of water, dried over sodium sulfate and evaporated to dryness under reduced pressure to yield predominately trans ethyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate which is purified by preparative scale gas-liquid chromatography.

B. By subjecting trans ethyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate to the procedure of Part B of Example 47, there is obtained trans 3,7,11-trimethyldodec-2-ene-1,11-diol.

cis 3,7,11-Trimethyldodec-2-ene-1,11-diol is similarly obtained.

EXAMPLE 49

28 grams of trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate are added to a suspension of 3.0 g. of sodium hydride in 110 ml. of benzene. This mixture, stirred until evolution of hydrogen ceases, and 47 g. of ethyl iodide are then added with stirring. This mixture is refluxed for 2 hours and then washed with water. Evaporation of solvent in vacuo yields trans, trans ethyl 3,7,11-trimethyl-11-ethoxydodeca-2,6-dienoate. Upon subjecting this compound to the procedure of Part B of Example 47 there is obtained trans, trans 3,7,11-trimethyl-11-ethoxydodeca-2,6-dien-1-ol.

Through the use of other alkyl halides such as methyl iodide, propyl bromide and the like, the corresponding 11-alkoxy derivatives are obtained, as for example trans, trans 3,7,11-trimethyl-11-methoxydodeca-2,6-dien-1-ol and trans, trans 3,7,11-trimethyl-11-propoxydodeca-2,6-dien-1-ol.

Similarly from the following starting materials listed under 5, there are obtained according to the procedure of this example the derivatives listed under 6.

5

cis, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate

trans, cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate

cis, cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate

trans ethyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate

cis ethyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate

6

cis, trans 3,7,11-trimethyl-11-ethoxydodeca-2,6-dien-1-ol

trans, cis 3,7,11-trimethyl-11-ethoxydodeca-2,6-dien-1-ol

cis, cis 3,7,11-trimethyl-11-ethoxydodeca-2,6-dien-1-ol

trans 3,7,11-trimethyl-11-ethoxydodec-2-en-1-ol

cis 3,7,11-trimethyl-11-ethoxydodec-2-en-1-ol

EXAMPLE 50

10 grams of methyl 2,3-oxido-3,7,11-trimethyltrideca-6,10-dienoate are added to 100 ml. of a 0.01N aqueous perchloric acid solution. The solution is allowed to stand at room temperature for 24 hours. Then, the solution is washed with aqueous sodium bicarbonate solution, dried over sodium sulfate and evaporated to an oil which is purified by silica chromatography to give methyl 2,3-dihydroxy-3,7,11-trimethyltrideca-6,10-dienoate.

By repeating the above procedure using in place of the aqueous perchloric acid solution, a 0.1N solution of perchloric acid in a lower monohydric alcohol, e.g., methanol, ethanol, propanol, and the like, the corresponding 2-hydroxy-3-alkoxy-derivatives is obtained, e.g., methyl 2-hydroxy-3-methoxy-3,7,11-trimethyltrideca-6,10-dienoate.

EXAMPLE 51

A. To a stirred solution of 7 g. of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate in 350 ml. of dioxane is added 20 ml. of 4N aqueous NaOH and 20 ml. of 30 percent hydrogen peroxide, maintaining a temperature of approximately 0° C. The solution is allowed to stand until complete (tlc) and poured into ice water. The mixture is washed with water, dried and evaporated to furnish methyl 2,3-oxido-3,7,11-trimethyltrideca-6,10-dienoate which is purified by chromatography.

By substituting other C-2 unsaturated compounds described herein (see Examples 1 through 5, for example) as the starting material in place of methyl 3,7,11-trimethyltrideca-3,6,10-trienoate, for example, methyl 3,7,11-trimethyltrideca-2,6,10-trienoate, methyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, methyl 7,11-dimethyl-3-ethyltrideca-2,6,10-trienoate, ethyl 3,7,11-trimethyltrideca-2,6,10-trienoate, methyl 3,7,11-trimethyl-11-ethoxytrideca-2,6-dienoate, and

the like, the corresponding 2,3-epoxides are obtained, i.e., methyl 2,3-oxido-3,7,11-trimethyltrideca-6,10-dienoate, methyl 2,3-oxido-3,11-dimethyl-7-ethyltrideca-6,10-dienoate, and the like.

B. A suspension of 0.5 g. of 5 percent palladium-on-carbon catalyst in 50 ml. of benzene is hydrogenated for 10 minutes. A mixture of 2 g. of methyl 2,3-oxido-3,7,11-trimethyltrideca-6,10-dienoate in 100 ml. of methanol is added and hydrogenated with agitation until the theoretical amount of hydrogen has been absorbed. The catalyst is removed by filtration and the solution evaporated to an oil which is purified and separated by gas-liquid chromatography to furnish methyl 2,3-oxido-3,7,11-trimethyltridecanoate, methyl 2,3-oxido-3,7,11-trimethyltridec-6-enoate and methyl 2,3-oxido-3,7,11-trimethyltridec-10-enoate.

Alternatively, methyl 2,3-oxido-3,7,11-trimethyltrideca-6,10-dienoate is subjected to the process of Example 48 to furnish the corresponding 6,7;10,11-tetrahydro, 10,11-dihydro and 6,7-dihydro derivatives.

By repeating the above hydrogenation processes using as the starting material, the other 2,3-epoxides containing at least one double bond as described in Part A above, the dihydro and tetrahydro derivatives thereof are obtained, e.g. methyl 2,3-oxido-3,7,11-trimethyltridecanoate and the 6-dehydro and 10-dehydro derivative:

methyl 2,3-oxido-3,11-dimethyl-7-ethyltridecanoate and the 6-dehydro and 10-dehydro derivative:

methyl 2,3-oxido-7,11-dimethyl-3-ethyltridecanoate and the 6-dehydro and 10-dehydro derivative;

ethyl 2,3-oxido-3,7,11-trimethyltridecanoate and the 6-dehydro and 10-dehydro derivatives;

methyl 2,3-oxido-3,7,11-trimethyl-11-ethoxytridecanoate; and the like.

In like manner, the unsaturated compounds of Example 25 are hydrogenated to furnish the dihydro and tetrahydro derivatives thereof, e.g.,

10,11-oxido-3,11-dimethyl-7-ethyltridec-2-en-1-ol and

10,11-oxido-3,11-dimethyl-7-ethyltridecan-1-ol;

6,7-oxido-3,11-dimethyl-7-ethyltridec-2-3n-1-ol and 6,7-oxido-3,11-dimethyl-7-ethyltridecan-1-ol;

6,7;10,11-(bis) oxido-3,11-dimethyl-7-ethyltridecan-1-ol;

methyl 10,11-oxido-3,11-dimethyl-7-ethyltridec-2-enoate and the corresponding 2,3-dihydro;

methyl 10,11-oxido-3,7,11-trimethyltridec-2-enoate and the corresponding 2,3-dihydro;

10,11-oxido-3,7,11-trimethyltridec-2-enoic acid and the corresponding 2,3-dihydro;

10,11-oxido-3,11-dimethyl-7-ethyltridec-2-enoic acid and the corresponding 2,3-dihydro; and the like.

Similarly, the unsaturated compounds of Example 39 are hydrogenated to obtain the corresponding 6,7-dihydro and 2,3; 6,7-tetrahydro derivatives, e.g.,

methyl 3,7,11-trimethyl-11-ethoxytridec-2-enoate and the corresponding 2,3-dihydro;

methyl 3,11-dimethyl-7-ethyl-11-ethoxytridec-2-enoate and the corresponding 2,3-dihydro; and the like.

By repeating the process of Example 6 using as the starting material, the acid esters prepared above, e.g., methyl 2,3-oxido-3,7,11-trimethyltrideca-6,10-dienoate, methyl 2,3-oxido-3,7,11-trimethyltridecanoate, and the like, there are obtained the corresponding free acids, e.g., 2,3-oxido-3,7,11-trimethyltrideca-6,10-dienoic acid, and the like.

EXAMPLE 52

The procedure of Example 29 is repeated with the exception of using bromine in place of chlorine and the corresponding 6,7-dibromo derivatives are obtained, e.g., methyl 6,7-dibromo-10,11-oxido-3,7,11-trimethyltridec-2-enoate, methyl 6,7-dibromo-10,11-oxido-3,7,11-trimethyltridec-2-enoate, and the like.

Similarly, by employing as the starting material in the above process and that of Examples 29 and 46 other epoxides

described herein (see for example, Examples 25, 38, 41 and 51) containing at least one double bond in the carbon chain, the dichloro, dibromo and difluoro derivatives are obtained, e.g., methyl 10,11-dichloro-6,7-oxido-3,7,11-trimethyltridec-2-enoate, methyl 6,7,10,11-tetrachloro-2,3-oxido-3,7,11-trimethyltridecanoate, methyl 6,7-dichloro-2,3-oxido-3,7,11-trimethyltridec-10-enoate, methyl 10,11-dichloro-2,3-oxido-3,7,11-trimethyltridec-6-enoate, and the corresponding bromo and fluoro derivatives, methyl 6,7-difluoro-10,11-oxido-3,7,11-trimethyltridec-2-enoate, and the corresponding 6,7-oxido and 2,3-oxido derivatives; and the like.

EXAMPLE 53

To a solution of 24 g. of 3,7,11-trimethyldodeca-2,6,10-trienoic acid in 100 ml. of benzene is added 2.44 g. of sodium hydride and this mixture is stirred at 25° C until evolution of hydrogen ceases and then cooled to 7° C. Oxalyl chloride (14.5 gn) in 25 ml. of benzene is next added slowly with stirring and the mixture is then allowed to stand at 25° C for 6 hours. At the end of this time, 20 ml. of methanol are added and the resulting mixture is stirred at 25° C for an additional 14 hours. This mixture is washed three times with 200 ml. portions of water, dried and evaporated in vacuo to yield methyl 3,7,11-trimethyldodeca-2,6,10-trienoate.

Use of other alcohols in the foregoing procedure such as ethanol, propanol, isopropanol, hexanol, octanol and the like in place of methanol yields the corresponding alkyl esters.

EXAMPLE 54

Dry hydrogen chloride is bubbled through 100 ml. of dry CCl₄ at 0° C for about 15 minutes. 1 gram of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienoic acid is added and the resulting solution is allowed to stand at 0° C for 5 hours. The solution is then washed with water, aqueous sodium bicarbonate solution and again with water, dried over sodium sulfate and evaporated to yield an oil. Upon purification by thin layer chromatography there is obtained trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid.

By substituting the corresponding cis, trans; trans, cis; and cis, cis isomeric starting materials in each of these variations there are obtained:

cis, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid;
cis, trans 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid;
trans, cis 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid;
trans, cis 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid;
cis, cis 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid;
and cis, cis 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid.

EXAMPLE 55

1 gram of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienoic acid is added to a solution of anhydrous hydrogen fluoride in tetrahydrofuran. The mixture is allowed to stand at 0° C for 15 hours and is then washed with water, aqueous sodium bicarbonate and again with water, dried and evaporated to yield an oil. This is purified by thin layer chromatography to produce trans, trans 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid.

Alternatively, 1 g. of trans, trans 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid in 20 ml. of acetonitrile is refluxed with 500 mg. of anhydrous silver fluoride for 12 hours. The reaction mixture is then cooled, filtered and diluted with ether. This organic solution is washed with water, dried over sodium sulfate and evaporated. The residue thus obtained is chromatographed to yield trans, trans 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid.

In similar fashions there are obtained:

cis, trans 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid;

trans, cis 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid;
and cis, cis 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid.

EXAMPLE 56

2 grams of trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid in 10 ml. of ether are added to a solution of 0.6 g. of diazoethane in 15 ml. of ether. This mixture is allowed to stand at 0° C for 1 hour and the excess diazoethane is then destroyed by the careful addition of acetic acid until the solution is colorless. The solvent is removed under vacuum to yield trans, trans ethyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate.

In a similar fashion there is obtained:

cis, trans ethyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate; cis, trans ethyl 3,7,11-trimethyl-11-bromododeca-2,6-dienoate; cis, trans ethyl 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid; trans, cis ethyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate; trans, cis ethyl 3,7,11-trimethyl-11-bromododeca-2,6-dienoate; trans, cis ethyl 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid; cis, cis ethyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate; cis, cis ethyl 3,7,11-trimethyl-11-bromododeca-2,6-dienoate; and cis, cis ethyl 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid.

By substituting diazomethane and diazopropane in the foregoing procedure, the corresponding methyl and propyl esters are obtained, e.g., trans, trans methyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate, trans, trans propyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate and the like.

Alternatively, 3,7,11-trimethyldodeca-2,6,10-trienoic acid may be esterified according to the procedure of this example and the resulting ester then hydrohalogenated as described in Example 54.

EXAMPLE 57

To a solution of 28 g. of trans, trans ethyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate in 250 ml. of dry ethyl acetate are added 500 mg. of (4 percent) activated palladium-on-barium sulfate. The resulting mixture is hydrogenated at room temperature until 10 percent molar excess of gaseous hydrogen has been consumed. The mixture is then filtered through diatomaceous earth, diluted with 500 ml. of benzene, washed with 4 150 ml. portions of water, dried over sodium sulfate and evaporated to dryness under reduced pressure to predominately yield trans ethyl 3,7,11-trimethyl-11-chlorododec-2-enoate which is purified by preparative scale gas-liquid chromatography.

Similarly, trans ethyl 3,7,11-trimethyl-11-fluorododec-2-enoate is prepared from trans, trans ethyl 3,7,11-trimethyl-11-fluorododeca-2,6-dienoate or from trans, cis ethyl 3,7,11-trimethyl-11-fluorododeca-2,6-dienoate via the procedure of this example.

By the procedure described herein, the compounds listed under Column 4 are prepared from the respective compounds listed under Column 3.

3	4
cis, trans 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid	cis 3,7,11-trimethyl-11-bromododec-2-enoic acid
cis, cis 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid	cis 3,7,11-trimethyl-11-chlorododec-2-enoic acid
trans, cis 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid	trans 3,7,11-trimethyl-11-fluorododec-2-enoic acid
trans, cis methyl 3,7,11-trimethyl-11-fluorododeca-2,6-dienoate	trans methyl 3,7,11-trimethyl-11-fluorododec-2-enoate
trans, cis propyl 3,7,11-trimethyl-11-bromododeca-2,6-dienoate	trans propyl 3,7,11-trimethyl-11-bromododec-2-enoate
cis, cis isopropyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate	cis isopropyl 3,7,11-trimethyl-11-chlorododec-2-enoate
cis, trans hexyl 3,7,11-	cis hexyl 3,7,11-trimethyl-

trimethyl-11-fluorododeca-
2,6-dienoate

11-fluorododec-2-enoate

EXAMPLE 58

A solution of 0.5 g. of trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid in absolute methanol is titrated with a methanolic solution of sodium methoxide. Ether is added and the solid is collected, washed with methanol and dried to yield sodium trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate.

EXAMPLE 59

The procedure of Example 55 is repeated with the exception of using other 2,6,10-triunsaturated compounds described herein as the starting material to obtain the corresponding 11-fluoro-2,6-diunsaturated derivatives, e.g., 11-fluoro-3,7,11-trimethyltrideca-2,6-dienoic acid, 11-fluoro-3,11-dimethyl-7-ethyltrideca-2,6-dienoic acid, methyl 11-fluoro-3,7,11-trimethyltrideca-2,6-dienoate. Similarly, by the procedure of Example 32B, there is obtained 11-fluoro-3,7,11-trimethyltrideca-2,6-dien-1-ol, 11-fluoro-3,11-dimethyl-7-ethyltrideca-2,6-dien-1-ol, 1-acetoxy-11-fluoro-3,7,11-trimethyltrideca-2,6-diene, and the like.

EXAMPLE 60

The process of Example 35 is repeated with the exception of using hydrogen bromide in place of hydrogen chloride and the corresponding 11-bromo-10-hydroxy and 7,11-dibromo-10-hydroxy derivatives are obtained, e.g., methyl 11-bromo-10-hydroxy-3,7,11-trimethyltrideca-2,6-dienoate, methyl 7,11-dibromo-10-hydroxy-3,7,11-trimethyltridec-2-enoate, and the like.

EXAMPLE 61

30 grams of trans,trans 3,7,11-trimethyldodeca-2,6,10-trienoic acid are added to a mixture of 300 ml. of 98 percent formic acid, 200 ml. of water, 1.5 g. of sodium formate and 0.5 g. of cetylpyridinium chloride. This mixture is then stirred vigorously at 30° C for 4 days and then partitioned between water and ethyl acetate. The ethyl acetate solution is washed with water, dried over sodium sulfate and evaporated under vacuum to yield trans,trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid and trans 3,7,11-trimethyl-7,11-dihydroxydodeca-2-enoic acid which are purified and separated by silica chromatography.

EXAMPLE 62

20 grams of trans,trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid in 100 ml. of ether are added to a solution of 6 g. of diazoethane in 150 ml. of ether. This mixture is allowed to stand at 0° C for 1 hour and the excess diazoethane is destroyed by the careful addition of acetic acid until the solution is colorless. The ether is evaporated under vacuum to yield trans,trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate.

In a similar fashion, there is obtained cis,trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate; trans,cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate; and cis, cis ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate.

By substituting diazomethane and diazopropane, the corresponding methyl and propyl esters are obtained, e.g., trans, trans methyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate and trans,trans propyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate.

EXAMPLE 63

The process of Example 61 is repeated with the exception of substituting other 2,6,10-triunsaturated compounds described herein (see, for example, Example 6) as the starting material and there is obtained the corresponding 11-hydroxy and 7,11-dihydroxy derivatives, e.g., 3,7,11-trimethyl-11-hydroxytrideca-2,6-dienoic acid, 3,7,11-trimethyl-7,11-dihydrox-

tridec-2-enoic acid; 3,11-dimethyl-7-ethyl-11-hydroxytrideca-2,6-dienoic acid, 3,11-dimethyl-7-ethyl-7,11-dihydroxytridec-2-enoic acid; 3,7-diethyl-11-methyl-11-hydroxytrideca-2,6-dienoic acid, 3,7-diethyl-11-methyl-7,11-dihydroxytridec-2-enoic acid, and the like.

By repeating the procedure of Examples 62 and 20 using the above-prepared 11-hydroxy derivatives, the corresponding alkyl esters and C-1 alcohols respectively, are obtained, e.g., methyl 3,7,11-trimethyl-11-hydroxytrideca-2,6-dienoate and 3,7,11-trimethyltrideca-2,6-diene-1,11-diol, respectively, and the like.

EXAMPLE 64

By repeating the process of Example 61 with the exception of substituting the corresponding cis, trans; trans, cis; and cis, cis isomers of 3,7,11-trimethyldodeca-2,6,10-trienoic acid for the starting material, there are respectively obtained cis, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid, cis 3,7,11-trimethyl-7,11-dihydroxydodeca-2-enoic acid, trans, cis 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid, trans 3,7,11-trimethyl-7,11-dihydroxydodeca-2-enoic acid, cis, cis 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid and cis 3,7,11-trimethyl-7,11-dihydroxydodeca-2-enoic acid.

EXAMPLE 65

28 grams of trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate are added to a suspension of 3.0 g. of sodium hydride in 110 ml. of benzene. This mixture stirred until evolution of hydrogen ceases, and 47 g. of ethyl iodide are then added with stirring. This mixture is refluxed for 2 hours and then washed with water. Evaporation of solvent in vacuo yields trans, trans ethyl 3,7,11-trimethyl-11-ethoxydodeca-2,6-dienoate.

Through the use of other alkyl iodides or alkyl bromides, the corresponding ethers are obtained, e.g., trans, trans ethyl 3,7,11-trimethyl-11-methoxydodeca-2,6-dienoate and cis, trans ethyl 3,7,11-trimethyl-11-propoxydodeca-2,6-dienoate.

Use of benzyl bromide or phenethyl bromide in the foregoing procedure yields trans, trans ethyl 3,7,11-trimethyl-11-benzyloxydodeca-2,6-dienoate and trans, trans ethyl 3,7,11-trimethyl-11-phenylethoxydodeca-2,6-dienoate.

By use of the procedure of Example 27, the 6,7-dichloro derivatives of the above compounds are obtained, e.g., trans ethyl 3,7,11-trimethyl-6,7-dichloro-11-ethoxydodec-2-enoate.

EXAMPLE 66

30 grams of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienal are added to a mixture of 300 ml. of 98 percent formic acid, 200 ml. of water and 1.5 g. of sodium formate. This mixture is agitated vigorously at 30° C for 4 days and then partitioned between water and ethyl acetate. The organic layer is washed with water and evaporated under vacuum to yield trans, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienal and trans 3,7,11-trimethyl-7,11-hydroxydodeca-2,6-dienal and trans 3,7,11-trimethyl-7,11-dihydroxydodeca-2-enal which are purified and separated by silica chromatography.

EXAMPLE 67

To a mixture of 1.6 grams of bromine in 100 ml. of carbon tetrachloride is slowly added 2.1 grams of trans, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienal in 25 ml. of carbon tetrachloride at 10° C. The reaction mixture is stirred until it is faintly yellow. Then the mixture is evaporated at ice temperature to an oil which is purified by chromatography on silica to furnish trans 3,7,11-trimethyl-11-hydroxy-6,7-dibromododec-2-enal.

EXAMPLE 68

To a solution of 25 g. of trans, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienal in 40 ml. of ethanol cooled to 0° C is added a solution of 40 g. of silver nitrate in 60 ml. of water.

This is followed by the dropwise addition of a solution of 20 g. of potassium hydroxide in 340 ml. of water. This mixture is stirred for 48 hours at 20° C and then filtered. The solid is washed with hexane and the filtrate is acidified to pH 2 and extracted with ether. These extracts are dried over sodium sulfate and evaporated to yield trans, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid, identical to that obtained in Example 61.

EXAMPLE 69

1 gram of trans, trans ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate in 10 ml. of diglyme is added in a dropwise fashion over a 20 minute period to a slurry of 1 g. of sodium hydride in 10 ml. of diglyme under a nitrogen atmosphere. There is next added in a dropwise fashion over a 10 minute period 0.9 g. of 2-chlorotetrahydropyran. This mixture is stirred at about 25° C for 30 minutes and then quenched in ice water. The organic phase is separated and extracted with ether. These extracts are washed with water, dried over sodium sulfate and evaporated to yield trans, trans ethyl 3,7,11-trimethyl-11-(tetrahydropyran-2'-yloxy)dodeca-2,6-dienoate. Upon subjecting this compound to the procedure of Example 47 Part B, there is obtained trans, trans 3,7,11-trimethyl-11-(tetrahydropyran-2'-yloxy)dodeca-2,6-dien-1-ol.

Similarly obtained from trans ethyl 3,7,11-trimethyl-11-hydroxydodec-2-enoate is trans 3,7,11-trimethyl-11-(tetrahydropyran-2yloxy)-dodec-2-en-1-ol.

By employing 2-chlorotetrahydrofuran in the foregoing procedure the corresponding tetrahydrofuranyl ether is obtained.

EXAMPLE 70

Dry hydrogen chloride is bubbled through 100 ml. of dry CCl₄ at 0° C for about 15 minutes. 1 gram of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienoic acid is added and the resulting solution is allowed to stand at 0° C for 5 hours. The solution is then washed with water, aqueous sodium bicarbonate solution and again with water, dried over sodium sulfate and evaporated to yield an oil. Upon purification by thin layer chromatography there is obtained trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid.

2 grams of trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid in 10 ml. of ether are added to a solution of 0.6 g. of diazoethane in 15 ml. of ether. This mixture is allowed to stand at 0° C for 1 hour and the excess diazoethane is then destroyed by the careful addition of acetic acid until the solution is colorless. The solvent is removed under vacuum to yield trans, trans ethyl 3,7,11-chlorododeca-2,6-dienoate.

Upon subjecting trans, trans ethyl 3,7,11-trimethyl-11-chlorododeca-2,6-dienoate to the procedure of Example 47 Part B, there is obtained trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dien-1-ol.

By substituting hydrogen bromide for hydrogen chloride in the foregoing and completing the steps thereafter described there is obtained trans, trans 3,7,11-trimethyl-11-bromododeca-2,6-dien-1-ol.

EXAMPLE 71

1 gram of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienoic acid is added to a solution of anhydrous hydrogen fluoride in tetrahydrofuran. The mixture is allowed to stand at 0° C for 15 hours and is then washed with water, aqueous sodium bicarbonate and again with water, dried and evaporated to yield an oil. This is purified by thin layer chromatography to produce trans, trans 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid.

Alternatively 1 g. of trans, trans 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid in 20 ml. of acetonitrile is refluxed with 500 mg. of anhydrous silver fluoride for 12 hours. The reaction mixture is then cooled, filtered and diluted with ether. This organic solution is washed with water, dried over sodium sulfate and evaporated. The residue thus

obtained is chromatographed to yield trans, trans 3,7,11-trimethyl-11-fluorododeca-2,6-dienoic acid.

Upon esterification of this compound as described in Example 70 and reduction as described in Example 47 Part B, there is obtained trans, trans 3,7,11-trimethyl-11-fluorododeca-2,6-dien-1-ol.

EXAMPLE 72

To a solution of 28 g. of trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dien-1-ol in 250 ml. of dry ethyl acetate are added 500 mg. of (4 percent) activated palladium-on-barium-sulfate. The resulting mixture is hydrogenated at room temperature until 10 percent molar excess of gaseous hydrogen has been consumed. The mixture is then filtered through diatomaceous earth, diluted with 500 ml. of benzene, washed with 4 150 ml. portions of water, dried over sodium sulfate and evaporated to dryness under reduced pressure to predominately yield trans 3,7,11-trimethyl-11-chlorododec-2-en-1-ol which is purified by preparative scale gas-liquid chromatography.

Similarly, trans 3,7,11-trimethyl-11-fluorododec-2-en-1-ol is prepared from trans, trans 3,7,11-trimethyl-11-fluorododeca-2,6-dien-1-ol or from trans, cis 3,7,11-trimethyl-11-fluorododeca-2,6-dien-1-ol via the procedure of this example.

EXAMPLE 73

A mixture of 1 g. of trans, trans 3,7,11-trimethyldodeca-2,6-diene-1,11-diol, 4 ml. of pyridine and 2 ml. of acetic anhydride is allowed to stand at room temperature for 15 hours. The mixture is then poured into water and stirred. This mixture is extracted with methylene chloride and the organic extracts are dried and evaporated to yield trans, trans 1-acetoxy-3,7,11-trimethyldodeca-2,6-dien-1-ol which can be further purified through chromatography.

EXAMPLE 74

A mixture of 1 g. of trans, trans 3,7,11-trimethyldodeca-2,6-diene-1,11-diol, 1 g. of p-toluenesulfonic acid monohydrate, 50 ml. of acetic acid and 25 ml. of acetic anhydride is allowed to stand at room temperature for 25 hours, and is then poured into water and stirred. This mixture is extracted with methylene chloride and these extracts are dried and evaporated to yield trans, trans 1,11-diacetoxy 3,7,11-trimethyldodeca-2,6-diene which is purified through chromatography.

EXAMPLE 75

1 gram of trans, trans 1,11-diacetoxy-3,7,11-trimethyldodeca-2,6-diene is treated with 7.1 ml. of a 0.3 percent solution of potassium carbonate in 9:1 methanol:water. The mixture is allowed to stand for 5 hours and then poured into water. This mixture is extracted with methylene chloride and the combined organic extracts are dried and evaporated to yield trans, trans 3,7,11-trimethyl-11-acetoxydodeca-2,6-dien-1-ol.

EXAMPLE 76

2 milliliters of dihydropyran are added to a solution of 1 g. of trans, trans 3,7,11-trimethyl-11-acetoxydodeca-2,6-dien-1-ol in 15 ml. of benzene. About 1 ml. is removed by distillation to remove moisture and 0.4 g. of p-toluene-sulfonic acid is added to the cooled solution. This mixture is allowed to stand at room temperature for 4 days and is then washed with an aqueous sodium carbonate solution and water, dried and evaporated. The oily residue is chromatographed on neutral alumina, eluting with hexane, to yield trans, trans 1-(tetrahydropyran-2'-yloxy)-3,7,11-trimethyl-11-acetoxydodeca-2,6-diene.

EXAMPLE 77

A solution of 0.17 g. of potassium hydroxide in 0.2 ml. of water and 2.5 mo. of methanol is added over 30 minutes to a refluxing solution of 1 g. of trans, trans 1-(tetrahydropyran-2'-yloxy)-3,7,11-trimethyl-11-acetoxydodeca-2,6-diene in 30 ml. of methanol under nitrogen. The solution is refluxed for 2 hours, cooled, neutralized with acetic acid and concentrated under reduced pressure. After the addition of water, the mixture is extracted with methylene chloride and the combined organic extracts are dried and evaporated to yield trans, trans 1-(tetrahydropyran-2'-yloxy)-3,7,11-trimethyldodeca-2,6-dien-11-ol which is purified through chromatography.

EXAMPLE 78

By repeating the procedure of paragraph 4 of Example 31 using the products of Example 35 and 60 as the starting material, the corresponding lower alkoxy derivatives are obtained, e.g. methyl 11-chloro-10-methoxy-3,7,11-trimethyltrideca-2,6-dienoate, methyl 7,11-dichloro-10-methoxy-3,7,11-trimethyltridec-2-enoate, methyl 11-bromo-10-methoxy-3,7,11-trimethyltrideca-2,6-dienoate, methyl 7,11-dibromo-10-methoxy-3,7,11-trimethyltridec-2-enoate, and the like.

In a like manner, by using a lower monohydric alcohol as the reaction medium in the process of Example 36 (Part A), the corresponding 11-alkoxy, 7-alkoxy, and 7,11-dialkoxy derivatives are obtained, e.g. methyl 3,7,11-trimethyl-10-bromo-11-methoxytrideca-2,6-dienoate, methyl 3,7,11-trimethyl-6-bromo-7-methoxytrideca-2,10-dienoate, methyl 3,7,11-trimethyl-6,10-dibromo-7,11-dimethoxytridec-2-enoate, methyl 3,7,11-trimethyl-11-methoxytrideca-2,6-dienoate, methyl 3,11-dimethyl-7-ethyl-11-methoxytrideca-2,6-dienoate, and the like and the corresponding 10-chloro, 6-chloro, and 6,10-dichloro derivatives, and the like.

EXAMPLE 79

The 2,3-methylene compounds (Example 23, for example) can be modified at positions C-6, C-7, C-10 and C-11 in accordance with the procedures described herein (for example, the procedures of Examples 25-27, 29-32, 35-39, 42-44, 46, 51B, 52, 59, 60, 63 and 78) to obtain the corresponding substituted 2,3-methylene derivatives and the saturated and mono-unsaturated derivatives thereof.

EXAMPLE 80

To a solution of 10 g. of methyl 2,3-oxido-3,7,11-trimethyltrideca-6,10-dienoate in 150 ml. of ether is added 1 molar equivalent of lithium aluminum hydride. The solution is then allowed to stand at 0° C for 30 minutes and then 5 ml. of ethyl acetate is cautiously added followed by 2 ml. of water. Then a small amount of sodium sulfate is added with stirring, the mixture is filtered and the filtrate is evaporated to give 3,7,11-trimethyltrideca-6,10-diene-1,3-diol and 3,7,11-trimethyltrideca-6,10-dien-1-ol which can be purified and separated by silica chromatography.

By the above process, 3,7,11-trimethyldodeca-6,10-diene-1,3-diol and 3,11-dimethyl-7-ethyltrideca-6,10-diene-1,3-diol and the corresponding 6,10-dien-1-ol's are obtained from the corresponding 2,3-oxido compound.

Similarly, by use of the Reformatsky reaction (see U.S. Pat. No. 3,031,481, Example 1), the ketones of formula VIII above obtained via procedure of Example 1 (Part B), are converted into the corresponding 3-hydroxy acids, e.g. 6,10-dimethyl-dodeca-5,9-dien-2-one is converted into 3-hydroxy-3,7,11-trimethyltrideca-6,10-dienoic acid.

The above-described 3-hydroxy alcohols can be etherified and esterified to obtain the 3-alkoxy and 3-acyloxy derivatives by procedures described herein (see, e.g. Examples 21, 22 and 39). Additional substituents and modifications can be made at positions C-6, C-7, C-10 and C-11 via the procedures described herein, procedures of Examples 30, 42-44, 46, 51B,

52, 59, 60 and 78 to obtain 3-hydroxy, 3-alkoxy and 3-acyloxy substituted saturated and mono-unsaturated derivatives.

EXAMPLE 81

To a solution of 2 grams of 11-chloro-3,7,11-trimethyltrideca-2,6-dienoic acid in 50 ml. of benzene, there is added with stirring a molar equivalent of potassium bicarbonate. The mixture is stirred until the evolution of carbon dioxide ceases and then the mixture is evaporated to furnish potassium 11-chloro-3,7,11-trimethyltrideca-2,6-dienoate which can be purified by silica chromatography, if desired.

By subjecting other acids described herein (see Examples 25-27, 29, 30, 35-39 and 63, for example) to the above process, the corresponding potassium acid salts are obtained.

Similarly, by using sodium bicarbonate, and the like, in the above process, the corresponding sodium acid salts are obtained.

EXAMPLE 82

6 grams of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate is dissolved in 250 ml. of dioxane and 150 ml. of water. The solution is cooled to 10° C and treated with 4 g. of N-bromosuccinimide, added in portions with stirring. The mixture is stirred at about 25° C for 15 hours and then diluted with water, treated with sodium bisulfite, and extracted with ether. These ethereal extracts are washed with water, dried over sodium sulfate and evaporated to yield methyl 3,7,11-trimethyl-10-bromo-11-hydroxydodeca-2,6-dienoate which may be purified via chromatography on silica, eluting with 1 percent methanol in chloroform.

A solution of 2.8 g. of this ester in 50 ml. of ethanol is stirred for 2 hours at 20° C with a suspension of 5.5 g. of Raney nickel in 5 ml. of ethanol. The mixture is then filtered through Celite diatomaceous earth and the filtrate is evaporated to yield methyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate which may be purified via chromatography on silica, eluting with 1 percent methanol in chloroform.

A solution of 2.8 g. of this ester in 50 ml. of ethanol is stirred for 2 hours at 20° C with a suspension of 5.5 g. of Raney nickel in 5 ml. of ethanol. The mixture is then filtered through Celite diatomaceous earth and the filtrate is evaporated to yield methyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate which may be purified via chromatography on silica, eluting with 1% methanol in chloroform.

EXAMPLE 83

To a solution of 10 g. of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate in 50 ml. of benzene is added 1.2 molar equivalents of trimethyltrifluoromethyl tin and 1.2 molar equivalents of sodium iodide in 10 ml. of monoglyme. The mixture is refluxed for 2 hours after which it is cooled, washed with water, and evaporated to an oil which is purified and separated by gas-liquid chromatography to give methyl 6,7-difluoromethylene-3,7,11-trimethyltrideca-2,10-dienoate, methyl 10,11-difluoromethylene-3,7,11-trimethyltrideca-2,6-dienoate and methyl 6,7,10,11-(bis) difluoromethylene-3,7,11-trimethyltridec-2-enoate.

By repeating the above process with the exceptions of using 2.5 molar equivalents of trimethyltrifluoromethyl tin and sodium iodide, a predominate amount of the 6,7,10,11-bis(difluoromethylene) is obtained.

EXAMPLE 84

To a solution of 10 g. of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate in 50 ml. of benzene is added 1.2 molar equivalents of phenyldichlorobromomethyl mercury. The mixture is refluxed for 4 hours after which it is cooled and evaporated to an oil which is purified and separated by silica chromatography to give methyl 6,7-dichloromethylene-3,7,11-trimethyltrideca-2,10-dienoate, methyl 10,11-dichloromethylene-3,7,11-trimethyltrideca-2,6-dienoate, and

methyl 6,7;10,11-(bis)dichloromethylene-3,7,11-trimethyltridec-2-enoate.

By repeating the above process using 2.5 molar equivalents of phenyldichlorobromo-methyl mercury, there is obtained predominantly the 6,7;10,11-(bis)dichloromethylene compound.

EXAMPLE 85

Dry hydrogen chloride is bubbled through 100 ml. of ethyl ether at 0° C for about 15 minutes. 1 gram of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienoic acid is added and the resulting solution is allowed to stand at 0° C for 5 hours. The solution is then washed with water, aqueous sodium bicarbonate solution and again with water, dried over sodium sulfate and evaporated to yield an oil. Upon purification by a thin layer chromatography there is obtained trans, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid.

By substituting hydrogen bromide for hydrogen chloride in the foregoing procedure, there is obtained trans, trans 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid.

By substituting the corresponding cis, trans; trans, cis; and cis, cis isomeric starting materials in each of these variations there are obtained:

cis, trans 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid; cis, trans 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid; trans, cis 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid; trans, cis 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid; cis, cis 3,7,11-trimethyl-11-chlorododeca-2,6-dienoic acid; and cis, cis 3,7,11-trimethyl-11-bromododeca-2,6-dienoic acid.

EXAMPLE 86

50 grams of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienoic acid are added to 450 g. of 35 percent aqueous sulfuric acid and shaken under nitrogen at 3° C for 15 hours. The mixture is then diluted with water, neutralized with sodium bicarbonate and extracted with ether. The ethereal extracts are evaporated to dryness to yield trans, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoic acid.

In a like fashion the corresponding cis, trans; trans, cis, and cis, cis derivatives are obtained from the corresponding isomeric starting material.

24 grams of trans, trans 3,7,11-trimethyldodeca-2,6,10-trienal is shaken at -20° C with 3 N aqueous sulfuric acid for 16 hours. The mixture is neutralized with sodium bicarbonate, and extracted with ether. The ether extracts are dried and evaporated to yield trans, trans 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienal which is further purified through chromatography on silica.

The aliphatic hydrocarbon acids, esters and alcohols having a free hydroxyl at C-11 can be etherified by a monovalent hydrocarbon group. This hydrocarbon group may be an alkyl group of from one to eight carbon atoms such as methyl, ethyl, propyl, isopropyl, butyl, sec-butyl, pentyl or the like, an alkenyl group of from two to eight carbon atoms such as allyl, butenyl, and the like or an aralkyl group such as benzyl, phenethyl or the like.

Esters of the aliphatic hydrocarbon acids may also be obtained through conversion of the aliphatic hydrocarbon acid, e.g., 3,7,11-trimethyl-11-halododeca-2,6-dienoic acid, to the corresponding acid chloride and treatment of this acid chloride with a suitable alcohol such as ethanol, propanol, methanol, butanol, and the like.

EXAMPLE 87

The procedure of Example 24 is repeated with the exception of using as the starting material, ethyl 3,7,11-trimethyldodeca-2,10-dienoate, ethyl 3,11-dimethyl-7-ethyldodeca-2,10-dienoate, ethyl 3,7-dimethyl-11-ethyltrideca-2,10-dienoate, ethyl 3,11-dimethyl-11-ethyltrideca-2,10-dienoate and ethyl 3,7,11-trimethyltrideca-2,10-dienoate in place of methyl 3,7,11-trimethyltrideca-2,6,10-trienoate and the respective 10,11-methylene derivatives are obtained, i.e.

ethyl 10,11-methylene-3,7,11-trimethyldodeca-2-enoate, ethyl 10,11-methylene-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 10,11-methylene-3,11-dimethyl-7-ethyldodec-2-enoate, ethyl 10,11-methylene-3,7-dimethyl-11-ethyltridec-2-enoate, and ethyl 10,11-methylene-3,7,11-trimethyltridec-2-enoate.

The thus-obtained ethyl esters are hydrolyzed using the procedure of Example 6 to yield the corresponding acids, e.g., 10,11-methylene-3,7,11-trimethyldodec-2-enoic acid.

By use of the procedure of Example 20, the ethyl esters are converted to the corresponding C-1 alcohols, e.g., 10,11-methylene-3,7,11-trimethyldodec-2-en-1-ol, which on treatment with sodium hydride and an alkyl halide, e.g. ethyl iodide (Example 22), affords the corresponding C-1 ether, e.g. the ethyl ether of 10,11-methylene-3,7,11-trimethyldodec-2-en-1-ol.

EXAMPLE 88

6 grams of methyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate is dissolved in 250 ml. of tetrahydrofuran and 150 ml. of water. The solution is cooled to 10° C and 4 g. of N-bromosuccinimide is added in small portions over a period of about 2 hours with stirring. The mixture is then diluted with water, treated with sodium bisulfite and extracted with ether. The ethereal extracts are washed with water, dried over sodium sulfate and evaporated to yield methyl 10-bromo-11-hydroxy-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, a small amount of methyl 6-bromo-7-hydroxy-3,11-dimethyl-7-ethyltrideca-2,10-dienoate and methyl and methyl 6,10-dibromo-7,11-dihydroxy-3,11-dimethyl-7-ethyltridec-2-enoate which are purified by chromatography.

By repeating the above procedure using an equivalent amount of N-chlorosuccinimide in place of N-bromosuccinimide, the corresponding chlorohydrins are obtained, i.e., methyl 10-chloro-11-hydroxy-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, methyl 6-chloro-7-hydroxy-3,11-dimethyl-7-ethyltrideca-2,10-dienoate and methyl 6,10-dichloro-7,11-dihydroxy-3,11-dimethyl-7-ethyltridec-2-enoate.

By use of the above procedure other aliphatic hydrocarbon esters (see, for example, Examples 1-5, 8-14, 19, 23 and 24) having unsaturation at at least one of positions C-6, 7 and C-10, 11 are converted into the corresponding bromohydrins and chlorohydrins. For example, ethyl 3,7,11-trimethyldodeca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, ethyl 3,11-dimethyl-7-ethyldodeca-2,6,10-trienoate, ethyl 3,7-dimethyl-11-ethyltrideca-2,6,10-trienoate, and ethyl 3,7,11-trimethyltrideca-trienoate, respectively, are converted into ethyl 10-bromo-11-hydroxy-3,7,11-trimethyldodeca-2,6-dienoate, ethyl 10-chloro-11-hydroxy-3,7,11-trimethyldodeca-2,6-dienoate, ethyl 10-bromo-11-hydroxy-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, ethyl 10-chloro-11-hydroxy-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, ethyl 10-bromo-11-hydroxy-3,11-dimethyl-7-ethyldodeca-2,6-dienoate, ethyl 10-chloro-11-hydroxy-3,11-dimethyl-7-ethyldodeca-2,6-dienoate, ethyl 10-bromo-11-hydroxy-3,7-dimethyl-11-ethyltrideca-2,6-dienoate, ethyl 10-chloro-11-hydroxy-3,7-dimethyl-11-ethyltrideca-2,6-dienoate, ethyl 10-bromo-11-hydroxy-3,7,11-trimethyltrideca-2,6-dienoate, ethyl 10-chloro-11-hydroxy-3,7,11-trimethyltrideca-2,6-dienoate and the corresponding ethyl 6-bromo-7-hydroxy-2,10-dienoates, ethyl 6-chloro-7-hydroxy-2,10-dienoates, ethyl 6,10-dibromo-7,11-dihydroxy-2-enoates and ethyl 6,10-dichloro-7,11-dihydroxy-2-enoates, respectively.

Similarly, there is obtained ethyl 10-bromo-11-hydroxy-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 10-chloro-11-hydroxy-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 10-bromo-11-hydroxy-2,3-methylene-3,11-dimethyl-7-ethyltridecanoate, ethyl 10-chloro-11-hydroxy-2,3-methylene-3,11-dimethyl-7-ethyltridecanoate, ethyl 6-bromo-7-hydroxy-10,11-methylene-3,11-dimethyl-7-ethyltridec-7-enoate, ethyl 6-chloro-7-hydroxy-10,11-methylene-3,11-dimethyl-7-ethyltridec-7-enoate, ethyl 10-bromo-11-hydroxy-2,3,6,7-bismethylene-3,7,11-trimethyldodecanoate, and ethyl 10-chloro-11-hydroxy-2,3,6,7-bismethylene-3,7,11-trimethyl-

dodecanoate, from ethyl 3,11-dimethyl-7-ethyltrideca-2,10-dienoate, ethyl 2,3-methylene-3,11-dimethyl-7-ethyltrideca-10-enoate, ethyl 10,11-methylene-3,11-dimethyl-7-ethyltrideca-2,6-dienoate, and ethyl 2,3;6,7-bismethylene-3,7,11-trimethyldodec-10-enoate, respectively.

EXAMPLE 89

Into a mixture of 2 g. of ethyl 3,7,11-trimethyl-6,7;10,11-bisoxidododec-2,3noate in 150 ml. of ether, there is introduced a slow stream of hydrogen chloride for 1 hour at 0° C. The mixture is then allowed to stand at 0° C for 18 hours. Then the mixture is washed with a 5 percent aqueous sodium bicarbonate solution, dried over sodium sulfate and evaporated to an oil containing a mixture of chlorohydrins including ethyl 3,7,11-trimethyl-6,10-dihydroxy-7,11-dichlorododec-2-enoate which is purified and separated by chromatography. This procedure is also applicable to epoxides of other aliphatic hydrocarbon esters and aliphatic hydrocarbon alcohols such as ethyl 3,7,11-trimethyl-6,7;10,11-bisoxidotridec-2-enoate and ethyl 3,11-dimethyl-7-ethyl-6,7;10,11-bisoxidotridec-2-enoate.

By use of the above procedure, ethyl 10,11-methylene-6,7-oxido-3,7,11-trimethyldodec-2-enoate is converted into ethyl 10,11-methylene-6-hydroxy-7-chloro-3,7,11-trimethyldodec-2-enoate.

EXAMPLE 90

Anhydrous hydrogen chloride is bubbled into 100 ml. of diethyl ether at 0° C until a saturated solution is obtained. 1 gram of ethyl 3,7,11-trimethyl-11-hydroxydodeca-2,6-dienoate is added and the resulting mixture allowed to stand at 0° C for 4 days. The mixture is then evaporated under reduced pressure to yield an oil which is purified by chromatography to furnish ethyl 3,7,11-trimethyl-7-chloro-11-hydroxydodec-2-enoate.

Ethyl 3,7,11-trimethyl-7-chloro-10,11-methylenedodec-2-enoate is prepared from ethyl 3,7,11-trimethyl-10,11-methylenedodeca-2,6-dienoate using the above procedure.

EXAMPLE 91

To a stirred solution of 7 g. of ethyl 3,7,11-trimethyl-10,11-methylenedodeca-2,6-dienoate in 350 ml. of dioxane is added 20 ml. of 4N aqueous sodium hydroxide and 20 ml. of 30 percent hydrogenperoxide, maintaining a temperature of approximately 0° C. The solution is allowed to stand until the reaction is complete as followed by thin layer chromatography and then poured into ice water. The mixture is washed with water, dried and evaporated to furnish ethyl 3,7,11-trimethyl-2,3-oxido-10,11-methylenedodec-6-enoate which is purified by chromatography.

Similarly, ethyl 3,7,11-trimethyl-2,3-oxido-10,11-methylenedodecanoate prepared from ethyl 3,7,11-trimethyl-2,3-oxide-6,7;10,11-bismethylenedodecanoate is prepared from ethyl 3,7,11-trimethyl-6,7;10,11-bismethylenedodec-2-enoate.

EXAMPLE 92

To a solution of 2 g. of ethyl 7,11-dichloro-3,7,11-trimethyldodec-2-enoate and 5 ml. of anhydrous ether at 0° C is added with stirring 0.36 g. of lithium aluminum hydride. After one hour, 2.4 ml. of acetic acid is added. The mixture is washed with ice water and the ether phase dried and evaporated to give 7,11-dichloro-3,7,11-trimethyldodec-2-en-1-ol of which is converted into the corresponding ethyl ether by treatment with diazoethane.

Methyl 10,11-methylene-3,7,11-trimethyldodeca-2,6-dienoate and methyl 6,7;10,11-bismethylene-3,7,11-trimethyldodec-2-enoate are converted into 10,11-methylene-3,7,11-trimethyldodeca-2,6-dien-1-ol and the ethyl ether thereof and 6,7;10,11-bismethylene-3,7,11-trimethyldodec-2-en-1-ol and the ethyl ether thereof using the above procedure.

EXAMPLE 93

The process of Example 84 is repeated using ethyl 10,11-methylene-3,7,11-trimethyldodeca-2,6-dienoate; ethyl 6,7-methylene-3,7,11-trimethyldodeca-2,10-dienoate; ethyl 3,7,11-trimethyldodeca-2,10-dienoate; ethyl 2,3-methylene-3,7,11-trimethyldodeca-6,10-dienoate; ethyl 2,3;6,7-bismethylene-3,7,11-trimethyldodec-10-enoate; and ethyl 2,3;10,11-bismethylene-3,7,11-trimethyldodec-6-enoate as the starting material to yield ethyl 10,11-methylene-6,7-dichloromethylene-3,7,11-trimethyldodec-2-enoate; ethyl 6,7-methylene-10,11-dichloromethylene-3,7,11-trimethyldodec-2-enoate; ethyl 10,11-dichloromethylene-3,7,11-trimethyldodec-2-enoate; ethyl 2,3-methylene-6,7-dichloromethylene-3,7,11-trimethyldodec-10-enoate; ethyl 2,3-methylene-10,11-dichloromethylene-3,7,11-trimethyldodec-6-enoate, and ethyl 2,3-methylene-6,7;10,11-bisdichloromethylene-3,7,11-trimethyldodecanoate; ethyl 2,3;6,7-bismethylene-10,11-dichloromethylene-3,7,11-trimethyldodecanoate; and ethyl 2,3;10,11-bismethylene-6,7-dichloromethylene-3,7,11-trimethyldodecanoate, respectively.

EXAMPLE 94

To a refluxing solution of 2 g. of ethyl 10,11-methylene-3,7,11-trimethyldodec-2-enoate in 20 ml. of diglyme is added, over about a 2 hour period in a dropwise fashion with stirring, a solution of 10 equivalents of sodium chlorodifluoroacetate in 20 ml. of diglyme. After refluxing for an additional hour, the mixture is filtered. The filtrate is evaporated to yield ethyl 10,11-methylene-2,3-difluoromethylene-3,7,11-trimethyldodecanoate which is purified by chromatography.

By repeating the above procedure using an equivalent amount of sodium trichloroacetate in place of sodium chlorodifluoroacetate, there is obtained ethyl 10,11-methylene-2,3-dichloromethylene-3,7,11-trimethyldodecanoate.

By use of the above procedure, ethyl 6,7;10,11-bismethylene-3,7,11-trimethyldodec-2-enoate, ethyl 6,7-methylene-3,7,11-trimethyldodec-2-enoate, ethyl 3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 10,11-methylene-6,7-dichloromethylenedodec-2-enoate, ethyl 10,11-difluoromethylene-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 11-hydroxy-3,7,11-trimethyldodec-2-enoate, ethyl 7,11-dihydroxy-3,7,11-trimethyldodec-2-enoate, ethyl 7-hydroxy-3,7,11-trimethyldodec-2-enoate, ethyl 11-chloro-3,7,11-trimethyldodec-2-enoate, ethyl 11-bromo-3,7,11-trimethyldodec-2-enoate, ethyl 7,11-dibromo-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 7,11-dichloro-3,11-dimethyl-7-ethyltridec-2-enoate, ethyl 7-chloro-3,7,11-trimethyldodec-2-enoate, ethyl 11-hydroxy-7-chloro-3,7,11-trimethyldodec-2-enoate, ethyl 10,11-methylene-7-chloro-3,7,11-trimethyldodec-2-enoate, ethyl 11-chloro-6,7-methylene-3,7,11-trimethyldodec-2-enoate, ethyl 6,10-dichloro-3,7,11-trimethyldodec-2-enoate, ethyl 10-chloro-3,7,11-trimethyldodec-2-enoate, and the like are converted into the corresponding 2,3-difluoromethylene— and 2,3-dichloromethylene compounds.

EXAMPLE 95

A. 22 g. of 6,10-dimethyldodeca-5,9-dien-2-one is heated with 12.5 g. of ethylbromoacetate and 20 g. of zinc: copper couple in 80 g. of toluene in a water-bath. After the initial reaction subsides, the mixture is heated under reflux for 2 hours. The reaction mixture is cooled to room temperature, washed with aqueous acetic acid and then with water until neutral. The organic layer is separated, dried over sodium sulfate and evaporated to yield ethyl 3-hydroxy-3,7,11-trimethyltridec-6,10-dienoate.

B. Phosphorus tribromide (3 g.) in benzene (20 ml.) is added portionwise with stirring to ethyl 3-hydroxy-3,7,11-trimethyltrideca-6,10-dienoate (5 g.) in 50 ml. of benzene cooled in an ice-bath. The mixture is stirred for 1 hour and then heated (60° C) for 3 hours. After cooling to room temperature, the mixture is poured into water and additional benzene added. The organic phase is separated, washed with water, dried and evaporated under reduced pressure to give ethyl 3-bromo-3,7,11-trimethyltrideca-6,10-dienoate.

The corresponding 3-chloro compound is obtained by using phosphorus trichloride in place of phosphorus tribromide.

By use of the procedure of Example 55 (second paragraph) ethyl 3-fluoro-3,7,11-trimethyltrideca-6,10-dienoate is obtained from ethyl 3-bromo-3,7,11-trimethyltrideca-6,10-dienoate.

C. A mixture of 1 g. of ethyl 3-hydroxy-3,7,11-trimethyltrideca-6,10-dienoate, 60 ml. of ethanol, 0.1 g. of sodium carbonate and 6 ml. of water is heated at reflux for 2 hours. The mixture is then cooled, diluted with water and ether. The ethereal phase is washed with dilute aqueous acetic acid, dried and evaporated to yield 3-hydroxy-3,7,11-trimethyltrideca-6,10-dienoic acid which is converted into 3-bromo-3,7,11-trimethyltrideca-6,10-dienoylbromide and 3-chloro-3,7,11-trimethyltrideca-6,10-dienoyl chloride using the procedure of Part B or alternatively thionyl chloride, phosphorus pentabromide, and the like, can be used to prepare the acid halide.

A mixture of 1 g. of 3-chloro-3,7,11-trimethyltrideca-6,10-dienoyl chloride and 20 ml. of 20 percent aqueous tetrahydrofuran is stirred and allowed to stand at room temperature for four hours. Ethyl acetate (100 ml.) is added and the organic phase separated, dried and evaporated under reduced pressure to yield 3-chloro-3,7,11-trimethyltrideca-6,10-dienoic acid.

Similarly, there is obtained 3-bromo-3,7,11-trimethyltrideca-6,10-dienoic acid.

By use of other alkylbromoacetates, e.g., methyl bromoacetate, n-propylbromoacetate, and the like in place of ethyl bromoacetate in the procedure of Part A of this Example, the corresponding alkyl 3-hydroxy-6,10-dienoates are obtained. Similarly, by using other ketones in place of 6,10-dimethyldodeca-5,9-dien-2-one in the procedure of Part A, e.g., 6,10-dimethyldodec-9-en-2-one, 6,10-dimethyldodecan-2-one, 6,10-dimethyldodec-5-en-2-one, 6,10-dimethylundeca-5,9-dien-2-one, 6-ethyl-10-methyldodeca-5,9-dien-2-one, and the like, the corresponding 3-hydroxy alkyl esters are obtained.

EXAMPLE 96

A mixture of 1 g. of ethyl 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoate, 20 ml. of tetrahydrofuran and 1 equivalent of bis-3-methyl-2-butylborane is stirred at 0° C for 10 hours. The mixture is treated with aqueous hydrogen peroxide and sodium carbonate and then evaporated in vacuo to a low volume. This concentrate is extracted with ethyl acetate. The organic phase is washed with water and saturated salt solution, dried and evaporated to give ethyl 6-hydroxy-3,11-dimethyl-7-ethyltrideca-2,10-dienoate, ethyl 10-hydroxy-3,11-dimethyl-7-ethyltrideca-2,6-dienoate and ethyl 6,10-dihydroxy-3,11-dimethyl-7-ethyltridec-2-enoate which are separated by chromatography.

By use of the procedure of Part B of Example 95, the thus obtained 6-hydroxyl, 10-hydroxyl and 6,10-dihydroxyl are converted into the corresponding bromo, chloro and fluoro derivatives, e.g., ethyl 6-chloro-3,11-dimethyl-7-ethyltrideca-2,10-dienoate, ethyl 19-chloro-3,11-dimethyl-7-ethyltrideca-2,6-dienoate and ethyl 6,10-dichloro-3,11-dimethyl-7-ethyltridec-2-enoate.

By use of the procedure of this Example, other aliphatic hydrocarbon esters, aliphatic hydrocarbon acids and aliphatic hydrocarbon alcohols described herein having unsaturation at at least C-6,7 and/or C-10,11 are converted into the corresponding substituted C-6, C-10 or C-6,10 derivatives.

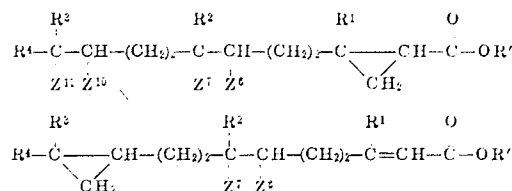
EXAMPLE 97

To a solution of 2 g. of 3,11-dimethyl-7-ethyltrideca-chloride 2,6,10-trienoic acid in 50 ml. of dry benzene, 1 g. of thionyl chloride in 20 ml. of dry benzene is added slowly with cooling to about 5° to 10° C. After addition is complete, the mixture is stirred at room temperature for two hours. The benzene and excess thionyl chloride are removed in vacuo giving 3,11-dimethyl-7-ethyltrideca-2,6,10-trienoyl chloride.

By use of the above procedure, other aliphatic hydrocarbon acids described herein are converted to the corresponding acid chloride. The corresponding acid bromides are obtained by treating the aliphatic hydrocarbon acid with phosphorus tribromide in benzene. Acid chlorides can also be prepared by treating the aliphatic hydrocarbon acid with sodium hydride and oxalyl chloride or by treatment with phosphorus trichloride.

What is claimed is:

1. A compound selected from those of the formulas:



wherein,

R' is hydrogen or lower alkyl;

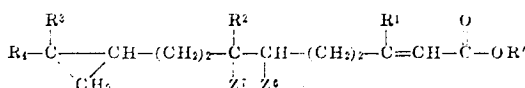
each of R¹, R², R³ and R⁴ is lower alkyl;

each of Z⁶ and Z⁷ is hydrogen or Z⁶ and Z⁷ taken together is a carbon-carbon double bond between C-6,7;

each of Z¹⁰ and Z¹¹ is hydrogen or Z¹⁰ and Z¹¹ taken together is a carbon-carbon double bond between C-10,11 or the group



2. A compound according to claim 1 of the formula:



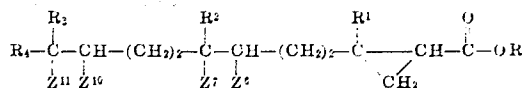
3. A compound according to claim 2 wherein each of R¹, R², R³ and R⁴ is methyl or ethyl and R' is hydrogen or lower alkyl.

4. A compound according to claim 3 wherein each of R¹, R² and R³ is methyl; R⁴ is methyl or ethyl; R' is lower alkyl; and Z⁷ taken together with Z⁶ is a carbon-carbon double bond.

5. The compound, methyl 10,11-methylene-3,7,11-trimethyltrideca-2,6-dienoate, according to claim 4.

6. A compound according to claim 3 wherein each of R¹ and R³ is methyl; each of R² and R⁴ is ethyl; R' is lower alkyl; and Z⁷ taken together with Z⁶ is a carbon-carbon double bond.

7. A compound according to claim 1 of the formula:



8. A compound according to claim 7 wherein each of R¹, R², R³ and R⁴ is methyl or ethyl.

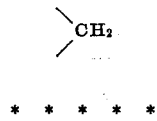
9. A compound according to claim 8 wherein Z⁷ taken together with Z⁶ is a carbon-carbon double bond and Z¹¹ taken together with Z¹⁰ is a carbon-carbon double bond.

10. A compound according to claim 9 wherein each of R¹, R² and R³ is methyl and R⁴ is methyl or ethyl.

11. A compound according to claim 10 wherein R' is hydrogen, methyl or ethyl.

12. A compound according to claim 9 wherein each of R¹ and R³ is methyl and each of R² and R⁴ is ethyl.

13. A compound according to claim 8 wherein Z¹¹ taken together with Z¹⁰ is the group



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