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(54) **COMPOSES A BASE DE NAPHTYLE, COMPOSITIONS ET
METHODES**

(54) **NAPHTHYL COMPOUNDS, COMPOSITIONS, AND METHODS**

(57) L'invention porte sur des composés de naphthyle, des formulations et des méthodes pour inhiber la perte osseuse ou la résorption osseuse, particulièrement l'ostéoporose, et les états pathologiques apparentés aux maladies cardio-vasculaires, dont l'hyperlipidémie, et le cancer oestrogéno-dépendant.

(57) The invention provides naphthyl compounds, formulations, and methods of inhibiting bone loss or bone resorption, particularly osteoporosis, and cardiovascular-related pathological conditions including hyperlipidemia, and estrogen-dependent cancer.

Abstract

The invention provides naphthyl compounds,
formulations, and methods of inhibiting bone loss or bone
5 resorption, particularly osteoporosis, and cardiovascular-
related pathological conditions including hyperlipidemia,
and estrogen-dependent cancer.

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NAPHTHYL COMPOUNDS, COMPOSITIONS,
AND METHODS

5 Osteoporosis describes a group of diseases which arises
from diverse etiologies, but which are characterized by the
net loss of bone mass per unit volume. The consequence of
this loss of bone mass and resulting bone fracture is the
failure of the skeleton to provide adequate support for the
10 body. One of the most common types of osteoporosis is
associated with menopause. Most women lose from about 20%
to about 60% of the bone mass in the trabecular compartment
of the bone within 3 to 6 years after the cessation of
menses. This rapid loss is generally associated with an
15 increase of bone resorption and formation. However, the
resorptive cycle is more dominant and the result is a net
loss of bone mass. Osteoporosis is a common and serious
disease among postmenopausal women.

There are an estimated 25 million women in the United
20 States alone who are afflicted with this disease. The
results of osteoporosis are personally harmful, and also
account for a large economic loss due to its chronicity and
the need for extensive and long term support
(hospitalization and nursing home care) from the disease
25 sequelae. This is especially true in more elderly patients.
Additionally, although osteoporosis is generally not thought
of as a life threatening condition, a 20% to 30% mortality
rate is related to hip fractures in elderly women. A large
percentage of this mortality rate can be directly associated
30 with postmenopausal osteoporosis.

The most vulnerable tissue in the bone to the effects
of postmenopausal osteoporosis is the trabecular bone. This
tissue is often referred to as spongy or cancellous bone and
is particularly concentrated near the ends of the bone (near
35 the joints) and in the vertebrae of the spine. The
trabecular tissue is characterized by small osteoid
structures which interconnect with each other, as well as

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the more solid and dense cortical tissue which makes up the outer surface and central shaft of the bone. This interconnected network of trabeculae gives lateral support to the outer cortical structure and is critical to the biomechanical strength of the overall structure. In postmenopausal osteoporosis, it is primarily the net resorption and loss of the trabeculae which leads to the failure and fracture of bone. In light of the loss of the trabeculae in the postmenopausal woman, it is not surprising that the most common fractures are those associated with bones which are highly dependent on trabecular support, for example, the vertebrae, the neck of the weight-bearing bones such as the femur and the forearm. Indeed, hip fracture, colliies fractures, and vertebral crush fractures are hallmarks of postmenopausal osteoporosis.

The most generally accepted method for the treatment of postmenopausal osteoporosis is estrogen replacement therapy. Although therapy is generally successful, patient compliance with the therapy is low, primarily because estrogen treatment frequently produces undesirable side effects. An additional method of treatment would be the administration of a bisphosphonate compound, such as, for example, Fosamax[®] (Merck & Co., Inc.).

Throughout premenopausal time, most women have less incidence of cardiovascular disease than men of the same age. Following menopause, however, the rate of cardiovascular disease in women slowly increases to match the rate seen in men. This loss of protection has been linked to the loss of estrogen and, in particular, to the loss of estrogen's ability to regulate the levels of serum lipids. The nature of estrogen's ability to regulate serum lipids is not well understood, but evidence to date indicates that estrogen can up regulate the low density lipid (LDL) receptors in the liver to remove excess cholesterol. Additionally, estrogen appears to have some effect on the biosynthesis of cholesterol, and other beneficial effects on cardiovascular health.

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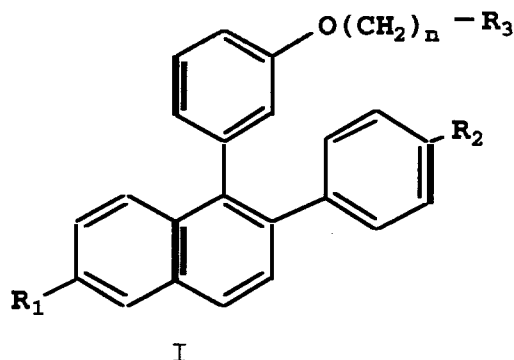
It has been reported in the literature that serum lipid levels in postmenopausal women having estrogen replacement therapy return to concentrations found in the premenopausal state. Thus, estrogen would appear to be a reasonable
5 treatment for this condition. However, the side effects of estrogen replacement therapy are not acceptable to many women, thus limiting the use of this therapy. An ideal therapy for this condition would be an agent which regulates serum lipid levels in a manner analogous to estrogen, but
10 which is devoid of the side effects and risks associated with estrogen therapy.

Estrogen dependent cancers are major diseases effecting both women, and to a lesser extent men. Cancer cells of this type are dependent on a source of estrogen to maintain
15 the original tumor as well as to proliferate and metastasize to other locations. The most common forms of estrogen dependent cancer are breast and uterine carcinomas. Current chemotherapy of these diseases relies primarily on the use of anti-estrogens, predominately tamoxifen. The use of
20 tamoxifen, although efficacious, is not without undesirable side-effects, for example, estrogen agonist properties, such as uterine hypertrophy and carcinogenic potential. Compounds of the current invention while showing the same or better potential for anti-cancer activity, also demonstrate
25 a lower potential for estrogen agonist activity.

In response to the clear need for new pharmaceutical agents which are capable of alleviating the symptoms described herein, the instant invention provides naphthyl compounds, pharmaceutical formulations, and methods of
30 using said compounds for the inhibition of the disease states as indicated herein.

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The instant invention relates to compounds of formula I:



wherein:

R_1 is -H, -OH, -O(C₁-C₄ alkyl),
-OCO(C₁-C₆ alkyl), -O(CO)O(C₁-C₆ alkyl), -OCOAr, -O(CO)OAr,
where Ar is phenyl or optionally substituted phenyl, or -
OSO₂(C₂-C₆ alkyl);

R_2 is -H, -OH, -O(C₁-C₄ alkyl),
-OCO(C₁-C₆ alkyl), -O(CO)O(C₁-C₆ alkyl), -OCOAr, -O(CO)OAr,
where Ar is phenyl or optionally substituted phenyl, -
OSO₂(C₂-C₆ alkyl), -Cl, or -F;

R_3 is 1-piperidinyl, 1-pyrrolidinyl, methyl-1-pyrrolidinyl, dimethyl-1-pyrrolidinyl, 4-morpholino, dimethylamino, diethylamino, or 1-hexamethyleneimino; and
 n is 2, 3, or 4;

or a pharmaceutically acceptable salt or solvate thereof.

The instant invention further provides pharmaceutical formulations containing compounds of formula I, and the use of said compounds at least for the inhibition of bone loss or bone resorption, particularly osteoporosis, and cardiovascular-related pathological conditions, including hyperlipidemia; and estrogen-dependent cancer.

General terms used in the description of compounds herein described bear their usual meanings. For example, "C₁-C₆ alkyl" refers to straight or branched aliphatic chains of 1 to 6 carbon atoms including methyl, ethyl, propyl, isopropyl, butyl, n-butyl, pentyl, isopentyl, hexyl, isoheptyl, and the like. Similarly, the term "-OC₁-C₄ alkyl" represents a C₁-C₄ alkyl group attached through an oxygen such as, for example, methoxy, ethoxy, n-propoxy, isopropoxy, and the like. Of these C₁-C₄ alkoxy groups, methoxy is highly preferred.

The term "substituted phenyl" refers to a phenyl group having one or more substituents selected from the group consisting of C₁-C₄ alkyl, -OC₁-C₄ alkyl, hydroxy, nitro, chloro, fluoro, or tri(chloro or fluoro)methyl.

The term "hydroxy protecting group" contemplates numerous functionalities used in the literature to protect a hydroxyl function during a chemical sequence and which can be removed to yield the phenol. Included within this group are acyls, mesylates, tosylates, benzyl, alkylsilyloxys, C₁-C₄ alkyls, and the like. Numerous reactions for the formation and removal of such protecting groups are described in a number of standard works including, for example, *Protective Groups in Organic Chemistry*, Plenum Press (London and New York, 1973); Green, T.W., *Protective Groups in Organic Synthesis*, Wiley, (New York, 1981); and *The Peptides*, Vol. I, Schroeder and Lubke, Academic Press (London and New York, 1965). Methods for removing preferred hydroxy protecting groups, particularly methyl, are essentially as described in the Examples, *infra*.

The term "leaving group" means a chemical entity which is capable of being displaced by an amino function via an S_N2 reaction. Such reactions are well known in the art and such groups would include halogens, mesylates, tosylates, and the like. A preferred leaving group is bromo.

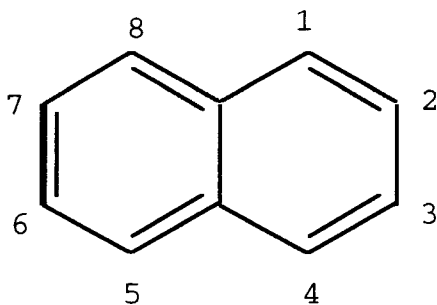
The term "inhibit" includes its generally accepted meaning which includes prohibiting, preventing, restraining,

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and slowing, stopping, or reversing progression, severity, or ameliorating a resultant symptom or effect.

The term "solvate" represents an aggregate that comprises one or more molecules of the solute, such as a
5 formula I compound, with one or more molecules of solvent.

The compounds of formula I are derivatives of naphthalene, which is named and numbered according to the Ring Index, The American Chemical Society, as follows:



10

Compounds of the present invention are named as derivatives of the amine functional group. Thus, the compound of formula I, wherein R₁ and R₂ are methoxy, R₃ is
15 piperidinyl, and n is three, is named 1-[3-[3-[2-(4-methoxyphenyl)-6-methoxynaphth-1-yl]phenyloxy]propyl]piperidine.

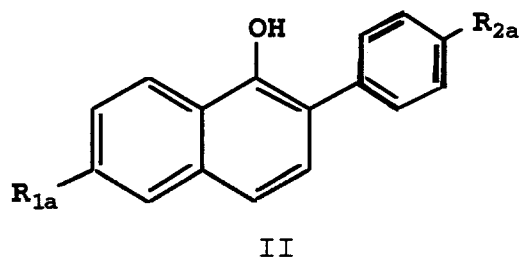
Compounds of formula I include, but are not limited to:
1-[2-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenyloxy]ethyl]piperidine;
20 1-[2-[3-[2-(4-Hydroxyphenyl)-6-hydroxynaphth-1-yl]phenyloxy]ethyl]piperidine;
1-[3-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenyloxy]propyl]piperidine;
25 1-[3-[3-[2-(4-Hydroxyphenyl)-6-hydroxynaphth-1-yl]phenyloxy]propyl]piperidine;
1-[4-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenyloxy]butyl]piperidine; and the like.

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Preferred embodiments of the current invention are those compounds wherein n is three and R₃ is piperidinyl.

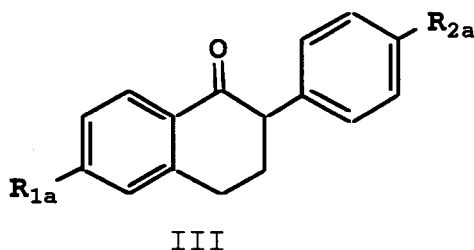
Several synthetic pathways are available for preparing the compounds of the instant invention. One synthetic route
5 begins with the aromatization of 2-phenyl substituted-1-tetralones to form compounds of formula II:



10

wherein R_{1a} and R_{2a} are independently -H or -O(C₁-C₄ alkyl). A preferred compound of formula II is one in which both R_{1a} and R_{2a} are methoxy.

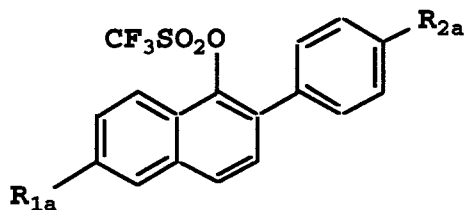
Tetralones of formula III are converted to their
15 acetylated enol isomers by refluxing in isopropenyl acetate in the presence of a strong acid such as para-toluenesulfonic acid. The intermediate acetyl-enol derivative is subsequently oxidized with DDQ (2,3-dichloro-5,6-dicyano-1,4-benzoquinone) in dichloromethane at ambient
20 temperature. The subsequent acetyl naphthol is hydrolyzed to compounds of formula II. The compounds of formula III may be obtained by methods known in the art, see, for example, Lednicer et al., *J. Med. Chem.*, 10, 78 (1967), U.S. Pat. No. 3,274,213, and U.S. Pat. No. 4,230,862 the
25 disclosures of which are herein incorporated by reference.



30 wherein R_{1a} and R_{2a} have their previous meanings.

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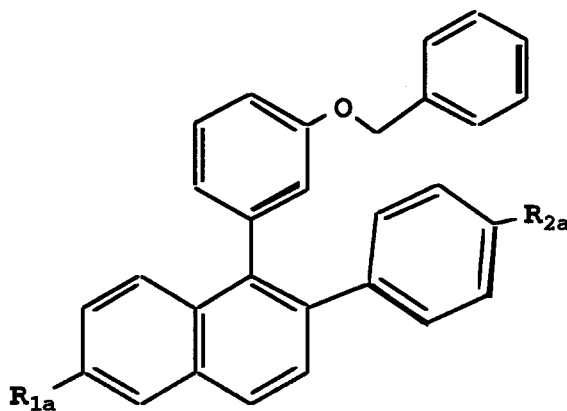
The compounds of formula II are converted to trifluoromethanesulfonic esters (formula IV) by treatment with trifluorosulfonic anhydride in the presence of an acid scavenger such as triethylamine, pyridine, and the like.



IV

wherein R_{1a} and R_{2a} have their previous meanings.

The compounds of formula IV are subsequently converted to the compounds of formula V by a palladium coupling reaction with *m*-benzyloxy-phenylboronic acid. In this reaction, a compound of formula IV is treated with *m*-benzyloxy-phenylboronic acid in the presence of $(PPh_3)_4Pd$ and Na_2CO_3 in a solvent mixture of toluene and EtOH at reflux temperature.

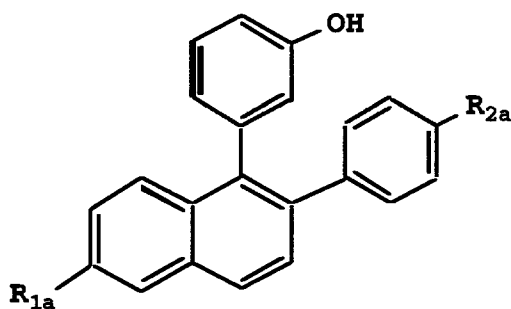


V

wherein R_{1a} and R_{2a} have their previous meanings.

The compounds of formula V are converted to their phenol analogs (compounds of formula VI) by removal of the benzyloxy protecting group via catalytic hydrogenation with $Pd(0)$.

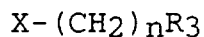
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VI

wherein R_{1a} and R_{2a} have their previous meanings.

5 The compounds of formula VI may be converted to the compounds of formula Ia by two different routes. The first method is by O-alkylation of the phenolic hydroxy with an aminoalkylhalide (a compound of formula VII) in the presence of a strong inorganic base, such as K₂CO₃, Cs₂CO₃, and the
 10 like, in an appropriate solvent such as DMF, methylethylketone, etc. This method leads directly to the compounds of formula Ia.

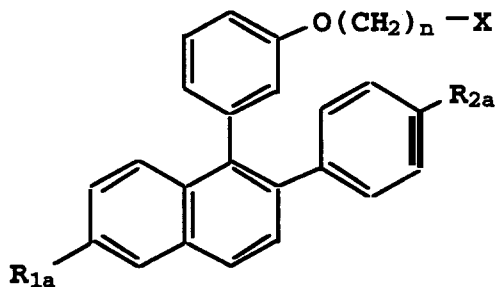


15

VII

wherein R₃, and n have their previous meanings, and X is chloro or bromo, or a salt thereof.

20 The second route consists of reacting a compound of formula VI with a di-haloalkyl (a compound of formula VIII) in the presence of a strong inorganic base, such as K₂CO₃, Cs₂CO₃, to form an intermediate halo compound of formula IX.



IX

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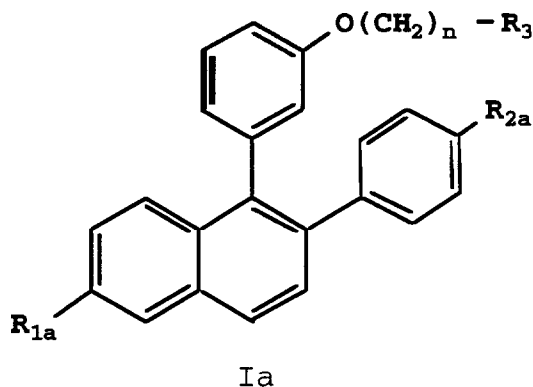
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wherein R_{1a} , R_{2a} , and n have their previous meanings, and X is chloro or bromo.

The final step of this reaction sequence is the displacement of the halogen (X) of a compound of formula IX
5 with an amine of formula X to form the compounds of formula Ia.

$$HR_3$$
$$X$$

10 wherein R_3 has its previous meanings, or a salt thereof.



15 wherein R_{1a} , R_{2a} , R_3 , and n have their previous meanings.

The compounds of formula I (which include the compounds of formula Ia) may be prepared from the compounds of formula Ia wherein R_1 and R_2 are $-O(C_1-C_4 \text{ alkyl})$, preferred being methoxy. Demethylation of the di-methoxy compounds of
20 formula Ia can be accomplished by treatment with BBr_3 at $0^\circ C$ to yield the di-hydroxy compounds. It should be noted that care must be taken in doing this reaction in order that the basic side chain is not cleaved. Further ester and sulfonate derivatives of formula I may be derived from the
25 di-hydroxy compounds by methods known in the art, for example, U.S. Pat. Nos. 5,393,763 and 5,482,949, the disclosures of which are herein incorporated by reference.

Although the free-base form of formula I compounds can be used in the methods of the instant invention, it is
30 preferred to prepare and use a pharmaceutically acceptable

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salt form. The term "pharmaceutically acceptable salt" refers to either acid or base addition salts which are known to be non-toxic and are commonly used in the pharmaceutical literature. The pharmaceutically acceptable salts generally have enhanced solubility characteristics compared to the compound from which they are derived, and thus are often more amenable to formulation as liquids or emulsions. The compounds used in the methods of this invention primarily form pharmaceutically acceptable acid addition salts with a wide variety of organic and inorganic acids, and include the physiologically acceptable salts which are often used in pharmaceutical chemistry. Such salts are also part of this invention.

Typical inorganic acids used to form such salts include hydrochloric, hydrobromic, hydroiodic, nitric, sulfuric, phosphoric, hypophosphoric, and the like. Salts derived from organic acids, such as aliphatic mono and dicarboxylic acids, phenyl-substituted alkanolic acids, hydroxyalkanoic and hydroxyalkandioic acids, aromatic acids, aliphatic and aromatic sulfonic acids, may also be used. Such pharmaceutically acceptable salts thus include acetate, phenylacetate, trifluoroacetate, acrylate, ascorbate, benzoate, chlorobenzoate, dinitrobenzoate, hydroxybenzoate, methoxybenzoate, methylbenzoate, o-acetoxybenzoate, naphthalene-2-benzoate, bromide, isobutyrate, phenylbutyrate, β -hydroxybutyrate, butyne-1,4-dioate, hexyne-1,4-dioate, caproate, caprylate, chloride, cinnamate, citrate, formate, fumarate, glycolate, heptanoate, hippurate, lactate, malate, maleate, hydroxymaleate, malonate, mandelate, mesylate, nicotinate, isonicotinate, nitrate, oxalate, phthalate, terephthalate, phosphate, monohydrogenphosphate, dihydrogenphosphate, metaphosphate, pyrrophosphate, propiolate, propionate, phenylpropionate, salicylate, sebacate, succinate, suberate, sulfate, bisulfate, pyrosulfate, sulfite, bisulfite, sulfonate, benzenesulfonate, *p*-bromophenylsulfonate, chlorobenzenesulfonate, ethanesulfonate, 2-

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hydroxyethanesulfonate, methanesulfonate, naphthalene-1-sulfonate, naphthalene-2-sulfonate, *p*-toluenesulfonate, xylenesulfonate, tartarate, and the like. A preferred salt is the hydrochloride salt.

5 The pharmaceutically acceptable acid addition salts are typically formed by reacting a compound of formula I with an equimolar or excess amount of acid. The reactants are generally combined in a mutual solvent such as diethyl ether or ethyl acetate. The salt normally precipitates out of
10 solution within about one hour to 10 days and can be isolated by filtration, or the solvent can be stripped off by conventional means. The instant invention further provides for pharmaceutically acceptable formulations for administering to a mammal, including humans, in need of
15 treatment, which comprises an effective amount of a compound of formula I and a pharmaceutically acceptable diluent or carrier.

As used herein, the term "effective amount" means an amount of compound of the instant invention which is capable
20 of inhibiting, alleviating, ameliorating, treating, or preventing further symptoms in mammals, including humans, suffering from bone loss or bone resorption, particularly osteoporosis, and cardiovascular-related pathological conditions, including hyperlipidemia.

25 In the case of estrogen-dependent cancers, the term "effective amount" means the amount of compound of the instant invention which is capable of alleviating, ameliorating, inhibiting cancer growth, treating, or preventing the cancer and/or its symptoms in mammals,
30 including humans.

By "pharmaceutically acceptable formulation" it is meant that the carrier, diluent, excipients and salt must be compatible with the active ingredient (a compound of formula I) of the formulation, and not be deleterious to the
35 recipient thereof. Pharmaceutical formulations can be prepared by procedures known in the art. For example, the compounds of this invention can be formulated with common

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excipients, diluents, or carriers, and formed into tablets, capsules, and the like. Examples of excipients, diluents, and carriers that are suitable for such formulations include the following: fillers and extenders such as starch, 5 sugars, mannitol, and silicic derivatives; binding agents such as carboxymethyl cellulose and other cellulose derivatives, alginates, gelatin, and polyvinyl pyrrolidone; moisturizing agents such as glycerol; disintegrating agents such as agar agar, calcium carbonate, and sodium 10 bicarbonate; agents for retarding dissolution such as paraffin; resorption accelerators such as quaternary ammonium compounds; surface active agents such as cetyl alcohol, glycerol monostearate; adsorptive carriers such as kaolin and bentonite; and lubricants such as talc, calcium 15 and magnesium stearate and solid polyethylene glycols. Final pharmaceutical forms may be: pills, tablets, powders, lozenges, syrups, aerosols, saches, cachets, elixirs, suspensions, emulsions, ointments, suppositories, sterile injectable solutions, or sterile packaged powders, and the 20 like, depending on the type of excipient used.

Additionally, the compounds of this invention are well suited to formulation as sustained release dosage forms. The formulations can also be so constituted that they release the active ingredient only or preferably in a 25 particular part of the intestinal tract, possibly over a period of time. Such formulations would involve coatings, envelopes, or protective matrices which may be made from polymeric substances or waxes.

The particular dosage of a compound of formula I 30 required to inhibit the symptoms and/or disease of a mammal, including humans, suffering from the above maladies according to this invention will depend upon the particular disease, symptoms, and severity. Dosage, routes of administration, and frequency of dosing is best decided by 35 the attending physician. Generally, accepted and effective doses will be from 10mg to 800mg, and more typically from 20mg to 200mg, one to three times per day. Such dosages

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will be administered to a patient in need thereof for at least one month, or more typically for six months, or chronically.

The instant invention also provides methods for
5 inhibiting estrogen deficient pathologies including, for example, lack of birth control, postmenopausal syndrome including, for example, osteoporosis, cardiovascular disease, restenosis, and hyperlipidemia, certain cancers in men such as prostate cancer, acne, hirsutism, dysfunctional
10 uterine bleeding, dysmenorrhea, and atrophic vaginitis comprising administering to a mammal in need of treatment an effective amount of a compound of formula I, and, optionally, an effective amount of a progestin. One of skill in the art will recognize that estrogenic agents have
15 a multitude of applications for treating estrogen deficient pathologies well beyond those listed, *infra*. The instant invention contemplates and encompasses such maladies although not specified by name.

The formulations which follow are given for purposes of
20 illustration and are not intended to be limiting in any way. The total active ingredients in such formulations comprises from 0.1% to 99.9% by weight of the formulation. The term "active ingredient" means a compound of formula I.

25 Formulation 1: Gelatin Capsules

Ingredient	Quantity (mg/capsule)
Active Ingredient	0.1-1000
Starch NF	0-500
30 Starch flowable powder	0-500
Silicone fluid 350 centistokes	0-15

The ingredients are blended, passed through a No. 45 mesh U.S. sieve, and filled into hard gelatin capsules.

35

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Formulation 2: Tablets

	Ingredient	Quantity (mg/tablet)
	Active Ingredient	2.5-1000
5	Starch	10-50
	Cellulose, microcrystalline	10-20
	Polyvinylpyrrolidone	5
	(as 10% solution in water)	
	Sodium carboxymethylcellulose	5
10	Magnesium stearate	1
	Talc	1-5

The active ingredient, starch, and cellulose are passed through a No. 45 mesh U.S. sieve and mixed thoroughly. The solution of polyvinylpyrrolidone is mixed with the resultant powders which are then passed through a No. 14 mesh U.S. sieve. The granules thus produced are dried at 50-60 °C and passed through a No. 18 mesh U.S. sieve. The sodium carboxymethylcellulose, magnesium stearate, and talc, previously passed through a No. 60 mesh U.S. sieve, are added to the above granules and thoroughly mixed. The resultant material is compressed in a tablet forming machine to yield the tablets.

25 Formulation 3: Aerosol

	Ingredient	Weight %
	Active Ingredient	0.25
30	Ethanol	29.75
	Propellant 22	70.00
	(Chlorodifluoromethane)	
	Total	100.00

35

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The active ingredient is mixed with ethanol and the mixture added to a portion of the propellant 22, cooled to - 30 °C and transferred to a filling device. The required amount is then fed to a stainless steel container and
5 diluted with the remainder of the propellant. The valve units are then fitted to the container.

Formulation 4: Suppositories

10	Ingredient	Weight
	Active ingredient	150 mg
	Saturated fatty acid	
	glycerides	3000mg

15

The active ingredient is passed through a No. 60 mesh U.S. sieve and suspended in the fatty acid glycerides which had previously heated to their melting point. The mixture is poured into a suppository mold and allowed to cool.

20

Formulation 5: Suspension

Suspensions each containing 0.1-1000 mg of a compound of formula I per 5 mL dose.

25

	Ingredient	Weight
	Active Ingredient	0.1-1000 mg
	Sodium carboxymethyl	
30	cellulose	50 mg
	Syrup	1.25 mL
	Benzoic acid solution (0.1M)	0.10 mL
	Flavor	q.v.
	Color	q.v.
35	Purified water to total	Total 5 mL

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A compound of formula I is passed through a No. 45 mesh U.S. sieve and mixed with the sodium carboxymethyl cellulose and syrup to form a smooth paste. The benzoic acid solution, flavor, and color diluted in water are added and mixture stirred thoroughly. Additional water is added to bring the formulation to final volume.

The following Preparations and Examples are provided to better elucidate the practice of the instant invention and should not be interpreted in any way as to limit the scope of same. Those skilled in the art will recognize that various modifications may be made while not departing from the spirit and scope of the invention. All publications and patent applications mentioned in the specification are indicative of the level of those skilled in the art to which this invention pertains.

NMR data for the following Examples were generated on a GE 300 MHz NMR instrument, and anhydrous CDCl_3 was used as the solvent unless otherwise indicated. Field strength for ^{13}C NMR spectra was 75.5 MHz, unless otherwise indicated.

Preparation A

2-(3-Methoxyphenyl)ethanol

30 g (790 mmol) of LiAlH_4 was slurried in 500 mL of THF and cooled to -70°C . 131 g (790 mmol) of 3-methoxyphenylacetic acid was dissolved in 600 mL of THF and slowly over a period of one hour to the reaction. After one hour, the reaction was allowed to warm to 0°C and was quenched with the careful addition of MeOH. To the quenched reaction was added 1 L of 1 N HCl and the reaction was stirred. After several minutes an additional 300 mL of 5 N HCl was added, along with 600 mL of ether. The reaction was shaken and the layers allowed to separate. The organic layer was reduced in volume by evaporation *in vacuo*. The aqueous layer was extracted three times with ether and all

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the ether extracts were combined. The ether extract was washed twice with brine and dried by filtration through anhydrous Na_2SO_4 and evaporated to a yellow oil. This yielded 115 g of the title compound.

5 PMR: Consistent with the proposed structure.

MS: $m/e=152$ (M) FD

EA: Calc: C, 71.03; H, 7.95 Fd: C, 70.84; H, 7.75
 $\text{C}_9\text{H}_{12}\text{O}_2$

10

Preparation B

2-(3-Methoxyphenyl)ethylbromide

15

114.1 g (750 mmol) of 2-(3-methoxyphenyl)ethanol was dissolved in 500 mL of benzene and cooled to 0°C . 35.5 mL (375 mmol) of PBr_3 was slowly added to the stirring reaction and the reaction then heated to reflux under a nitrogen atmosphere for three hours. The reaction was quenched by the addition of water and the organic layer separated. The aqueous layer was washed twice with benzene and all the benzene extracts were combined. The benzene extract was washed twice with brine, dried with Na_2SO_4 , and evaporated to an oil. The oil was distilled and the fraction at $115-124^\circ\text{C}$ @ 4mm Hg was taken. This yielded 131.7 g of the title compound as a clear oil.

20

25

PMR: Consistent with the proposed structure.

MS: $m/e=214, 216$ (M) FD

EA: Calc: C, 50.26; H, 5.16 Fd: C, 50.22; H, 5.02
 $\text{C}_9\text{H}_{11}\text{BrO}$

30

Preparation C

2-(4-Methoxyphenyl)-4-(3-Methoxyphenyl)butyric Acid

35

50.68 g (305 mmol) of 4-methoxyphenylacetic acid was dissolved in 1.4 L of THF and cooled to -70°C under a nitrogen atmosphere. 400 mL of 1.6 M (640.5 mmol) of $n\text{-BuLi}$ in hexane was slowly added. 72.1 g (335.5 mmol) of 2-(3-methoxyphenyl)ethylbromide in 400 mL of THF was slowly added

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and the reaction allowed to proceed for 1.5 hours. The reaction was allowed to warm to ambient temperature. The reaction quenched with 500 mL of 0.5 N NaOH and heated to 50°C for one hour and cooled to ambient temperature. The reaction mixture was extracted three times with ether, the aqueous layer was acidified with 150 mL of 5N HCl and extracted twice with CHCl₃. The CHCl₃ extract was washed twice with brine, dried with Na₂SO₄, and evaporated to a yellow solid. This yielded 78.2 g of the title compound.

PMR: Consistent with the proposed structure.

MS: m/e=300 (M) FD

EA: Calc: C, 71.98; H, 6.71 Fd: C, 71.04; H, 6.77
C₁₈H₂₀O₄

15

Preparation D

2-(4-methoxyphenyl)-6-methoxy-1-tetralone

2.31 g (7.7 mmol) of 2-(4-methoxyphenyl)-4-(3-Methoxyphenyl)butyric acid was dissolved in 30 mL of CH₂Cl₂ and cooled to 0° C. To this solution was added 3.4 ml (23.1 mmol) of trifluoroacetic acid, the reaction was allowed to proceed for 30 minutes. The reaction was quenched by pouring into an aqueous solution of NaHCO₃. The organic layer was separated, washed twice with NaHCO₃ solution washed twice with brine, dried with Na₂SO₄, and evaporated to a solid. This yielded 1.5 g of the title compound as a tan amorphous solid.

30

Preparation 1

2-(4-Methoxyphenyl)-6-methoxy-1-naphthol

8.50 g (30.14 mmol) of 2-(4-methoxyphenyl)-6-methoxy-1-tetralone was dissolved in 50 mL of isopropenyl acetate and 1 g of para-toluenesulfonic acid was added. The reaction mixture was heated to reflux under a nitrogen atmosphere for six hours. The reaction mixture was then allowed to cool to ambient temperature and 200 mL of CH₂Cl₂ was added. The

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reaction mixture was washed four times with 200 mL portions of 0.2 N NaOH, twice with 200 mL portions of water, and the resulting solution was dried with Na₂SO₄ and evaporated to a dark colored solid. This yielded the intermediate phenolic acetate which was removed by dissolving the solid in 200 mL of MeOH-THF (1:1) (v/v) and added an excess amount of MeONa. An orange precipitate formed which was filtered off. The resulting filtrate was acidified to pH 4 with 5 N HCl and diluted with 200 mL of water. The solution was extracted three times with 100 mL portions of EtOAc and organic layers combined, dried with Na₂SO₄, evaporated to dryness. The final product was crystallized from EtOAc-hexane, which yielded 4.24g of the title compound as a white solid.

PMR: Consistent with the proposed structure.

MS: M/e=280 (M)FD

EA: Calc: C, 77.12; H, 5.75 Fd: C, 76.83; H, 5.90 C₁₈H₁₆O₃.

Preparation 2

20 2-(4-Methoxyphenyl)-6-methoxy-1-naphthyl Trifluoromethyl Sulfonate

10.6 g (38.0 mmol) of 2-(4-methoxyphenyl)-6-methoxy-1-naphthol was dissolved in 1 L of CH₂Cl₂ and cooled to 0° C.

25 To this solution was added 10.8 mL (76 mmol) of Et₃N and 7.2 mL (41.8 mmol) of trifluoromethylsulfonyl anhydride, the reaction mixture was stirred at ambient temperature for several hours. The reaction was quenched by pouring it into water. The organic layer was separated, washed twice with

30 water, twice with brine, and dried with Na₂SO₄. The solution was reduced in volume by evaporation and chromatographed on a silica gel column eluted with CHCl₃. The desired fractions were determined by tlc, combined and evaporated to dryness. This yielded 6.4 g of the title

35 compound as a pink solid.

PMR: Consistent with the proposed structure.

MS: m/e=412 (M) FD

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EA: Calc: C, 55.34; H, 3.667 Fd: C, 55.15; H, 3.76
C₁₉H₁₅F₃O₅S

Preparation 3
3-Benzyloxybromobenzene

5

40 g (232 mmol) of 3-bromophenol was combined with 29.6 mL (255 mmol) of benzylchloride and 128 g (928 mmol) of K₂CO₃ in 500 mL of anhydrous DMF. The reaction mixture was stirred vigorously for sixteen hours at ambient temperature.
10 The mixture was filtered and evaporated to a gummy solid and re-dissolved in 500 mL of EtOAc. The EtOAc solution was washed thrice with water, twice with brine, dried with Na₂SO₄, and evaporated to a white solid. This yielded 56.4 g of the title compound.

15 PMR: Consistent with the proposed structure.

MS: m/e=261 and 263 (M) FD

EA: Calc: C, 59.34; H, 4.21 Fd: C, 59.47; H, 4.28
C₁₃H₁₁BrO

Preparation 4
3-Benzyloxyphenylboronic Acid

20

20 g (76 mmol) of 3-Benzyloxybromobenzene was dissolved in 200 mL of anhydrous THF and cooled to -78° C under a nitrogen atmosphere. To the stirring solution, 90 mL of 1.6
25 M n-BuLi (83.6 mmol) was slowly added. After several minutes, 33.6 mL (83.6 mmol) tripropylborate was added and the reaction was allowed to slowly warm to ambient temperature over the next four hours. The reaction was quenched with the addition of 400 mL of 1N HCl. The
30 reaction mixture was extracted three times with EtOAc. The EtOAc solution was washed twice with brine, dried with Na₂SO₄, and evaporated to dryness. The final product was crystallized from EtOAc-hexane. This yielded 10 g of the title compound as a white solid.

35 PMR: Consistent with the proposed structure.

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Preparation 5

1-(3-Benzyloxyphenyl)-2-(4-methoxyphenyl)-6-methoxynaphthalene

5 6.2 g (15 mmol) of 2-(4-methoxyphenyl)-6-methoxy-1-naphthyl trifluoromethyl sulfonate and 4.8 g (21 mmol) of 3-benzyloxyphenylboronic acid were dissolved a solvent mixture of 150 mL of toluene, 30 mL of EtOH, and 30 mL of 2N Na₂CO₃. 0.87g (0.75 mmol) of

10 tetrakis(triphenylphosphine)palladium(0) was added and the reaction mixture heated to reflux for one hour. An additional 0.5 g of the boronic acid was added and the reaction was continued for another hour. The reaction was allowed to cool and 500 mL of EtOAc was added. The reaction

15 mixture was extracted twice with 100 mL of 0.1N NaOH, twice with 100 mL of brine, dried with Na₂SO₄, and evaporated to dryness. The product was chromatographed on a silica gel column eluted with a linear gradient begining with EtOAc-Hexane (19:1) (v/v) and ending with EtOAc-Hexane (9:1)

20 (v/v). This yielded 5.3 g of the title compound as a white powder.

PMR: Consistent with the proposed structure.

MS: m/e=446 (M) FD

EA: Calc: C, 83.38; H, 5.87 Fd: C, 83.56; H, 6.07

25 C₃₁H₂₆O₃

Preparation 6

1-(3-Hydroxyphenyl)-2-(4-methoxyphenyl)-6-methoxynaphthalene

30 5.11g (11.4 mmol) of 1-(3-benzyloxyphenyl)-2-(4-methoxyphenyl)-6-methoxynaphthalene, 1.16 g (10.8 mmol) of Palladium(0) black, and 3.6 g (57 mmol) of ammonium formate was slurried in a solvent mixture of 150 mL of EtOH, 30 mL of EtOAc, and 6 mL of water. The reaction mixture was heated to reflux for ninety minutes, then filtered hot

35 through celite. The filtrate was evaporated to a small volume and 250 mL of EtOAc was added. The EtOAc layer was washed twice with water, once with brine, dried with Na₂SO₄,

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and evaporated to dryness. This yielded 3.52 g of the title compound as a white amorphous powder.

PMR: Consistent with the proposed structure.

MS: m/e=356(M) FD

5 EA: Calc: C, 80.88; H, 5.66 Fd: C, 80.69; H, 5.71
C₂₄H₂₀O₃

Example 1

1-[2-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]ethyl]piperidine

10

1.4 g (3.9 mmol) of 1-(3-hydroxyphenyl)-2-(4-methoxyphenyl)-6-methoxynaphthalene was dissolved in 100 mL of DMF, along with 1 g (5.85 mmol) of 1-(2-chloroethyl)piperidine hydrochloride and 2.7 g (19.5 mmol) of K₂CO₃. The reaction was allowed to proceed for sixteen hours. The reaction mixture was filtered and evaporated to dryness. The residue was dissolved in 200 mL of EtOAc and extracted with water. The water layer was separated and extracted four times with EtOAc. All the EtOAc extracts were combined, washed twice with water, twice with brine, dried with Na₂SO₄, and evaporated to a brown oil. This yielded 1.7g of the title compound.

15

20

PMR: Consistent with the proposed structure.

MS: m/e= 467 (M+) FD

25 EA: Calc: C, 79.63; H, 7.11; N, 2.99 Fd: C, 79.90; H, 6.78; N, 3.04
C₃₁H₃₃NO₃

Example 2

1-[2-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]ethyl]piperidine Hydrochloride

30

1.7g (3.6 mmol) of 1-[2-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]ethyl]piperidine was dissolved in 100 mL of EtOAc and 100 mL of EtOAc saturated with HCl gas was added. The solvents were removed by evaporation in vacuo. This yielded 1.8 g of the title compound as a tan amorphous powder.

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PMR: Consistent with the proposed structure.

MS: m/e= 467 (M-Cl) FD

EA: Calc: C, 73.87; H, 6.80; N, 2.78 Fd: C, 74.31; H, 6.98; N, 2.25

5 C₃₁H₃₃NO₃-HCl

Example 3

1-[2-[3-[2-(4-Hydroxyphenyl)-6-hydroxynaphth-1-yl]phenoxy]ethyl]piperidine

10 1.5 g (3 mmol) of 1-[2-[3-[2-(4-methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]ethyl]piperidine hydrochloride was dissolved in 100 mL of CH₂Cl₂ and cooled to 0° C. 0.7 mL (7.5 mmol) of BBr₃ was slowly added and the reaction allowed to proceed for twenty-four hours. An additional 3
15 mL of BBr₃ was added and the reaction was continued for two more hours. The reaction was quenched by pouring into water, followed by three extractions with EtOH-CHCl₃ (1:9) (v/v). The organic extracts were combined, washed twice with brine, dried with Na₂SO₄, and evaporated to dryness.
20 The final product was purified by chromatography on a silica gel column eluted with a linear gradient beginning with CH₂Cl₂ and ending with CH₂Cl₂-MeOH (9:1) (v/v). This yielded 0.5 g of the title compound as a white amorphous powder.

25 PMR: Consistent with the proposed structure.

MS: m/e=440 (M+) FD

Example 4

1-[2-[3-[2-(4-Hydroxyphenyl)-6-hydroxynaphth-1-yl]phenoxy]ethyl]piperidine Hydrochloride

30

In a manner similar to that used in Example 2, 0.5g (1.1 mmol) of 1-[2-[3-[2-(4-hydroxyphenyl)-6-hydroxynaphth-1-yl]phenoxy]ethyl]piperidine was converted to 0.5 g of the title compound, isolated as a tan amorphous powder.

35 PMR: Consistent with the proposed structure.

MS: m/e=439 (M-HCl) FD

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Example 5

1-[3-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]propyl]piperidine

- 5 In a manner similar to that used in Example 2, 1.04 g (2.9 mmol) of 1-(3-hydroxyphenyl)-2-(4-methoxyphenyl)-6-methoxynaphthalene, 0.86 g (4.35 mmol) of 1-(3-chloropropyl)piperidine hydrochloride, and 2 g (14.4 mmol) of K₂CO₃ were converted to 1.29 g of the title compound, isolated as a brown oil.
- PMR: Consistent with the proposed structure.
- MS: m/e=481 (M+) FD
- EA: Calc: C, 79.80; H, 7.33; N, 2.91 Fd: C, 80.01; H, 7.52; N, 3.06
- 15 C₃₂H₃₅NO₃

Example 6

1-[3-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]propyl]piperidine Hydrochloride

- 20 In a manner similar to that used in Example 2, 0.83 g (1.7 mmol) of 1-[3-[3-[2-(4-methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]propyl]piperidine was converted to 0.88 g of the title compound, isolated as a white amorphous powder.
- PMR: Consistent with the proposed structure.
- 25 MS: m/e=481 (M-Cl) FD
- EA: Calc: C, 74.19; H, 7.00; N, 2.70 Fd: C, 73.91; H, 6.72; N, 2.76
- C₃₂H₃₅NO₃-HCl

Example 7

- 30 1-[3-[3-[2-(4-Hydroxyphenyl)-6-hydroxynaphth-1-yl]phenoxy]propyl]piperidine

- In a manner similar to that used in Example 3, 0.75g (1.45 mmol) of 1-[3-[3-[2-(4-methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]propyl]piperidine hydrochloride and 0.34 mL (3.62 mmol) of BBr₃ were converted to 0.6 g of the title compound, isolated a tan amorphous powder.
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PMR: Consistent with the proposed structure.

MS: m/e =454 (M+) FD

Example 8

1-[3-[3-[2-(4-Hydroxyphenyl)-6-hydroxynaphth-1-yl]phenoxy]propyl]piperidine Hydrochloride

In a manner similar to that used in Example 4, 0.5 g (1.1 mmol) of 1-[3-[3-[2-(4-hydroxyphenyl)-6-hydroxynaphth-1-yl]phenoxy]propyl]piperidine was converted to 0.38 g of the title compound, isolated as a tan amorphous powder.

PMR: Consistent with the proposed structure.

MS: m/e=453 (M-HCl) FD

IR: Consistent with the proposed structure.

Example 9

1-[3-(4-Bromobutyl)phenyl]-2-(4-methoxyphenyl)-6-methoxynaphthalene

2.06 g (6.0 mmol) of 1-(3-hydroxyphenyl)-2-(4-methoxyphenyl)-6-methoxynaphthalene was dissolved in 100 mL of 2-butanone and 14.3 mL (120 mmol) of 1,4-dibromobutane and 1.9 g (13.8 mmol) of K₂CO₃ were added. The reaction mixture was heated to reflux for three hours under a nitrogen atmosphere. The reaction mixture was filtered and evaporated to dryness. The final product was purified by chromatography on a silica gel column eluted with a linear gradient beginning with EtOAc-hexane (1:19) (v/v) and ending with EtOAc-hexane (1:9) (v/v). This yielded 2.6 g of the title compound as a white amorphous powder.

PMR: Consistent with the proposed structure.

MS: m/e=490 and 492 (M) FD

EA: Calc: C, 66.44; H, 5.54 Fd: C, 67.02; H, 5.49
C₂₈H₂₇BrO₃

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Example 10

1-[4-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]butyl]piperidine

5 2.3 g (4.7 mmol) of 1-[3-(4-bromobutyl)phenyl]-2-(4-methoxyphenyl)-6-methoxynaphthalene was dissolved in 100 mL of DMF and 1.6 mL (18.8 mmol) of piperidine and 2.6 g (18.8 mmol) of K₂CO₃ were added. The reaction mixture was heated to reflux for one hour under a nitrogen atmosphere.
10 The reaction mixture was filtered and evaporated to an oil. The oil was dissolved in 200 mL of EtOAc and extracted with water. The aqueous layer was separated and extracted three times with EtOAc. All of the EtOAc extracts were combined, washed three times with brine, dried with Na₂SO₄ and
15 evaporated to a solid. This yielded 2.32 g of the title compound.

PMR: Consistent with the proposed structure.

MS: m/e=495 (M) FD

EA: Calc: C, 79.97; H, 7.52; N, 2.83 Fd: c, 79.99; H, 7.64; N, 3.05
20 C₃₃H₃₇NO₃

Example 11

1-[4-[3-[2-(4-Methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]butyl]piperidine Hydrochloride

25

In a manner similar to that used in Example 2, 1.8 g (3.6 mmol) of 1-[4-[3-[2-(4-methoxyphenyl)-6-methoxynaphth-1-yl]phenoxy]butyl]piperidine was converted to 1.91 g of the title compound, isolated as a white amorphous powder.

30 PMR: Consistent with the proposed structure.

IR: Consistent with the proposed structure.

MS: m/e=496 (M-Cl) FD

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In the examples illustrating the methods, a postmenopausal model was used in which effects of different treatments upon circulating lipids were determined.

Seventy-five day old female Sprague Dawley rats (weight
5 range of 200 to 225g) were obtained from Charles River
Laboratories (Portage, MI). The animals were either
bilaterally ovariectomized (OVX) or exposed to a sham
surgical procedure at Charles River Laboratories, and then
shipped after one week. Upon arrival, they were housed in
10 metal hanging cages in groups of 3 or 4 per cage and had *ad libitum*
access to food (calcium content approximately 0.5%)
and water for one week. Room temperature was maintained at
22.2° ± 1.7° C with a minimum relative humidity of 40%. The
photoperiod in the room was 12 hours light and 12 hours
15 dark.

Dosing Regimen Tissue Collection. After a one week
acclimation period (therefore, two weeks post-OVX) daily
dosing with test compound was initiated. 17 α -ethynyl
20 estradiol or the test compound were given orally, unless
otherwise stated, as a suspension in 1%
carboxymethylcellulose or dissolved in 20% cyclodextrin.
Animals were dosed daily for 4 days. Following the dosing
regimen, animals were weighed and anesthetized with a
25 ketamine:xylazine (2:1, V:V) mixture and a blood sample was
collected by cardiac puncture. The animals were then
sacrificed by asphyxiation with CO₂, the uterus was removed
through a midline incision, and a wet uterine weight was
determined.

30 Cholesterol Analysis. Blood samples were allowed to clot at
room temperature for 2 hours, and serum was obtained
following centrifugation for 10 minutes at 3000 rpm. Serum
cholesterol was determined using a Boehringer Mannheim
35 Diagnostics high performance cholesterol assay. Briefly the
cholesterol was oxidized to cholest-4-en-3-one and hydrogen
peroxide. The hydrogen peroxide was then reacted with

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phenol and 4-aminophenazone in the presence of peroxidase to produce a p-quinone imine dye, which was read spectrophotometrically at 500 nm. Cholesterol concentration was then calculated against a standard curve.

5

Uterine Eosinophil Peroxidase (EPO) Assay. Uteri were kept at 4° C until time of enzymatic analysis. The uteri were then homogenized in 50 volumes of 50 mM Tris buffer (pH - 8.0) containing 0.005% Triton X-100. Upon addition of 0.01% hydrogen peroxide and 10 mM O-phenylenediamine (final concentrations) in Tris buffer, increase in absorbance was monitored for one minute at 450 nm. The presence of eosonophils in the uterus is an indication of estrogenic activity of a compound. The maximal velocity of a 15 second interval was determined over the initial, linear portion of the reaction curve.

10
15

Source of Compound: 17 α -ethynyl estradiol was obtained from Sigma Chemical Co., St. Louis, MO.

20

Influence of Formula I Compounds on Serum Cholesterol and Determination of Agonist/Non-Agonist Activity

Data presented in Table 1 below show comparative results among ovariectomized rats, rats treated with 17 α -ethynyl estradiol (EE₂; an orally available form of estrogen), and rats treated with certain compounds of the instant invention. Although EE₂ caused a decrease in serum cholesterol when orally administered at 0.1 mg/kg/day, it also exerted a stimulatory action on the uterus so that EE₂ uterine weight was substantially greater than the uterine weight of ovariectomized test animals. This uterine response to estrogen is well recognized in the art.

25
30

Not only did the compounds of the instant invention generally reduce serum cholesterol compared to the ovariectomized control animals, but uterine weight was only minimally increased to slightly decreased with the majority of the formula compounds tested. Compared to estrogenic

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compounds known in the art, the benefit of serum cholesterol reduction without adversely affecting uterine weight is quite rare and desirable.

As is expressed in the data below, estrogenicity also
 5 was assessed by evaluating the adverse response of
 eosinophil infiltration into the uterus. The compounds of
 the instant invention did not cause any increase in the
 number of eosinophils observed in the stromal layer of
 ovariectomized rats, while estradiol cause a substantial,
 10 expected increase in eosinophil infiltration.

The data presented in Table 1 below reflects the
 response of 5 to 6 rats per treatment.

Table 1

Compound No.	Dose mg/kg ^a	Uterine Weight % Inc ^b	Uterine Eosinophil (Vmax) ^c	Serum Cholest. % Dec. ^d
EE ₂ ^e	0.1	128.8*	76*	66.7*
Example 2	0.1	53.7*	21	24.6*
	1.0	81.5*	90*	69.6*
	10.0	108.3*	92*	78.5*
Example 6	0.1	66.7*	38	43.5*
	1.0	61.1*	36	56.5*
	10.0	40.7	43*	50.7*

30 ^a mg/kg PO

^b Uterine Weight % increase versus the ovariectomized controls

^c Eosinophil peroxidase Vmax

^d Serum cholesterol decrease versus ovariectomized controls

35 ^e 17- α -Ethinyl-estradiol

* p<.05

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In addition to the demonstrated benefits of the compounds of the instant invention, the above data clearly demonstrate that compounds of formula I are not estrogen mimetics. Furthermore, no deleterious toxicological effects (for example, survival numbers) were observed with any treatment.

Osteoporosis Test Procedure

Following the General Preparation Procedure, *infra*, the rats are treated daily for 35 days (6 rats per treatment group) and sacrificed by carbon dioxide asphyxiation on the 36th day. The 35 day time period is sufficient to allow maximal reduction in bone density, measured as described herein. At the time of sacrifice, the uteri are removed, dissected free of extraneous tissue, and the fluid contents are expelled before determination of wet weight in order to confirm estrogen deficiency associated with complete ovariectomy. Uterine weight is routinely reduced about 75% in response to ovariectomy. The uteri are then placed in 10% neutral buffered formalin to allow for subsequent histological analysis.

The right femurs are excised and digitized x-rays generated and analyzed by an image analysis program (NIH image) at the distal metaphysis. The proximal aspect of the tibiae from these animals are also scanned by quantitative computed tomography.

In accordance with the above procedures, compounds of the instant invention and ethynyl estradiol (EE₂) in 20% hydroxypropyl β -cyclodextrin are orally administered to test animals. Distal femur metaphysis and proximal tibiae data are compared to intact and ovariectomized test animals. Results are reported as percent protection relative to ovariectomy.

Ovariectomy of the test animals causes a significant reduction in femur density compared to intact, vehicle treated controls. Orally administered ethynyl estradiol

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(EE₂) prevents this loss, but the risk of uterine stimulation with this treatment is ever-present.

Estrogen Dependent Breast Cancer:

5 MCF-7 Proliferation Assay Test Procedure

MCF-7 breast adenocarcinoma cells (ATCC HTB 22) are maintained in MEM (minimal essential medium, phenol-red free, Sigma St.Louis MO) supplemented with 10% fetal bovine serum (FBS) (v/v), L-glutamine (2mM), sodium pyruvate (1mM),
10 HEPES (10mM), non-essential amino acids and bovine insulin (1ug/mL). Ten days prior to the assay, the MCF-7 cells are switched to maintenance medium supplemented with 10% dextrancoated charcoal stripped fetal bovine serum (DCC-FBS) assay medium in place of the 10% FBS to deplete internal
15 stores of estrogen. MCF-7 cells are removed from the maintenance flasks using a cell dissociating medium (Ca/Mg free HBSS (phenol-red free) supplemented with 10 mM HEPES and 2 mM EDTA. Cells are washed twice with the assay medium and adjusted to 80,000 cells/mL. Approximately 100µL (8,000
20 cells) are added to a flat-bottomed microculture well (Costar 3596) and incubated at 37° C in a 5% CO₂ humidified incubator for 48 hours to allow cell adherence and equilibrium after transfer. Serial dilutions of the compounds of formula I or DMSO as a diluent control are
25 prepared in assay medium and 50 µL transferred to triplicate microcultures followed by 50 µL of assay medium for a final volume of 200 µL. After an additional 48 hours of incubation, the microcultures are pulsed with tritiated thymidine (1 µCi/well) for 4 hours.
30 Culture are terminated by freezing at -70° C for 24 hours followed by thawing and harvesting of microcultures using a Skatron Semiautomatic Cell Harvester. Samples are counted by liquid scintillation. Fifty percent inhibitory concentration of the test drugs (IC₅₀) are determined versus
35 the control (DMSO).

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DMBA-Induced Mammary Tumor Inhibition

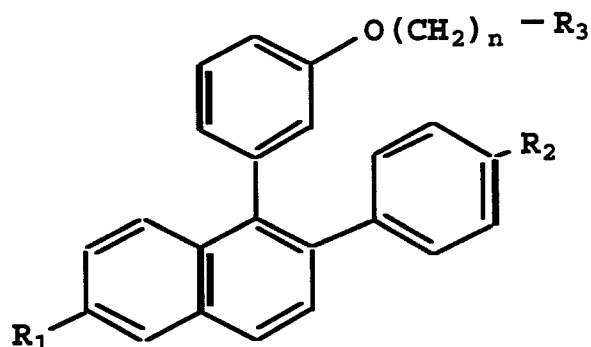
Estrogen-dependent mammary tumors are produced in female Sprague-Dawley rats which are purchased from Harlan Industries, Indianapolis, Indiana. At about 55 days of age, the rats receive a single oral feeding of 20 mg of 7,12-dimethylbenzo[a]anthracene (DMBA). About 6 weeks after DMBA administration, the mammary glands are palpated at weekly intervals for the appearance of tumors. Whenever one or more tumors appear, the longest and shortest diameters of each tumor are measured with a metric caliper, the measurements are recorded, and that animal is selected for experimentation. An attempt is made to uniformly distribute the various sizes of tumors in the treated and control groups such that average-sized tumors are equivalently distributed between test groups. Control groups and test groups for each experiment contain 5 to 9 animals.

Compounds of Formula I are administered either through intraperitoneal injections in 2% acacia, or orally. Orally administered compounds are either dissolved or suspended in 0.2 mL corn oil. Each treatment, including acacia and corn oil control treatments, is administered once daily to each test animal. Following the initial tumor measurement and selection of test animals, tumors are measured each week by the above-mentioned method. The treatment and measurements of animals continue for 3 to 5 weeks at which time the final areas of the tumors are determined. For each compound and control treatment, the change in the mean tumor area is determined.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

- 5 1. A compound of formula I:



I

wherein:

R₁ is -H, -OH, -O(C₁-C₄ alkyl),
-OCO(C₁-C₆ alkyl), -O(CO)O(C₁-C₆ alkyl), -OCOAr, -O(CO)OAr,
15 where Ar is phenyl or optionally substituted phenyl, or -
OSO₂(C₂-C₆ alkyl);

R₂ is -H, -OH, -O(C₁-C₄ alkyl),
-OCO(C₁-C₆ alkyl), -O(CO)O(C₁-C₆ alkyl), -OCOAr, -O(CO)OAr,
where Ar is phenyl or optionally substituted phenyl, -
20 OSO₂(C₂-C₆ alkyl), -Cl, or -F;

R₃ is 1-piperidinyl, 1-pyrrolidinyl, methyl-1-
pyrrolidinyl, dimethyl-1-pyrrolidinyl, 4-morpholino,
dimethylamino, diethylamino, or 1-hexamethyleneimino; and
n is 2, 3, or 4;

25 or a pharmaceutically acceptable salt or solvate thereof.

2. A compound according to Claim 1 wherein n is 3.

3. A compound according to Claim 1 wherein R₃ is
30 piperidinyl.

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4. A pharmaceutical composition comprising a compound according to Claims 1-3, or a pharmaceutically acceptable salt thereof, and optionally an effective amount of estrogen or progestin, in combination with a pharmaceutically acceptable carrier, diluent, or excipient.

5. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of post-menopausal syndrome.

6. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of the post-menopausal syndrome pathological condition of osteoporosis.

7. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of the post-menopausal syndrome pathological condition related to a cardiovascular disease.

8. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of a cardiovascular disease related to hyperlipidemia.

9. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of the post-menopausal syndrome pathological condition of estrogen-dependent cancer.

10. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of breast or uterine cancer.

11. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of uterine fibroid disease.

12. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of endometriosis.

5 13. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of aortal smooth muscle cell proliferation.

10 14. A compound of formula I as claimed in any of Claims 1-3 for use in alleviating the symptoms of restenosis.