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CA 2259936 C 2009/02/03

(11)(21) 2 259 936

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 1997/07/08
(87) Date publication PCT/PCT Publication Date: 1998/01/15
(45) Date de délivrance/Issue Date: 2009/02/03
(85) Entrée phase nationale/National Entry: 1999/01/07
(86) N° demande PCT/PCT Application No.: US 1997/011564
(87) N° publication PCT/PCT Publication No.: 1998/001132
(30) Priorité/Priority: 1996/07/08 (US60/021,285)

(51) Cl.Int./Int.Cl. *C07D 295/192* (2006.01), *A61K 31/192* (2006.01), *A61K 31/343* (2006.01), *A61K 31/495* (2006.01), *C07C 235/84* (2006.01), *C07C 65/21* (2006.01), *C07D 307/80* (2006.01)

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(54) Titre : DERIVES D'ADAMANTYLE INDUISANT L'APOPTOSE ET LEUR UTILISATION COMME AGENTS ANTICANCEREUX

(54) Title: APOPTOSIS INDUCING ADAMANTYL DERIVATIVES AND THEIR USAGE AS ANTI-CANCER AGENTS

(57) Abrégé/Abstract:
The present invention relates to specific adamantyl or adamantyl group derivative containing retinoid compounds induce apoptosis of cancer cells. These adamantyl retinoid derivatives are useful for the treatment of many cancers and solid tumors, especially androgen-independent prostate cancer, skin cancer, pancreatic carcinomas, colon cancer, melanoma, ovarian cancer, liver cancer, small cell lung carcinoma, non-small cell lung carcinoma, cervical carcinoma, brain cancer, bladder cancer, breast cancer, neuroblastoma/glioblastoma, and leukemia. Also, the invention relates to novel adamantyl or adamantyl group derivative compounds which are useful as active agents for the treatment or prevention of keratinization disorders and other dermatological conditions, and other diseases.

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
A61K 31/36, 31/34

A1

(11) International Publication Number: WO 98/01132

(43) International Publication Date: 15 January 1998 (15.01.98)

(21) International Application Number: PCT/US97/11564

(22) International Filing Date: 8 July 1997 (08.07.97)

(30) Priority Data:
60/021,285 8 July 1996 (08.07.96) US

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(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: APOPTOSIS INDUCING ADAMANTYL DERIVATIVES AND THEIR USAGE AS ANTI-CANCER AGENTS

(57) Abstract

The present invention relates to specific adamantyl or adamantyl group derivative containing retinoid compounds induce apoptosis of cancer cells. These adamantyl retinoid derivatives are useful for the treatment of many cancers and solid tumors, especially androgen-independent prostate cancer, skin cancer, pancreatic carcinomas, colon cancer, melanoma, ovarian cancer, liver cancer, small cell lung carcinoma, non-small cell lung carcinoma, cervical carcinoma, brain cancer, bladder cancer, breast cancer, neuroblastoma/glioblastoma, and leukemia. Also, the invention relates to novel adamantyl or adamantyl group derivative compounds which are useful as active agents for the treatment or prevention of keratinization disorders and other dermatological conditions, and other diseases.

TITLE OF THE INVENTION

APOPTOSIS INDUCING ADAMANTYL DERIVATIVES AND THEIR USAGE AS ANTI-CANCER AGENTS

TECHNICAL FIELD OF THE INVENTION

The invention relates to the discovery that specific adamantyl or adamantyl group derivative containing retinoid related compounds induce apoptosis of cancer cells and therefore may be used for the treatment of cancer, including advanced cancers. Also, the present invention relates to novel adamantyl or adamantyl group derivative containing retinoid related compounds and their use for the treatment and/or prevention of cancer, keratinization disorders, dermatological conditions and other therapies.

BACKGROUND OF THE INVENTION

Solid tumors are the leading cause of death attributable to cancers worldwide. Conventional methods of treating cancer include surgical treatments, the administration of chemotherapeutic agents, and recently immune based treatments which typically involve the administration of an antibody or antibody fragment which may be conjugated to a therapeutic moiety such as a radionuclide. However, to date, such treatments have been of limited success.

Surgical treatments are generally only successful if the cancer is detected at an early stage, i.e., before the cancer has infiltrated major organs and surgery becomes non-feasible. Chemotherapeutic treatments

available today are also of limited usefulness because of their non-selective killing and/or toxicity to most cell types. Also, many tumor cells eventually become resistant against the chemotherapeutic agent, thus making treatment of solid tumors and other tumors non-feasible. For example, persons treated with cisplatin often develop tumors which are cisplatin resistant. Immune based treatments are also subject to numerous problems including difficulty in targeting antibodies to desired sites, e.g., solid tumors, and host immune reactions to the administered antibody, attributable to the fact that to date most therapeutic antibodies have been of murine origin.

The usage of retinoids for the prevention of cancer has also been reported. In contrast to most conventional chemotherapeutic agents, retinoids function via specific signal transduction pathways, activating defined receptors in the cell nucleus. These receptors, the RARs, and the RXRs bind to specific DNA sequences, retinoic acid response elements, or RAREs. In addition, retinoids interact with other transcription factors, in particular the activator protein-1 (AP-1).

It is believed that the selective action of certain synthetic retinoids is based on the ability of these molecules to selectively activate subclasses of RARs and/or RXRs in the context of specific DNA sequences and/or proteins. Because of this specificity, not all retinoids possess the same activities. Indeed, thousands of different retinoids have been synthesized with the object being the identification of retinoids having optimal therapeutic activity.

To date, most retinoids have been found to inhibit tumor progression or cell proliferation of certain cancers, but do not directly eliminate cancer cells. Consequently, retinoids have been considered predominantly

for the prevention of cancer but not for direct treatment.

One special class of retinoids or retinoid related compounds comprises adamantyl retinoid derivatives. These compounds are aromatic heterocyclic retinoids which contain an adamantyl group or an adamantyl group derivative. In contrast to normal retinoids such as retinoic acid (all -trans, 9-cis or 13-cis) and their synthetic analogs and derivatives, the adamantyl retinoid derivatives exhibit enhanced activity against specific tumor cells both *in vitro* and *in vivo*.

Retinoids also comprise known usage in the treatment of keratinization disorders and other dermatological diseases. For example, the use of retinoic acid, vitamin D or analogues thereof for the topical treatment of various dermatological diseases and in the cosmetic field is well known.

However, notwithstanding the large number of retinoids which have been reported, the identification of retinoids or retinoid related compounds having enhanced properties, in particular enhanced therapeutic activity, constitutes a significant need in the art.

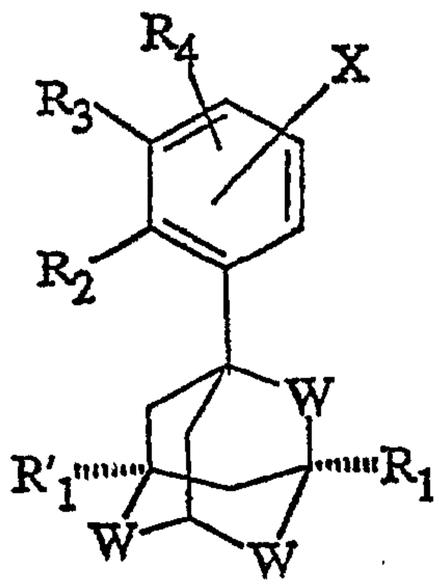
BRIEF DESCRIPTION AND OBJECTS OF THE INVENTION

It is an object of the invention to identify specific retinoid or retinoid related compounds having enhanced properties, in particular anti-cancer activity.

It is a more specific object of the invention to identify specific classes of adamantyl or adamantyl derivative containing retinoid related compounds having anti-cancer activity, preferably characterized by the ability to induce apoptosis of cancer cells.

It is an even more specific object of the invention to use an adamantyl retinoid compound in the manufacture of a medicament for use in a method of treating cancer which comprises the induction of apoptosis of cancer cells or for use in the prevention of a cancerous or precancerous condition wherein the adamantyl retinoid compound is of one of the following generic formulae set forth below or a pharmaceutically acceptable salt, optical and/or geometrical isomer thereof;

a compound of generic formula (I):

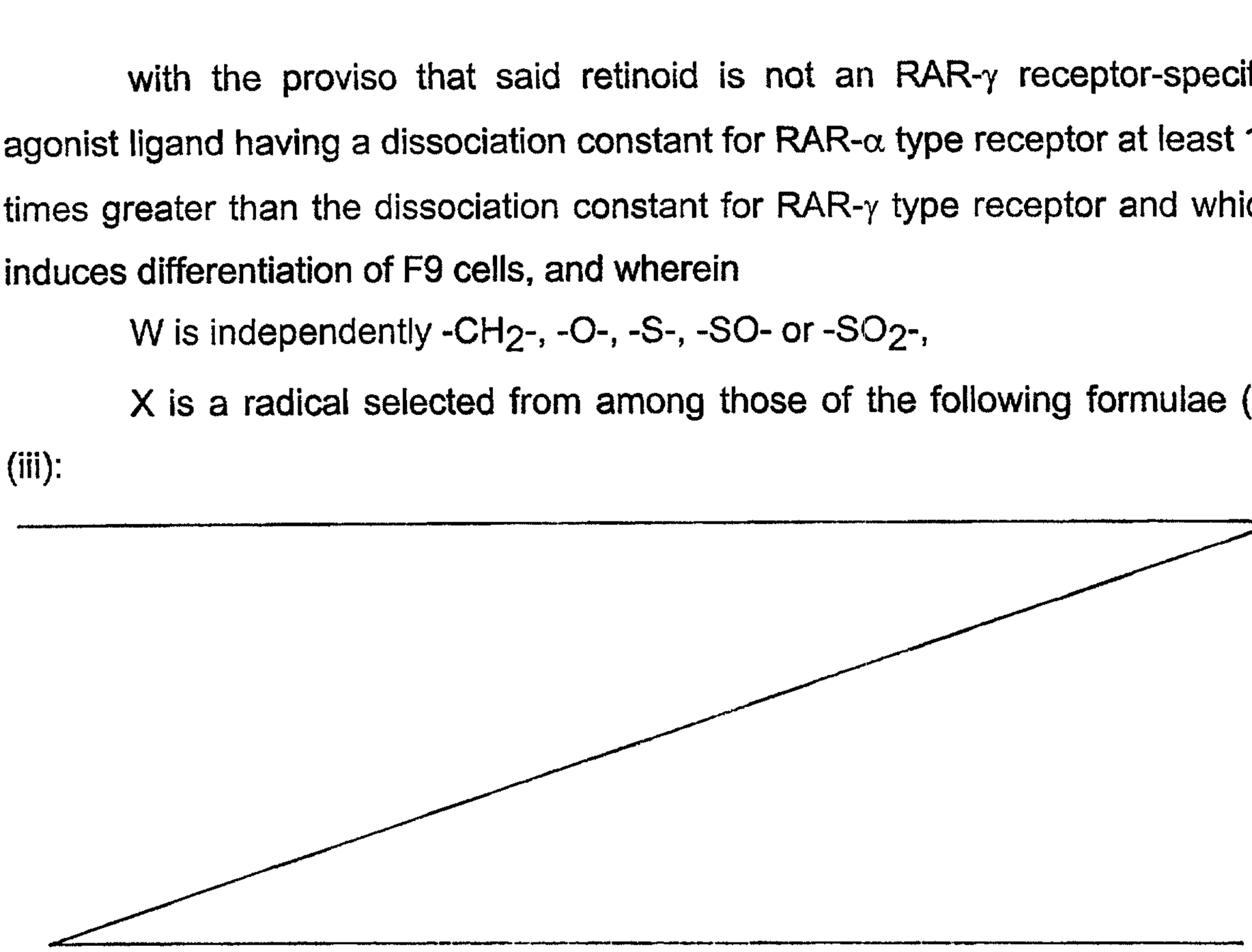


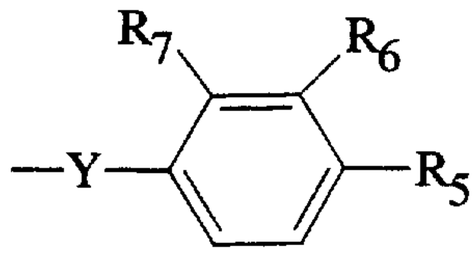
(I)

with the proviso that said retinoid is not an RAR-γ receptor-specific agonist ligand having a dissociation constant for RAR-α type receptor at least 10 times greater than the dissociation constant for RAR-γ type receptor and which induces differentiation of F9 cells, and wherein

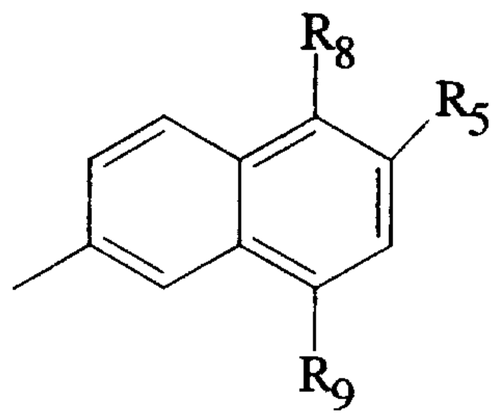
W is independently $-CH_2-$, -O-, -S-, -SO- or $-SO_2-$,

X is a radical selected from among those of the following formulae (i)-(iii):





(i)



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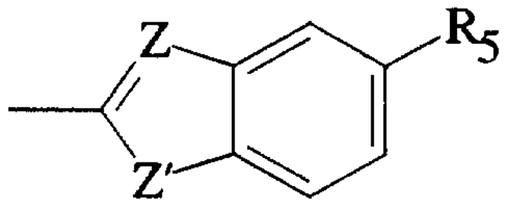
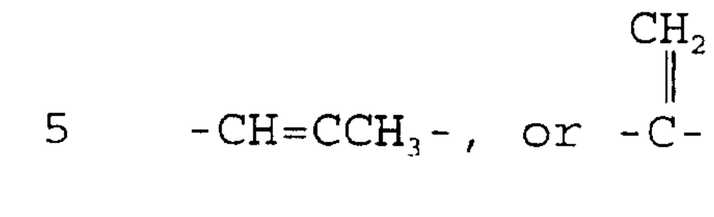
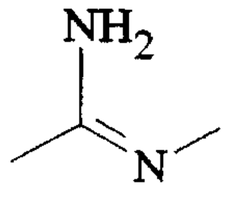


(iii)

wherein

Y is a radical -CO-V-, -CH=CH-, -CH_3C=CH-,





;

V is an oxygen atom (-O-), an aza radical (-NH-), a radical -CH=CH- or -C≡C-;

Z is a radical -CH- and Z′ is an oxygen atom, or

Z is a nitrogen atom (N) and Z′ is an aza radical (-NH-);

R_1 is a hydrogen atom, a halogen, or a lower alkyl radical;

R'_1 is a hydrogen atom, a halogen, or a lower alkyl radical;

R_2 is a hydroxyl radical, a halogen, an alkyl radical, optionally substituted by one or more hydroxyl or acyl groups, an alkoxyl radical, optionally substituted

by one or more hydroxyl, alkoxyl or aminocarbonyl groups, and/or optionally interrupted by one or more oxygen atoms, an acyl radical, an aminocarbonyl radical or a halogen;

R_3 is a hydrogen atom, a halogen, an hydroxyl radical, an alkyl radical, or an alkoxyl radical;

R_2 and R_3 can form together a radical $-O-CH_2-O-$;

R_4 is a hydrogen atom, an alkyl radical, an alkoxyl radical or a halogen;

R_5 is a radical $-CO-R_{10}$, an alkyl radical, optionally substituted by one or more hydroxyl groups, or a halogen;

R_6 is a hydrogen atom, a halogen atom, an alkoxyl radical, or hydroxyl group;

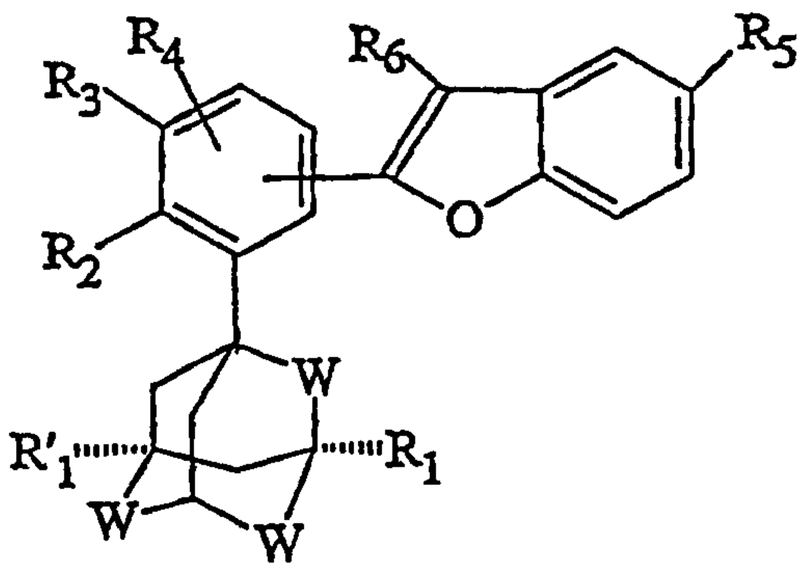
R_7 is a hydrogen atom or a halogen;

R_8 is a hydrogen atom, a halogen atom or an alkyl radical;

R_9 is a hydrogen atom, a hydroxyl radical or a halogen atom;

R_{10} is a hydroxyl radical, an alkoxy radical, a radical of formula -Nr'r", wherein r' and r" represent a hydrogen atom, an optionally substituted aminoalkyl radical, a mono- or polyhydroxyalkyl radical, an optionally substituted aryl radical or an amino acid or sugar residue or alternatively, taken together, form a heterocycle;

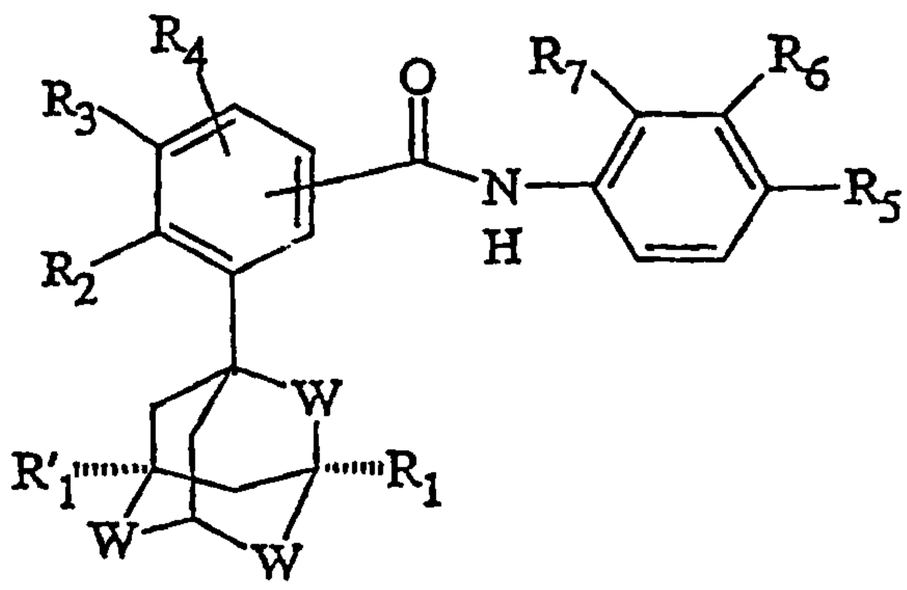
or a compound having generic formula (III):



(III)

wherein R'_1, R_1, R_2, R_3, R_4, R_5, R_6 and W are as defined for compounds of formula (I); or

a compound having generic formula:



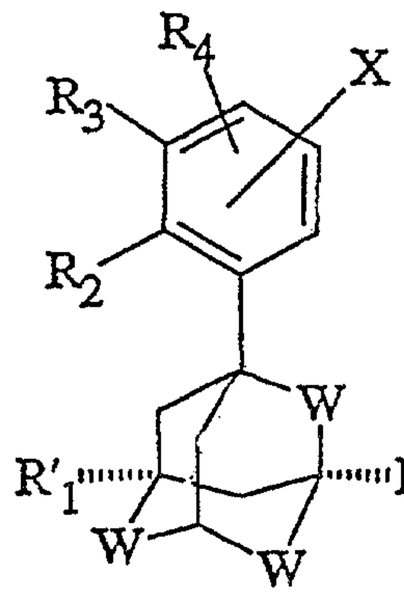
(IV)

wherein R'_1, R_1, R_2, R_3, R_4, R_5, R_6, R_7 and W are as defined for compounds of formula (I), wherein said lower alkyl radicals contain from 1 to 6 carbon atoms and wherein the cancer is selected from the group consisting of prostate cancer, pancreatic carcinoma, colon cancer, melanoma, liver cancer, small cell lung carcinoma, non-small cell lung carcinoma, cervical cancer, breast cancer, bladder cancer, brain cancer, neuroblastoma/glioblastoma, leukemia, head and neck cancer, kidney cancer, lymphoma, myeloma, and ovarian cancer.

For compounds having formula (IV), R_6 is preferably not hydrogen.

It is a more specific object of the invention to provide an adamantyl retinoid compound which consists of one of the following generic formulae or a pharmaceutically acceptable salt, geometric and/or optical isomer thereof:

– a compound of general formula (I):



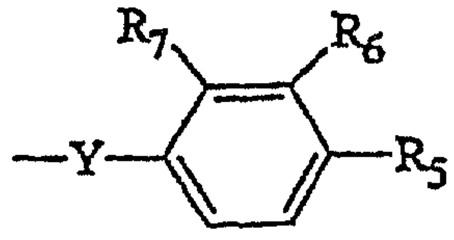
(I)

with the proviso that said retinoid of formula (I) is not an RAR-γ receptor-specific agonist ligand having a dissociation constant for RAR-α type receptor at least 10 times greater than the dissociation constant for RAR-γ type receptor and

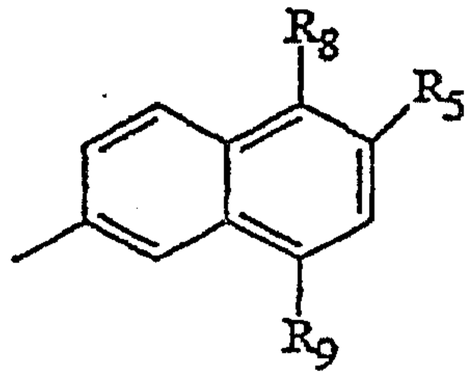
in which:

W is independently $-CH_2-$, -O-, -S-, -SO- or $-SO_2-$,

X is a radical selected from among those of the following formulae (i)-(iii):



(i)



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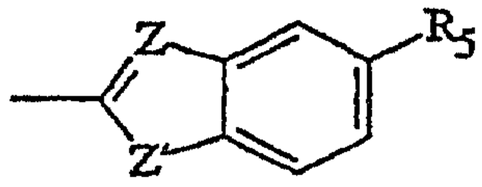
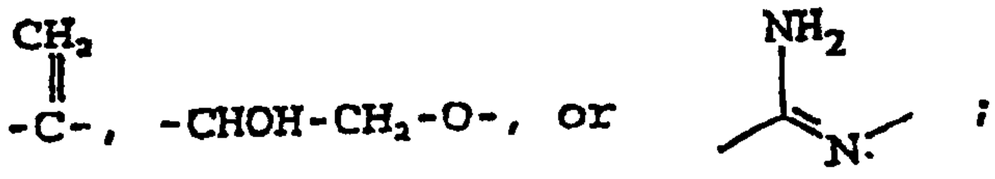


(iii)

wherein

Y is a radical -CO-V-, -CH=CH-, -CH_3C=CH-, -CH=CCH_3-, or



;

V is an oxygen atom (-O-), an aza radical (-NH-), a radical -CH=CH- or -C≡C-;

Z is a radical -CH- and Z' is an oxygen atom, or

Z is a nitrogen atom (N) and Z' is an aza radical (-NH-);

R_1 is a hydrogen atom, halogen atom, or a lower alkyl radical;

R'_1 is a hydrogen atom, halogen atom, or a lower alkyl radical;

R_2 is a hydroxyl radical, an alkyl radical, optionally substituted by one or more hydroxyl or acyl groups, an alkoxyl radical, optionally substituted by one or more hydroxyl, alkoxyl or aminocarbonyl groups, and/or optionally interrupted by one or more oxygen atoms, an acyl radical, an aminocarbonyl radical or a halogen;

R_3 is a hydrogen atom, a halogen atom, a hydroxyl radical, an alkyl radical, or an alkoxyl radical;

R_4 is a hydrogen atom, an alkyl radical, an alkoxyl radical, or a halogen;

R_5 is a radical -CO-R_{10}, an alkyl radical, optionally substituted by one or more hydroxyl groups, or a halogen;

R_6 is a hydrogen atom, a halogen atom, an alkoxyl radical, or a hydroxyl group;

R_7 is a hydrogen atom or a halogen;

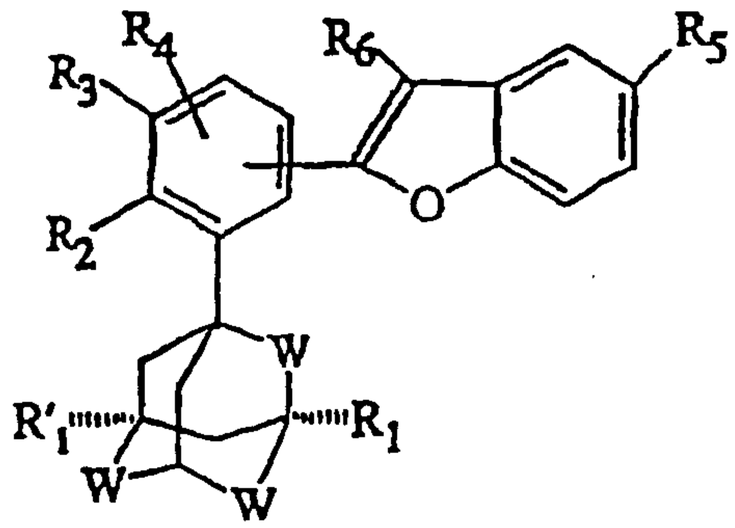
R_8 is a hydrogen atom, a halogen atom or an alkyl radical;

R_9 is a hydrogen atom, a hydroxyl radical or a halogen atom;

R_{10} is a hydroxyl radical, an alkoxyl radical, a radical of formula -Nr'r", wherein r' and r" represent a hydrogen atom, an aminoalkyl radical wherein the

amino residue is optionally substituted by at least one alkyl radical, a mono- or polyhydroxyalkyl radical, a phenyl radical optionally substituted by at least one halogen, a hydroxyl or a nitro functional group, or an amino acid or sugar residue, or alternatively, r' and r" together, form a heterocycle, with the proviso that at least one of R_3 and R_4 is not an hydrogen; or

– a compound having generic formula (III):

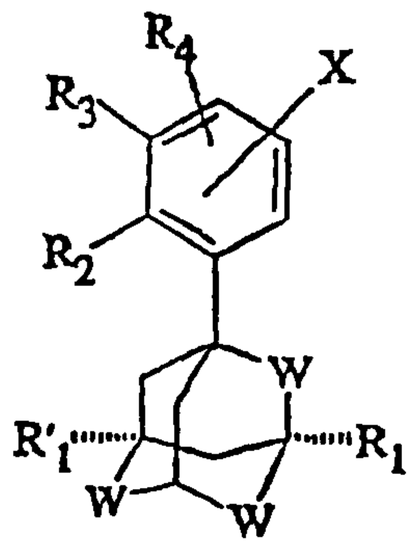


(III)

wherein W, R'_1, R_1, R_2, R_3, R_4, R_5, R_6 are as defined for compounds of formula (I), and

wherein said lower alkyl radicals contain from 1 to 6 carbon atoms.

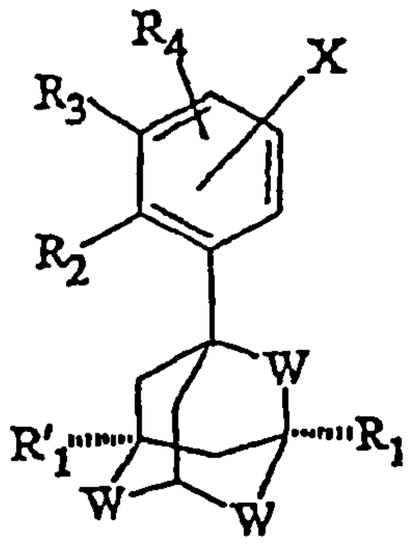
According to a preferred embodiment, the compound of formula (I) corresponds to a compound of formula (I'):



(I')

wherein V, W, X, Y, Z, Z', R_1', R_1-R_{10}, are as defined above with the proviso that at least one of W is -O-, -S-, -SO-, or -SO_2-, and/or at least one of R_1 and R_1' is halogen or a lower alkyl radical.

According to another preferred embodiment, the compound of formula (I) corresponds to a compound of generic formula (I"):



(I")

wherein V, W, X, Y Z, Z', R'_1, R_1-R_{10} are as defined above with the proviso that R_5 is -CO-R_{10}, and R_{10} is a radical of formula -Nr'r", wherein one of r' and r" is hydrogen and the other is an aminoalkyl radical wherein the amino residue is optionally substituted by at least one alkyl radical or alternatively r' and r", taken together, form a heterocycle.

It is another object of the invention to provide therapeutic and/or cosmetic compositions containing such novel retinoid compounds.

It is a further object of the invention to provide therapeutic/prophylactic/cosmetic methods involving the administration of a novel adamantyl or adamantyl derivative compound according to the invention. Such methods will include known usages of retinoid compounds, in particular, usage for treatment/prophylaxis of keratolytic associated disorders associated with differentiation and/or proliferation and other dermal related disorders.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 compares the activity of selected adamantyl retinoids according to the invention and all-trans-retinoic acid against human cancer cell lines.

Figure 2 compares the activity of selected adamantyl retinoids according to the invention and all-trans-retinoic acid against a human non-small lung carcinoma cell line.

Figure 3 compares the activity of selected adamantyl retinoids according to the invention and all-trans-retinoic acid against human prostate adenocarcinoma, human metastatic prostate adenocarcinoma, and human prostate carcinoma cell lines.

Figure 4 compares the activity of selected adamantyl retinoids according to the invention and all-trans-retinoic acid against a human liver cancer cell line.

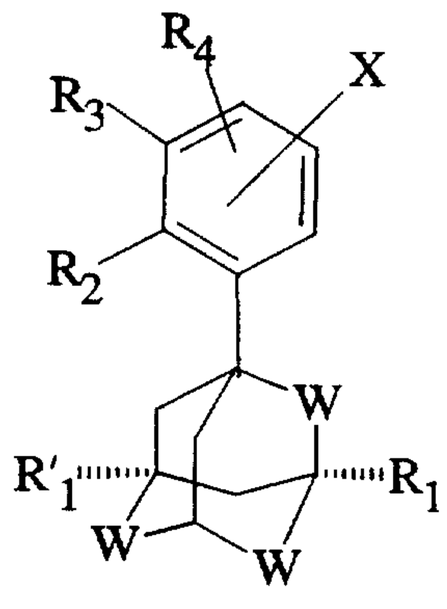
Figure 5 shows the effect of 6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid in a human pancreatic cancer BxP-3 animal model.

DETAILED DESCRIPTION OF THE INVENTION

Toward that end, the present inventors, quite surprisingly, have discovered that specific adamantyl retinoid derivatives induce apoptosis of cancer cells. This is highly unexpected as in contrast to most conventional chemotherapeutic agents, retinoids and also most known adamantyl retinoids, function via specific signal transduction pathways, activating defined receptors in the cell nucleus. By contrast, it has been unexpectedly discovered that the specific adamantyl retinoid derivatives which are disclosed *infra* induce cancer cell apoptosis and therefore may be used to eradicate cancer cells. Consequently, these retinoids may be used for

the direct treatment of cancers, including advanced cancers.

More specifically, the present invention relates to the use of adamantyl retinoid derivatives having the following formula (I) for inducing apoptosis:

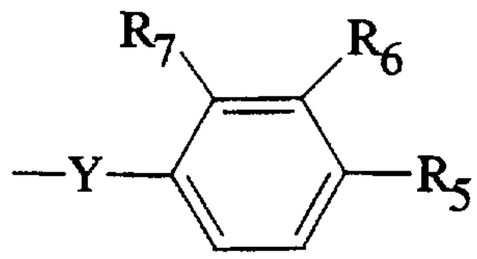


(I)

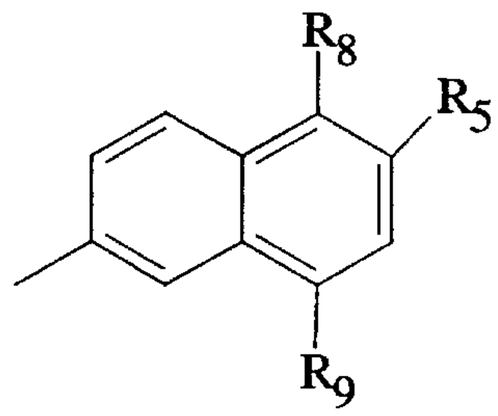
wherein

W is independently $-CH_2-$, -O-, -S-, -SO- or $-SO_2-$,

X is a radical selected from among those of the following formulae (i)-(iii)



(i)



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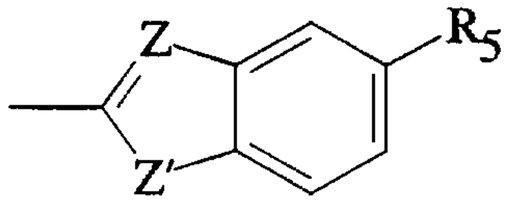
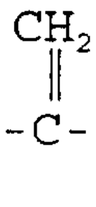
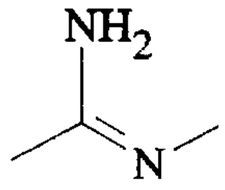


(iii)

wherein

Y is a radical -CO-V-, -CH=CH-, $-CH_3C=CH-$,

$-CH=CCH_3-$, or  , -CHOH-CH_2-O-, or  ;

V is an oxygen atom (-O-), an aza radical (-NH-), a radical -CH=CH- or -C≡C-;

Z is a radical -CH- and Z' is an oxygen atom, or

Z is a nitrogen atom (N) and Z' is an aza radical (-NH-);

R_1 is a hydrogen atom, halogen atom or a lower alkyl radical;

R'_1 is a hydrogen atom, halogen atom or a lower alkyl radical;

R_2 is a hydroxyl radical, halogen atom, an alkyl radical, optionally substituted by one or more hydroxyl or acyl groups, an alkoxyl radical, optionally substi-

tuted by one or more hydroxyl, alkoxyl or aminocarbonyl groups, and/or optionally interrupted by one or more oxygen atoms, an acyl radical or an aminocarbonyl radical, or a halogen;

R_3 is a hydrogen atom, halogen atom, a hydroxyl radical, an alkyl radical, or an alkoxyl radical;

R_2 and R_3 can form together a radical $-O-CH_2-O-$;

R_4 is a hydrogen atom, halogen atom, an alkyl radical, or an alkoxyl radical;

R_5 is a radical $-CO-R_{10}$ or an alkyl radical, optionally substituted by one or more hydroxyl groups,

R_6 is a hydrogen atom, a halogen atom, preferably fluorine, an alkoxyl radical, or a hydroxyl group;

R_7 is a hydrogen atom or a halogen atom, preferably a fluorine atom;

R_8 is a hydrogen atom, a halogen atom or an alkyl radical;

R_9 is a hydrogen atom, a halogen atom or a hydroxyl radical;

R_{10} is a hydroxyl radical, an alkoxy radical, a formula -Nr'r", wherein r' and r" represent a hydrogen atom, an optionally substituted aminoalkyl radical, a mono- or polyhydroxyalkyl radical, an optionally substituted aryl radical, or an amino acid or sugar residue, or alternatively, taken together, form a heterocycle, their pharmaceutically acceptable salts, or their optical and/or geometrical isomers thereof, with the proviso that such compounds do not include RAR-γ receptor-specific agonist ligands.

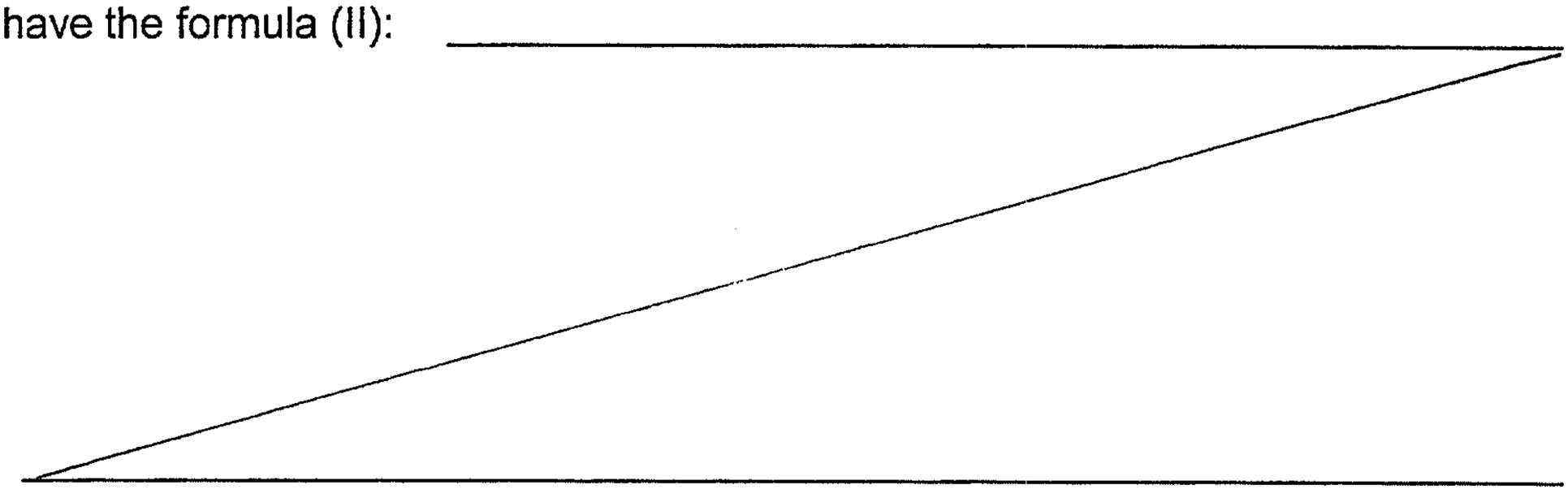
By RAR-γ receptor-specific agonist ligands in the subject application, it is intended ligands which possess a dissociation constant for ligands of the type RAR-α which is at least 10 times greater than the dissociation constant of these ligands for receptors of the

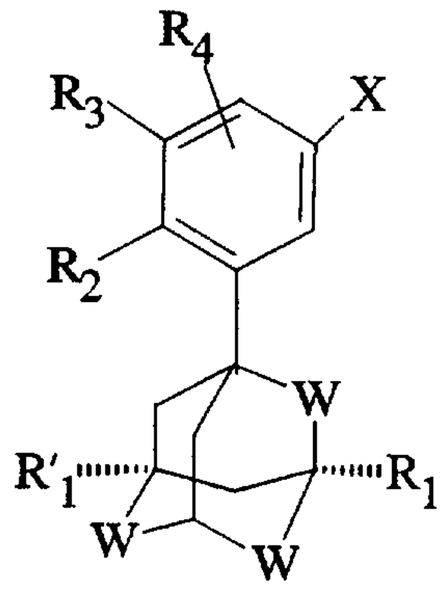
type RAR-γ, and wherein such ligands further induce the differentiation of F9 cells.

All trans-retinoic acid and certain analogs thereof are known to be capable of inducing the differentiation of embryonic tetracarcinoma F9 cells cultured in the presence of agonists of RARs receptors. Also, the secretion of plasminogen activator is known to accompany this differentiation and is an indicator of the biological response of these cells to retinoids. (See *Skin Pharmacol.*, 3:256-267 (1994).)

Methods for measuring these dissociation constants are known in the art. For example, suitable methods are disclosed in the following references. "Selective Synthetic Ligands for Nuclear Retinoic Acid Receptors Subtypes", in Retinoids, Progess in Research and Clinical Applications, Chapter 19 (pp 261-267), Marcel Dekker Inc., edited by Maria A. Livrea and Lester Packer; "Synthetic Retinoids: Receptor Selectivity and Biological Activity", in *Pharmacol. Skin*, Basal, Karger, 1993, Vol. 5:117-127; "Selective Synthetic Ligands for Human Nuclear Retinoic Acid Receptors", in *Skin Pharmacol.*, Vol. 5:57-65 (1992); "Identification of Synthetic Retinoids with Selectivity for Human Nuclear Retinoic Acid Receptor-γ", in Biochemical and Biophysical Research Communications, Vol. 186, No. 2, July 1992, pp 977-983; and "Selective High Affinity RAR-α or RAR-β Retinoic Acid Receptor Ligands", in *Molecular Pharmacology*, Vol. 40:556-562. See, also WO 97/13505, which discloses methods for identification of RAR-γ agonist ligands.

More preferably, the apoptosis inducing derivatives of formula (I) will have the formula (II):





(II)

in which W, X, R_1, R'_1, R_2, R_3 and R_4 are defined above, and wherein such compounds do not include RAR-γ receptor-specific agonist ligands.

In one preferred embodiment, at least two of the radicals W are $-CH_2-$. Still more preferably, all of the W radicals are $-CH_2-$.

In another preferred embodiment, at least one of R_1 and R_1' is a hydrogen atom. Still, more preferably, R_1 and R_1' are both hydrogen atoms.

According to the invention, lower alkyl radical refers to a radical having from 1 to 6 carbon atoms, especially methyl, ethyl, propyl, isopropyl, butyl, tert-butyl and hexyl radicals.

Alkyl radical refers to a radical having 1 to 20 carbon atoms, straight chain or branched, especially methyl, ethyl, propyl, isopropyl, butyl, tert-butyl, hexyl, 2-ethylhexyl, octyl, dodecyl, hexadecyl and octadecyl radicals.

Acyl radical refers to a radical having 1 to 20 carbon atoms, straight chain or branched, containing a CO group, such as acetyl or benzoyl.

Alkoxy radical refers to a radical having 1 to 20 carbon atoms, straight chain or branched, containing an alkoxy group.

Sugar residue refers to a residue derived in particular from glucose, galactose or mannose or alternatively from glucuronic acid.

Monohydroxyalkyl radical refers to a radical having 1 to 6 carbon atoms, especially a hydroxymethyl, 2-hydroxyethyl, 2-hydroxypropyl, 3-hydroxypropyl, 4-hydroxybutyl, 5-hydroxypentyl or 6-hydroxyhexyl radical.

Polyhydroxyalkyl radical refers to a radical having 3 to 6 carbon atoms and 2 to 5 hydroxyl groups, especially a 2,3 dihydroxypropyl, 2,3,4-trihydroxybutyl or 2,3,4,5-tetrahydroxypentyl radical or the pentaerythritol residue.

Aryl radical refers to a phenyl radical optionally substituted by at least one halogen, a hydroxyl or a nitro functional group.

Aminoalkyl radical optionally substituted refers to an alkyl radical substituted by an amino residue, the amino residue may also be substituted by at least one alkyl radical, such as aminoethyl, methylaminoethyl, or dimethylaminoethyl radical.

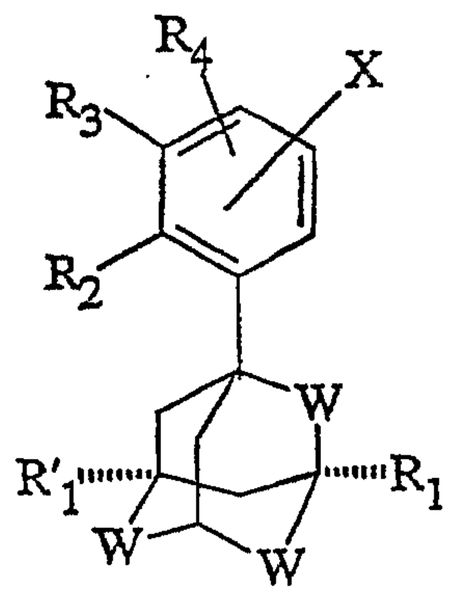
Amino acid residue refers to a residue derived from any amino acid, such as lysine, glycine or aspartic acid.

Heterocycle preferably refers to a piperidino, morpholino, pyrrolidino, piperazine or homologs thereof, optionally substituted at the 4-position by a C_1-C_6 alkyl radical or a mono- or polyhydroxyalkyl radical as defined above.

Some compounds having the above generic formulae and their preparation have been disclosed in the following patent and patent applications U.S. 4,740,519; U.S. 4,920,140; U.S. 5,059,621; U.S. 5,260,295; U.S. 5,428,052; U.S. 4,717,720; U.S. 4,940,696; U.S. 5,183,889; U.S. 5,212,303; U.S. Re 34440; U.S.

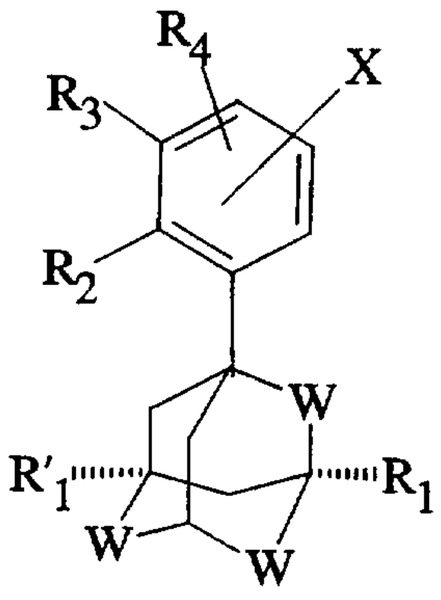
4,927,928; U.S. 5,200,550; U.S. 5,332,856; U.S. 5,468,897; U.S. Patent No. 5,547,983; 1992; U.S. 5,476,860; U.S. 5,015,758; U.S. 5,183,889; FR 2 676 052; French patent application No. FR 2 741 878, filed on December 1, 1995; and French patent application No. FR 2 741 876, filed on December 1, 1995.

Also, the present invention provides specific novel classes of adamantyl retinoid derivatives having the generic formulae set forth below, or their pharmaceutically acceptable salts, or optical and/or geometrical isomers thereof which induce apoptosis and/or which further comprise other desirable pharmacological properties:



(I)

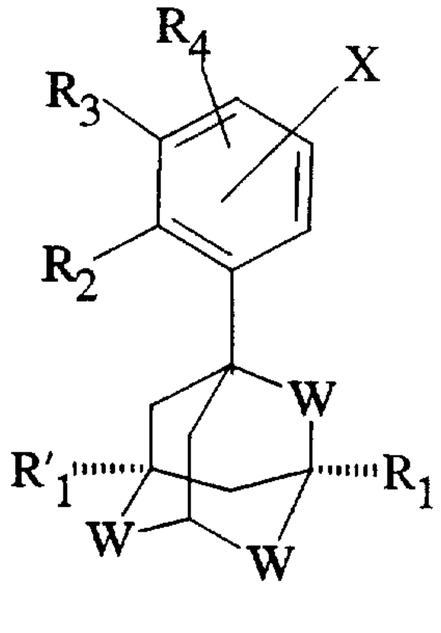
wherein R'_1, R_1, R_2, R_3, R_4, X and W are as defined *supra*, with the proviso that at least two of R_2, R_3 and R_4 are other than hydrogen; and with the further proviso that R_2 and R_3 cannot together form $-O-CH_2-O-$, or compounds of generic formula I, set forth below:



(I)

wherein W, X, R_1', R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{10}, Y, V are as defined *supra*, except with the proviso that at least one of W is -O-, -S-, -SO- or $-SO_2$ and/or at least one of R_1 and R_1' is halogen or a lower alkyl radical, preferably, wherein at least one of W is -O- and/or R_1 is a lower alkyl radical and/or R_1' is a lower alkyl radical, and/or also preferably wherein X comprises formula (ii), and/or R_8 is preferably hydrogen and/or R_9 is hydrogen and/or R_5 is $-CO-R_{10}$; or

compounds of generic formula I, set forth below:

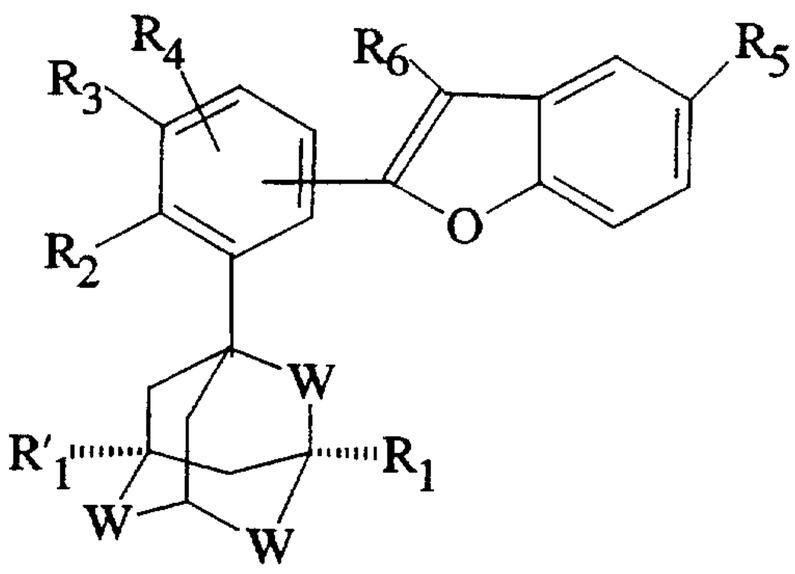


(I)

wherein W, X, R_1', R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{10}, Y, V are as defined *supra*, except with the proviso that R_5 is $-CO-R_{10}$, and R_{10} is a radical of formula Nr'r", wherein at least one of r' and r" is hydrogen and the

other is an optionally substituted aminoalkyl radical, or alternatively r′ and r", taken together, form a heterocycle, preferably a piperazino or a homolog thereof, preferably wherein X comprises formula (ii) and/or more preferably R_8 is hydrogen and/or R_9 is hydrogen. Also, preferred are compounds of formula (I) wherein R_2 is an alkoxy radical or hydroxyl group and/or R_3 is hydrogen and/or R_4 is hydrogen and/or R_2 and R_3 together form $-O-CH_2-O-$;

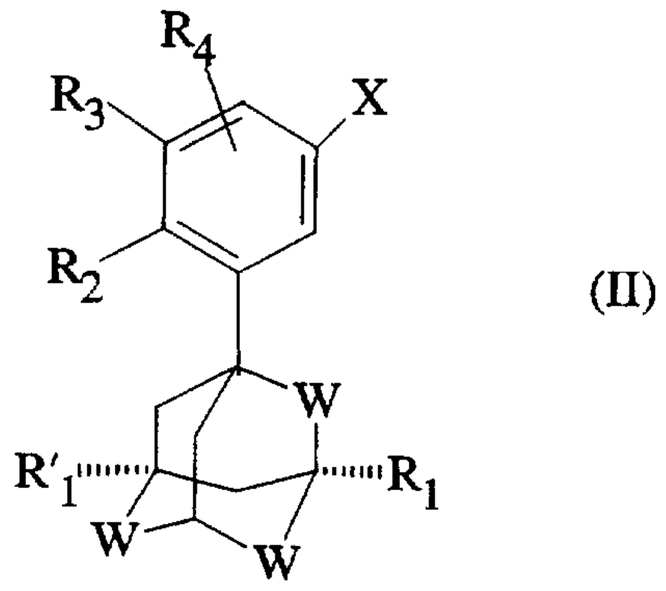
or compounds of formula (III):



(III)

wherein R'_1, R_1, R_2, R_3, R_4, R_5 and R_6 and W are as defined *supra*;

A more specific subclass of compounds of formula (I) comprises compounds of formula (II) below:

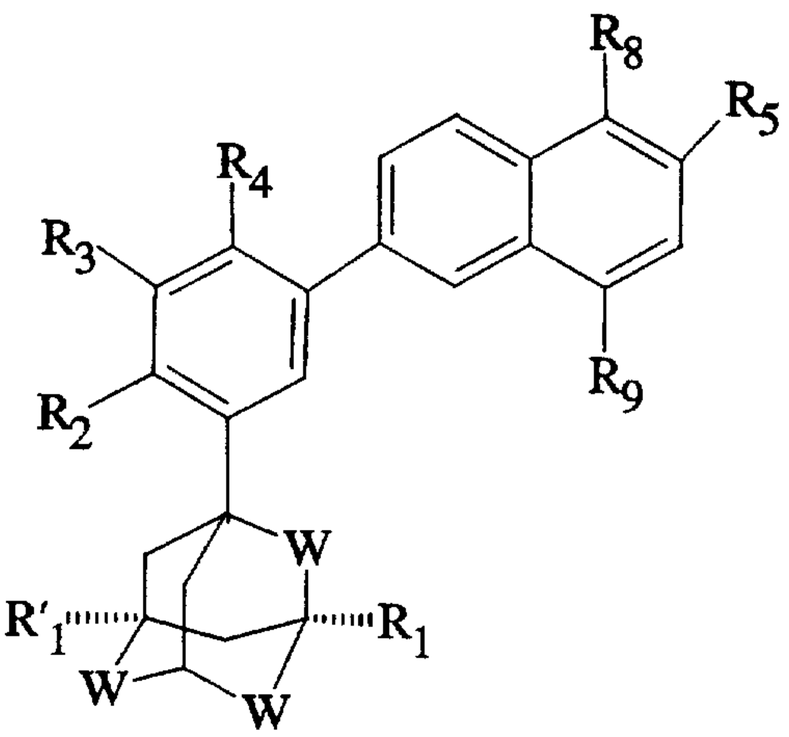


(II)

wherein R_1', R_1, R_2, R_3, R_4, X and W are as defined above and at least two of R_2, R_3 and R_4 are not hydrogen, and wherein R_2 and R_3 cannot together form $-O-CH_2-O$; or compounds of formula (II) wherein R_5 is $-C-O-R_{10}$, R_{10} is a radical of formula -Nr'r", wherein one of r' and r" is hydrogen and the other is an optionally substituted aminoalkyl radical, or alternatively r' and r" taken together form a heterocycle, preferably piperazino or a homolog thereof, and wherein preferably R_8 is hydrogen and/or R_9 is hydrogen; or compounds of formula (II) where at least one of W is -O-, -S-, -SO- or $-SO_2$ and/or at least one of R_1 and R_1' is halogen or a lower alkyl radical, wherein X preferably has formula (ii), and more preferably R_8 is hydrogen and/or R_9 is preferably hydrogen and/or R_5 is $-CO-R_{10}$.

Also preferred are compounds of formula (II) wherein R_2 is an alkoxy radical or hydroxyl group and/or R_3 is hydrogen and/or R_4 is hydrogen and/or R_2 and R_3 together form $-O-CH_2-O$.

An even more specific subclass of novel retinoid related compounds of formula (II) comprises adamantyl retinoid related compounds having the generic formula set forth below.



(V)

wherein R'_1, R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9 and W are as defined *supra*, with the proviso that at least two of R_2, R_3 and R_4 are other than hydrogen, and with the further proviso that R_2 and R_3 cannot together form $-O-CH_2-O-$.

Preferred compounds of formula (V) comprise retinoid related compounds wherein R_5 is a hydroxycarbonyl radical, preferably $-CO-R_{10}$, and/or compounds wherein R_2 is a hydroxyl radical, an alkoxyl radical, and/or R_8 is hydrogen, and/or R_9 is hydrogen and/or R_3 is a hydroxyl radical or alkoxyl radical, and/or R_4 is hydrogen or an alkyl radical.

Other preferred compounds of formula (V) include compounds wherein at least one of W is -O-, -S-, -SO- or $-SO_2-$ and/or at least one of R_1 and R_1' is halogen or a lower alkyl radical.

The novel retinoid derivatives of the present invention can be synthesized by known methods for synthesizing retinoids such as are disclosed in the patents and applications incorporated by reference herein. Further, specific methods for the synthesis of the retinoids of formula (V) are described below.

SCHEME I

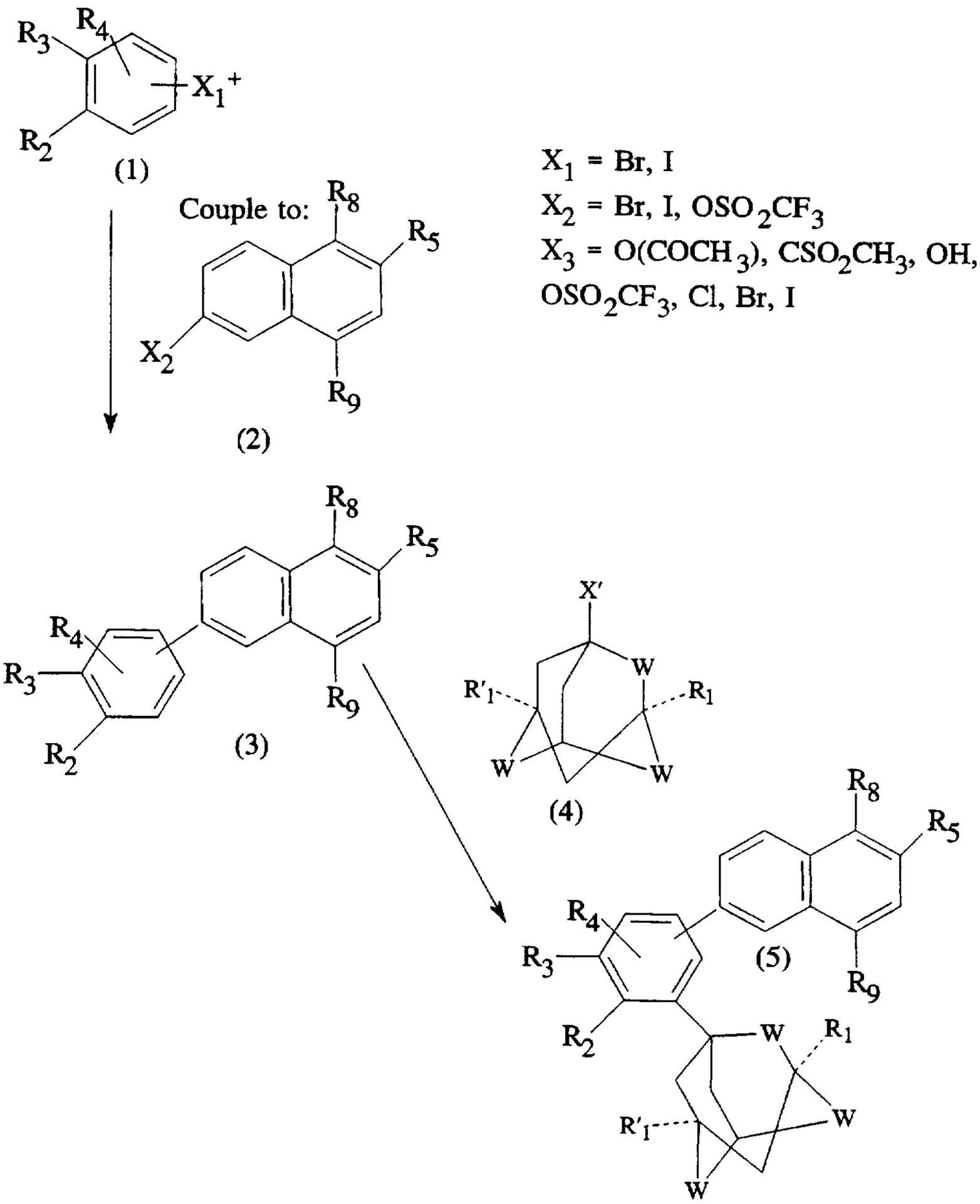
According to synthetic Scheme I a halobenzene derivative (1) (see schematic of Scheme I *infra*) is coupled to a naphthyl halide or 2-naphthyl trifluoromethanesulfonate (2) to form (3), e.g., through treatment of (1) in dry THF with butyl lithium at -78°C followed by zinc chloride, followed by (2) in the presence of nickel bis(diphenylphosphino)ethane dichloride. A tertiary ester or halide derived from an oxaadamantyl, adamantyl, thiaadamantyl or related molecule of formula (4) is then reacted with (3) in the presence of 0.1 to 1.3 molar equivalents of an appropriate acid (e.g., sulfuric acid or trifluoromethylsulfonic acid if X3 is acetoxy or mesyloxy) in a mixed solvent, preferably containing cyclohexane and either heptane, dichloromethane, or 1,2-dichloroethane at a temperature between 25°C and 90°C.

Esters obtained in accordance with the above methods wherein R_5 is an ester group may be converted, according to known procedures, into various analogs which are the objects of meanings for the radical R_5. For example, such esters include saponified acids which can be transformed into acid chlorides which are easily converted into amides. Alternatively, such amides can be obtained by the direct action of amines on the esters obtained as described above. Moreover, the reduction of the esters, aldehydes or amides by an appropriate reducing agent (for example lithium aluminohydride) further permits the production of the corresponding alcohols and amines.

The subject synthetic method is especially preferred if R_2 is an alkoxy or hydroxy group and R_5, R_8 and R_9 are not strongly electron-donating groups such as alkoxy, hydroxy or alkamino, and all of the functionalities other than R'_1, R_1, and W are compatible with butyl

lithium or can be used in a protected form that is compatible with butyl lithium.

SCHEME I



SCHEME II

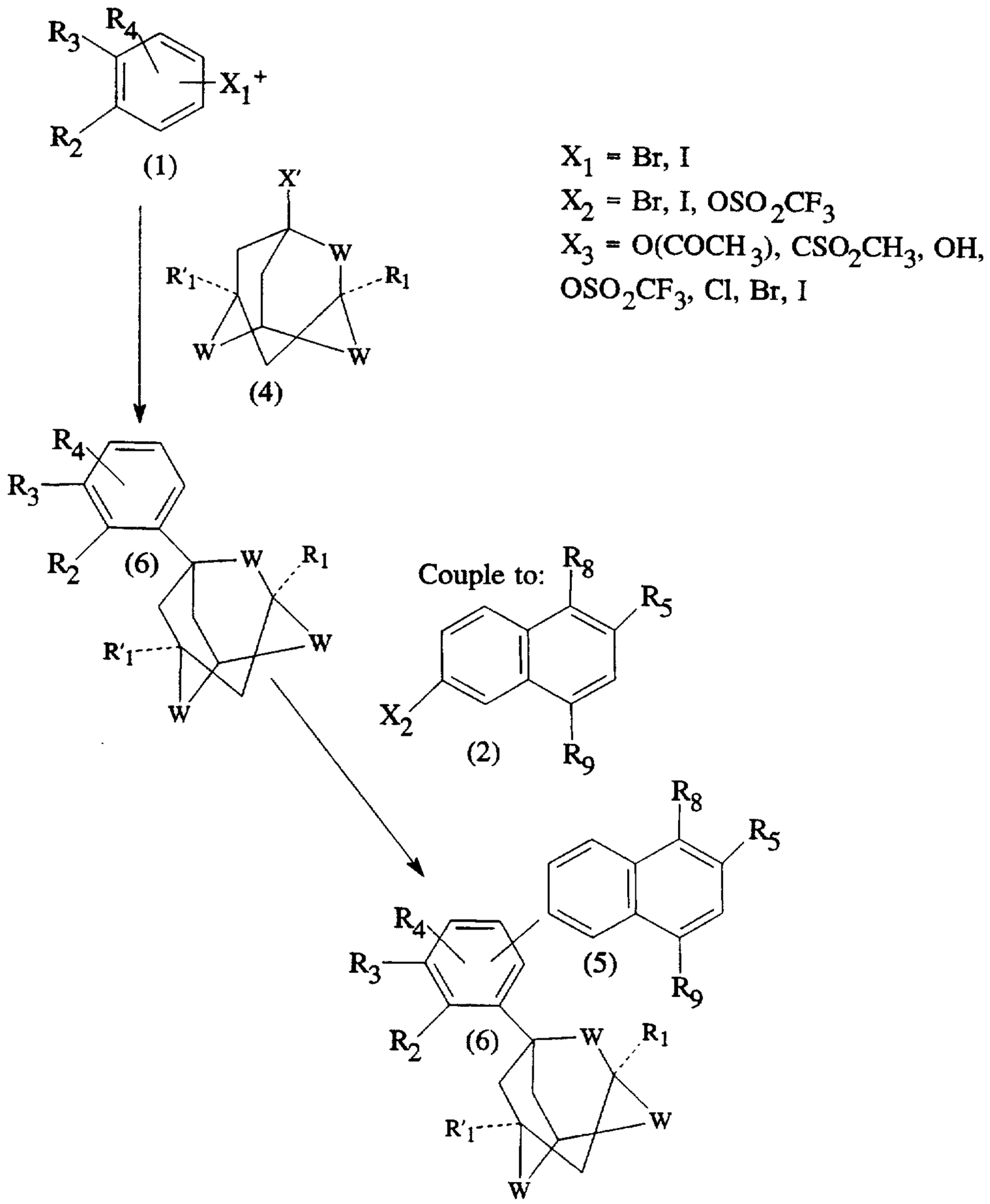
A second method (Scheme II) for synthesizing the novel adamantyl retinoids of formula (V) is shown in Scheme II. This method comprises reacting a tertiary ester or halide derived from an oxaadamantyl, adamantyl, thiaadamantyl or related molecule of formula (3) with a halobenzene derivative (1) in the presence of 0.1 to 1.3 molar equivalents of an appropriate acid (sulfuric acid or trifluoromethylsulfonic acid if X_3 is acetoxy, hydroxy or mesyloxy) in a mixed solvent containing cyclohexane and either heptane, dichloromethane, or 1,2-dichloroethane at a temperature between 25 and 90°C. The resulting adduct (6) is then coupled to the 2-naphthyl halide or 2-naphthyl trifluoromethanesulfonate (2) to form (5), e.g, through treatment of (6) in dry THF with butyl lithium at -78°C followed by zinc chloride, followed by (2) in the presence of nickel bis(diphenylphosphino)ethane dichloride.

Esters obtained in accordance with the methods described above wherein R_5 is an ester group may be converted, according to known procedures, into various analogs which are provided for based on the definition of the R_5 radical in generic formula (V). For example, such esters include saponified acids which can be transformed into acid chlorides which in turn are easily converted into amides. Alternatively, such amides can be obtained by the direct action of amines on the esters obtained earlier. The reduction of the esters, aldehydes or amides by an appropriate reducing agent (for example, lithium aluminohydride) further permits production of the corresponding alcohols and amines.

This synthetic scheme is preferred if R_5, R_8 and/or R_9 are strongly electron-donating groups such as alkoxy, hydroxy or alkamino, and all of the functionalities are

compatible with butyl lithium or can be used in a protected form that is compatible with butyl lithium.

SCHEME II



X_1 = Br, I
X_2 = Br, I, OSO_2CF_3
X_3 = $O(COCH_3)$, CSO_2CH_3, OH, OSO_2CF_3, Cl, Br, I

The subject adamantyl retinoid derivatives identified *supra* which induce apoptosis may be used for the treatment of many different cancers. Specific examples

of cancers treatable with the subject retinoid derivatives include by way of example bladder cancer, brain cancer, head and neck cancer, kidney cancer, lung cancers such as small cell lung cancer and non-small cell lung cancer, myeloma, neuroblastoma/glioblastoma, ovarian cancer, pancreatic cancer, prostate cancer, skin cancer, liver cancer, melanoma, colon cancer, cervical carcinoma, breast cancer, and leukemias. Moreover, because of their apoptosis inducing activity, the subject adamantyl retinoid derivatives are especially well suited for treatment of solid tumors and advanced cancers which cannot be treated by most conventional cancer therapies.

In treating cancer, the adamantyl or adamantyl derivative compounds of the present invention may be administered by any pharmaceutically acceptable means, e.g., systemically, enterally, parenterally or topically. An effective therapeutic dosage will comprise a dosage sufficient to induce apoptosis of cancer cells. This dosage will vary dependent upon factors such as the condition of the patient treated, the specific compound, whether it is used alone or in combination with other therapies, among other factors. In general, an effective dosage will vary from 0.01 mg/kg to 100 mg/kg of body weight, and more preferably 1 mg to 50 mg of body weight, typically administered at the rate of 1 to 3 dosages per diem.

As discussed, the adamantyl retinoid derivatives according to the invention which induce apoptosis are useful for treating many different types of cancers. Specific adamantyl retinoid compounds according to the invention which have been demonstrated to exhibit such activity are set forth below. The specific types of cancers that these compounds have been shown to be active against are also identified.

LIST OF ACTIVE COMPOUNDS

		Compound Name	Types of Cancers Active Against
	1	6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid	brain, cervical, head and neck, leukemia, lymphoma, prostate, skin
	2	2-[3-(1-adamantyl)-4-methoxyphenyl]-5-benzimidazole carboxylic acid	brain, colon, leukemia, lung, lymphoma, myeloma, ovarian, pancreatic, prostate, skin, liver
	3	6-[3-(1-adamantyl)-4-hydroxymethyl-phenyl]-2-naphthoic acid	bladder, brain, breast, cervical, colon, head and neck, leukemia, kidney, lung, myeloma, ovarian, pancreatic, prostate, skin, liver
5	4	6-[3-(1-adamantyl)-4-hydroxy-5-methoxyphenyl]-2-naphthoic acid	brain, breast, kidney, lung, leukemia, lymphoma, myeloma, ovarian, pancreatic, prostate, skin, liver
	5	6-[3-(1-adamantyl)-4-acetoxymethyl-phenyl]-2-naphthoic acid	head and neck, leukemia, lung, lymphoma, myeloma, pancreatic, skin
	6	6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid	brain, breast, head and neck, kidney, leukemia, lung, lymphoma, myeloma, ovarian, prostate, skin, liver
	7	N-{6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthalenecarboxoyl}-piperizide	brain, breast, head and neck, myeloma, prostate, skin
	8	4-{3-oxo-3-[3-(1-adamantyl)-4-methoxyphenyl]-1-propynyl}benzoic acid	brain, breast, leukemia, lung, lymphoma, skin, liver
10	9	4-[N-(3-(1-adamantyl)-4-methoxybenzoyl)amido]2-methoxybenzoic acid	head and neck, kidney, ovarian, skin
	10	2-[3-(1-adamantyl)-4-methoxyphenyl]-5-methylbenzimidazole	leukemia, lymphoma, myeloma
	11	6-[3-(1-adamantyl)-4-(1,2-dihydroxyethyl)phenyl]-2-naphthoic acid	brain, breast, leukemia, pancreatic, skin

	Compound Name	Types of Cancers Active Against
12	6-[3-(1-adamantyl)-4-hydroxy-6-methylphenyl]-2-naphthoic acid	head and neck, leukemia, pancreatic
13	6-[3-(1-adamantyl)-4-methoxy-6-methylphenyl]-2-naphthoic acid	brain, head and neck, leukemia, pancreatic
14	6-[3-(1-adamantyl)-4-hydroxyphenyl]-2-hydroxymethylnaphthalene	bladder, kidney, skin
15	4-[3-(1-adamantyl)-4-methoxybenzyloxy]benzoic acid	breast, leukemia, prostate
16	2-[3-(1-adamantyl)-4-methoxyphenyl]-5-benzofurancarboxylic acid	brain, breast, prostate
17	6-[3-(1-adamantyl)-4-hydroxyphenyl]-2-naphthoic acid methyl ester	leukemia
18	1-methyl-4-hydroxy-6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid methyl ester	lymphoma, liver
19	N-{4-[N-(3-(1-adamantyl)-4-methoxybenzoyl)amido]benzoyl}morpholide	kidney, myeloma, prostate, skin
20	4-[3-(1-adamantyl)-4-methoxybenzoyloxy]-2-fluorobenzoic acid	lymphoma, skin
21	4-hydroxycarbonyl-2-fluorophenyl ester of 3-(1-adamantyl)-4-methoxybenzoic acid	leukemia
22	6-[3-(1-adamantyl)-4-ethylphenyl]-2-naphthoic acid	breast, leukemia, myeloma
23	6-[3-(1-adamantyl)-4-(3-hydroxypropoxy)phenyl]-2-naphthoic acid	breast, leukemia, lymphoma
24	6-[3-(1-adamantyl)-4-aminocarbonylphenyl]-2-naphthoic acid	leukemia, lymphoma
25	N-(4-carboxyphenyl)-3-(1-adamantyl)-3-oxopropionamide	lymphoma
26	2-hydroxy-4-{2-[3-(1-adamantyl)-4-methoxyphenyl]-2-hydroxyethoxy}benzoic acid	lymphoma
27	(S)-6-[3-(1-adamantyl)-4-(2S,3-dihydroxypropoxy)phenyl]-2-naphthoic acid	leukemia
28	(E) 4-{3-oxo-3-[3-methoxy-4-(1-adamantyl)phenyl]prop-1-enyl}benzoic acid	leukemia
29	(E) 4-{3-oxo-3-[4-(2-methoxyethoxymethoxy)-3-(1-adamantyl)phenyl]prop-1-enyl}benzoic acid	brain, leukemia, lung, lymphoma, prostate

	Compound Name	Types of Cancers Active Against
30	(E) 4-{2-[4-(6-aminocarbonylpentyl-oxy)-3-(1-adamantyl)phenyl]ethenyl}-benzoic acid	lymphoma, myeloma
31	3-(1-adamantyl)-4-methoxy-N-(4-carboxyphenyl)benzamidine	leukemia
32	4"-Erythromycin A ester of 6-[3-(1-adamantyl)-4-methoxyphenyl]2-naphthoic acid	leukemia, lymphoma
33	4-carboxyphenyl ester of 3-(1-adamantyl)-4-(2,3-dihydroxypro-proxy)benzoic acid	leukemia, skin
34	6-[3-(1-adamantyl)-4-(2,3-dihydroxy-propoxy)phenyl]-2-naphthoic acid	leukemia, skin
35	N-4-carboxyphenyl 3-(1-adamantyl)-4-(methoxycarbonyl)benzamide	leukemia, lymphoma, myeloma
36	6-[3-(1-adamantyl)-4,5-dihydroxy-phenyl]-2-naphthoic acid	brain, head and neck, leukemia, lymphoma, myeloma, pancreatic
37	6-[3-(3-methyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid	kidney, leukemia, lung, lymphoma, skin
38	6-[3-(2-oxa-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid	leukemia, skin
39	6-[3-(2-oxa-1-adamantyl)-4-methoxy-phenyl]-2-naphthoic acid	kidney, lymphoma, skin, liver
40	6-[3-(2-oxa-3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid	bladder, breast, kidney, leukemia, lung, lymphoma, ovarian, prostate, skin
41	6-[3-(3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid	skin
42	6-[3-(3,5-dimethyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid	skin
43	6-[3-(3,5-dimethyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid	prostate, breast, neuroblastoma
44	N-{6-[3-(1-adamantyl)-4-methoxy-phenyl]-2-naphthalenecarboxoyl}homo-piperazide	bladder, kidney, epidermal, leukemia lung, neuroblastoma, hepatoma, cervix, skin

	Compound Name	Types of Cancers Active Against
45	N-(2-aminoethyl)-{6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthalenecarboxamide]	bladder, kidney, prostate, leukemia, breast, lung, neuroblastoma, hepatoma, pancreas, cervix skin
46	N-{6-[3-(1-adamantyl)-4,5-methylenedioxy]-2-naphthalenecarboxoyl}piperazide	prostate, neuroblastoma, hepatoma
47	N-{6-[3-(1-adamantyl)-4,5-methylenedioxy]-2-naphthalenecarboxoyl}homopiperazide	bladder, neuroblastoma, cervix, skin
48	N-(2-aminoethyl)-{6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthalenecarboxamide}	breast, hepatoma, skin
49	6-[3-(3-methyl-1-adamantyl)-4-hydroxyphenyl]-2-naphthalenecarboxylic acid	breast, neuroblastoma, leukemia

As can be seen from the above, the subject adamantyl retinoids exhibit a broad range of activity against numerous different types of cancers.

Moreover, the present invention also relates to the usage of the specific novel classes of adamantyl retinoid compounds identified *supra* for other therapeutic as well as cosmetic usages.

Depending on the nature of the radicals used, the subject adamantyl or adamantyl derivative containing retinoid compounds should exhibit either an agonist activity in the test for differentiation of embryonic teratocarcinoma cells (F9) in mice (*Cancer Research*, 43, p. 5268 (1983)) and/or in the test for inhibition of ornithine decarboxylase after induction by TPA in mice (*Cancer Research*, 38, p. 793-801 (1978)) or, in contrast, an antagonist activity with respect to the expression of one or more biological markers in the test for differentiation of embryonic teratocarcinoma cells (F9) in mice (*Skin Pharmacol.*, 3, pp. 256-267 (1990)) and/or for the *in vitro* differentiation of human keratinocytes (*Anal. Biochem.*, 192, pp. 232-236 (1991)).

Based on these properties, the novel adamantyl or adamantyl derivative containing retinoid compounds according to the invention are well suited in the following fields of therapy:

(1) for treating dermatological conditions associated with a keratinization disorder related to differentiation and proliferation, in particular for treating acne vulgaris, comedonic or polymorphic acne, acne rosacea, nodulocystic acne, acne conglobate, senile acne and secondary acnes such as solar, drug or occupational acne;

(2) for treating other types of keratinization disorders, in particular ichthyoses, ichthyosiform conditions, Darier's disease, palmoplantar keratoderma, leukoplakia and leucoplakiform conditions or cutaneous or mucosal (oral) lichen;

(3) for treating other dermatological conditions associated with a keratinization disorder manifesting an inflammatory and/or immunoallergic component and, in particular, all forms of psoriasis, whether cutaneous, mucosal or ungual, and even psoriatic rheumatism, or alternatively cutaneous or skin atopy, such as eczema, or respiratory atopy or alternatively gingival hypertrophy; the compounds can also be used in certain inflammatory conditions not exhibiting keratinization disorder;

(4) for treating all dermal or epidermal proliferations, whether benign or malignant, whether or not of viral origin, such as common warts, flat warts and epidermodysplasia verruciformis, florid oral papillomatoses and the proliferations which can be induced by ultraviolet radiation, in particular in the case of basal cell and prickle cell epithelioma;

(5) for treating other dermatological disorders, such as bullous dermatoses and collagen diseases;

(6) for treating certain ophthalmological disorders, in particular corneopathies;

(7) for repairing or controlling aging of the skin, whether photoinduced or chronologic, or for reducing actinic keratoses and pigmentations, or any pathology associated with chronologic or actinic aging;

(8) for preventing or treating the stigmata of epidermal and/or dermal atrophy induced by local or systemic corticosteroids, or any other form of cutaneous atrophy;

(9) for preventing or treating disorders of healing, or for preventing or for repairing stretch marks;

(10) for controlling disorders of the sebaceous function, such as hyperseborrhoea of acne or simple seborrhoea;

(11) for the prevention of cancerous or precancerous conditions;

(12) for the treatment of inflammatory conditions such as arthritis;

(13) for the treatment of any condition of viral origin at the cutaneous or general level;

(14) for the prevention or treatment of alopecia;

(15) for the treatment of dermatological or general conditions including an immunological component;

(16) for the treatment of ailments of the cardiovascular system, such as arteriosclerosis, and myocardial infarction; and

(17) for the treatment or prevention of osteoporosis.

For the aforesaid therapeutic or pharmaceutical applications, the novel compounds according to the invention can advantageously be used in combination with other compounds displaying a retinoid-type activity, with vitamins D or derivatives thereof, with corticosteroids, with compounds which control free radicals, α-

hydroxy or α-keto acids or derivatives thereof, or alternatively with ion channel blockers.

By "vitamins D or derivatives thereof" are intended, for example, derivatives of vitamin D_2 or D_3 and in particular 1,25-dihydroxyvitamin D_3. By "compounds which control free radicals" are intended, for example, α-tocopherol, superoxide dismutase, ubiquinol or certain metal chelating agents.

By "α-hydroxy or α-keto acids or derivatives thereof" are intended, for example, lactic, malic, citric, glycolic, mandelic, tartaric, glyceric or ascorbic acids or salts, amides or esters thereof.

By "ion channel blockers" are intended, for example, Minoxidil (2,4-diamino-6-piperidinopyrimidine 3-oxide) and derivatives thereof.

The present invention thus also features medicinal compositions containing at least one of the above-identified novel adamantyl retinoid compounds, one of its chiral or geometric isomers, or one of its pharmaceutically acceptable salts, or other derivatives thereof.

The pharmaceutical/therapeutic compositions of the present invention, intended especially for treating the aforesaid disease states comprise a pharmaceutically acceptable vehicle, carrier or diluent which is compatible with the mode or regime of administration selected for the given composition and at least one novel adamantyl compound according to the invention or one of its chiral or geometric isomers, or a pharmaceutically acceptable salt thereof.

The administration of the compounds according to the invention can be carried out by any suitable means of administration, e.g., systemically, enterally, parenterally, topically or ocularly.

For enteral administration, the medicinal/pharmaceutical compositions may be in the form of tablets,

hard gelatin capsules, dragees, syrups, suspensions, solutions, elixirs, powders, granules, emulsions or polymeric or lipid microspheres or nanospheres or vesicles which permit a controlled release. For parenteral administration, the compositions may be in the form of solutions or suspensions for perfusion or for injection.

Effective dosage of a novel retinoid compound according to the invention in the above-identified therapies may be determined by well known methods. In general, the compounds according to the invention are administered at a daily dose of approximately 0.01 mg/kg to 100 mg/kg by body weight, and at the rate or regime of 1 to 3 doses per diem.

For topical administration, the pharmaceutical compositions based on novel compounds according to the invention are more particularly intended for treating the skin and the mucosal membranes and can then be provided in the form of ointments, creams, milks, salves, powders, impregnated pads, solutions, gels, sprays, lotions or suspensions. They can also be provided in the form of polymeric or lipid vesicles or nanospheres or microspheres or of polymeric patches and of hydrogels which permit controlled release. These compositions for topical administration can, moreover, be provided either in anhydrous form or in an aqueous form, according to the particular clinical indication.

For ocular administration, they are principally eye washes.

These compositions for a topical or ocular application contain at least one novel adamantyl retinoid according to the invention, or one of its optical or geometric isomers or, alternatively one of its salts, at a concentration preferably ranging from 0.001% to 5% by weight relative to the total weight of the composition.

As discussed, the novel adamantyl compounds according to the invention also find application in the cosmetics field, in particular for body and hair care/hygiene, and especially for the treatment of skins tending to develop acne, for hair regrowth and combating hair loss, for combating the greasy appearance of the skin or the hair, for protecting against the deleterious effects of sunlight or in the treatment of physiologically dry skin, and for preventing and/or for controlling photoinduced or chronologic aging.

For cosmetic applications, the novel compounds according to the invention can, moreover, be advantageously be used in combination with other compounds displaying a retinoid-type activity, with vitamin D or derivatives thereof, with corticosteroids, with compounds which control free radicals, with α-hydroxy or α-keto acids or derivatives thereof, or alternatively with ion channel blockers, all of these various active agents being as defined above.

The present invention therefore also features cosmetic compositions comprising a cosmetically acceptable vehicle, carrier or diluent which is suitable for topical application, at least one of the novel adamantyl retinoid compounds identified *supra* or one of its chiral or geometric isomers, or one of its salts, etc. Such cosmetic compositions are advantageously in the form of a cream, milk, lotion, ointment, gel, polymeric or lipid vesicles or nanospheres or microspheres, soap or shampoo.

The concentration of the retinoid compound in the cosmetic compositions according to the invention advantageously ranges from 0.001% and 3% by weight relative to the total weight of the composition.

The medicinal and cosmetic compositions according to the invention can, in addition, contain inert or even

pharmacodynamically or cosmetically active additives or combinations of these additives, and, especially: wetting agents; depigmenting agents such as hydroquinone, azelaic acid, caffeic acid or kojic acid; emollients; hydrating or moisturizing agents such as glycerol, PEG 400, thiamorpholinone and its derivatives or alternatively urea; anti-seborrhoeic or anti-acne agents such as S-carboxymethylcysteine, S-benzylcysteamine, their salts or derivatives thereof, or benzoyl peroxide; antibiotics such as erythromycin and esters thereof, neomycin, clindamycin and esters thereof, or tetracyclines; anti-fungal agents such as ketoconazole or 4,5-polymethylene-3-isothiazolidones; agents promoting hair regrowth, such as Minoxidil* (2,4-diamino-6-piperidinopyrimidine 3-oxide) and derivatives thereof, Diazoxide (7-chloro-3-methyl-1,2,4-benzothiadiazine 1,1-dioxide) and phenytoin (5,5-diphenylimidazolidine-2,4-dione); non-steroidal anti-inflammatory agents; carotenoids and especially β-carotene; anti-psoriatic agents such as anthralin and its derivatives; and, lastly, eicosa-5,8,11,14-tetraynoic and eicosa-5,8,11-triynoic acids, and esters and amides thereof.

The compositions according to the invention can also contain flavor-enhancing agents, preservatives such as the esters of para-hydroxybenzoic acid, stabilizing agents, moisture-regulating agents, pH-regulating agents, osmotic-pressure-modifying agents, emulsifying agents, UV-A and UV-B screening agents and antioxidants such as α-tocopherol, butylated hydroxyanisole or butylated hydroxytoluene.

In order to further illustrate the present invention and the advantages thereof, the following specific examples are given, it being understood that same are intended only as illustrative and in nowise limitative.

* trademark

EXAMPLES

The following examples relate to synthesis of specific adamantyl retinoid related compounds. All starting materials were obtained from Aldrich Chemical Company except for the methyl ester of 6-(4-methoxyphenyl)-naphthoic acid (which was synthesized according to U.S. patent 5,015,758) and 3-methyl-2-oxa-1-adamantanol (which was synthesized according to Stetter, *Chemische Berichte*, 99, p. 1435 (1966)).

EXAMPLE 1

Synthesis 2-oxa-1-adamantanol

386.6 mg (2.54 mmoles) of bicyclo[3.3.1]nonane-3,7-dione is dissolved in 5 mL of methanol and treated with sodium borohydride (100 mg, 2.64 mmoles) at 0°C for 2 hours. The solution is treated with 5 mL of saturated aqueous sodium bicarbonate for 1 hour at 25°C and extracted with 3 x 10 mL portions of chloroform. The combined chloroform extracts are combined, dried over sodium sulfate, stripped of solvent in vacuo, and purified by column chromatography (silica, eluant=50% hexanes, 50% ethyl acetate) yielding 343 mg (88%) of the desired product. ^{1}HNMR ($CDCl_3$, 500 Mhz): d 1.563 (d, 2H), 1.70-1.76 (m, 1H), 1.788 (d, 2H, J=11.1 Hz), 1.839 (d, 2H, J=13.1 Hz), 1.925 (d, 2H, J=13.0 Hz), 2.310 (s, 2H), 2.690 (s, 1H), 4.283 (s, 1H).

EXAMPLE 2

Synthesis of 3-methyl-1-adamantyl acetate

121 mg (0.728 mmoles) of 3-methyl-1-adamantanol are dissolved in 0.2 mL n-heptane and 0.2 mL cyclohexane. A mixture of 0.2 mL (2.25 mmoles) of acetic anhydride and 2 microliters (0.036 mmoles) of concentrated sulfuric acid is added, and the mixture is stirred at ambient temperature for 20.5 hours. The solution is dissolved

in 10L of ether and extracted with 10 mL of water. The aqueous layer is extracted with 10 mL ether. The ether layers are combined, extracted with 2 x mL of water followed by 40 mL of aqueous sodium bicarbonate (10 g/liter), dried over magnesium sulfate, and stripped of solvent in vacuo. The product is a colorless oil with Rf 0.55 (silica: eluant hexane 75%, ethyl acetate 25%).

EXAMPLE 3

Synthesis of 3,5-dimethyl-1-adamantyl acetate

2.486 (10.2 mmoles) of 3,5-dimethyl-1-bromoadamantane is refluxed for 16 hours with 2.034 g (20.7 mmoles) of potassium acetate in 10 mL of acetic acid. The solution is poured over 100 grams of ice, allowed to melt, and extracted with 3 x 10 mL of diethyl ether. The combined ether extracts are washed with saturated aqueous sodium bicarbonate followed by saturated aqueous sodium chloride, then dried over sodium sulfate. The solvent is removed under vacuum, yielding 1.521 (67%) of the desired product, a colorless oil. TLC: Rf=0.68 (silica plate: eluant hexane 90%, ethyl acetate 10%). ^{1}HNMR ($CDCl_3$, 500 Mhz): 0.858 (s, 6H), 1.115 (d, 2H, J=12.4 Hz), 1.177 (d, 2H, J=12.4 Hz), 1.260 (d, 2H, J=12.3 Hz), 1.367 (d, 2H, J=12.3 Hz), 1.714 (d, 2H, J=11.6 Hz), 1.766 (d, 2H, J=11.6 Hz), 1.939 (s, 2H), 1.976 (s, 3H), 2.191 (m, 1H).

EXAMPLE 4

Synthesis of 2-oxa-1-adamantyl mesylate

340 mg (2.21 mmoles) of 2-oxa-1-adamantanol (see Example 1) and 20 mg (0.163 mmoles) of 4-dimethylaminopyridine are dissolved in 5 mL of dry pyridine under argon at -40°C. A suspension of 565 mg (3.25 mmoles) of methanesulfonic anhydride in 8 mL of dry pyridine is added at -40°C. The rest of solid methanesulfonic anhy-

dride was added into the reaction flask. The mixture is stirred at 0°C, and allowed to warm to 25°C over 18 hours. After removing the solvent in vacuo, the residue was dissolved in 20 mL dichloromethane, washed with 10 mL of water, and dried to yield 512 mg (100%) of the desired product. Rf= .50 (50% ethyl acetate in hexanes). ^{1}HNMR ($CDCl_3$, 500 Mhz): d 1.594 (d, 2H, J=13.0 Hz), 1.76-1.86 (m, 2H), 2.010 (d, 4H, J=12.5 Hz), 2.330 (d, 2H, J=11.9 Hz), 2.380 (s, 2H), 3148 (s, 3H), 4.439 (s, 1H).

EXAMPLE 5

Synthesis of 3-methyl-2-oxa-1-adamantyl mesylate

A mixture of 230 mg (1.37 mmoles) of 3-methyl-2-oxa-1-adamantanol, 20 mg (0.163 mmoles) of 4-dimethylaminopyridine, and 350 mg (2.0 mmoles) of methanesulfonic anhydride is treated with 10 mL of dry pyridine under argon at -40°C. The reaction mixture is warmed to 0°C and allowed to gradually warm to 25°C over 13 hours. The solvent is removed in vacuo, and the residue dissolved in 20 mL dichloromethane, washed with 10 mL of water, dried over sodium sulfate, and stripped of solvent in vacuo, yielding 341 mg of crude (approximately 95% pure) product. TLC: Rf=0.75 (Silica: 50% hexanes, 50% ethyl acetate).

EXAMPLE 6

Synthesis of methyl ester of 6-(3,4-methylenedioxyphenyl)-2-naphthoic acid

Magnesium turnings (1.48 g, 61 mmoles) were placed in a 250 mL three-neck flask attached to a reflux condenser. The flask was evacuated under vacuum with heat-gun. Argon and dry THF (100 mL) were introduced. 5-Bromo-1,3-benzodioxole (6.0 mL, 10.0 g, 49.8 mmoles) was added and the mixture was heated at 80°C oil bath. A

few minutes later the reaction was initiated and the mixture was refluxed for 3 hr. A portion of such Grignard solution (50 mL, 24.9 mmole) was added into a solution of anhydrous zinc chloride (3.46 g, 24.9 mmole) in dry THF (40 mL) and the resulting mixture was stirred for 30 minutes at room temperature. The organozinc solution was transferred into a flask containing 1,-bis(diphenylphosphono)ethane dichloronickel(II) (400 mg) and methyl 6-bromo-2-naphthoate (5.23 g, 19.9 mmole) in dry THF (40 mL). The reaction solution was stirred at room temperature for 18 hours. Water (150 mL) was added and the whole was extracted with ethyl acetate (200 mL). After drying over anhydrous sodium sulfate, concentration and recrystallization (heptane and dichloromethane) gave the desired product (3.25 g, 53%). M.p. 147-149°C.

EXAMPLE 7

Synthesis of methyl ester of 6-[3-(3,5-dimethyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid

121 mg ((0.54 mmoles) of the ester obtained in Example 3 and 147.5 mg (0.505 mmoles) of the methyl ester of 6-(4-methoxyphenyl)naphthoic acid were dissolved in a mixture of 0.4 mL cyclohexane and 1 mL of 1,2-dichloroethane. While stirring vigorously, concentrated sulfuric acid (15 microliters, 0.27 mmoles) was added. The mixture was heated to 75°C for 5 hours while stirring and stirred at 25°C for 28 days. The solvent was removed in vacuo, and the material purified by column chromatography on silica using toluene as an eluant, yielding 157 mg (68%) of the desired product. M.p.=143-147°C.

EXAMPLE 8

Synthesis of methyl ester of 6-[3-(3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid

36.4 mg (0.175 mmoles) of the ester obtained in Example 2 and 51 mg (0.175 mmoles) of the methyl ester of 6-(4-methoxyphenyl)naphthoic acid are dissolved in a mixture of 0.14 mL cyclohexane and 0.35 mL of 1,2-dichloroethane. While stirring vigorously, concentrated sulfuric acid (5 microliters, 0.09 mmoles) is added. The mixture is stirred at 90°C for 14 hours and at 25°C for 24 hours. The solvent is removed in vacuo, and the material is purified by column chromatography on silica using toluene as an eluant, yielding 15.8 mg (20.5%) of the desired product. M.p.=146-147°C.

EXAMPLE 9

Synthesis of methyl ester of 6-[3-(2-oxa-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid

142 mg (0.61 moles) of 2-oxa-1-adamantyl mesylate (from Example 4) and 137.5 mg (0.47 mmoles) of the methyl ester of 6-(4-methoxyphenyl)naphthoic acid are dissolved in 2 mL of dichloromethane and 0.2 mL of cyclohexane. 80 microliters (0.9 mmoles) of concentrated trifluorosulfonic acid are added. The mixture is stirred for 90 hours, dissolved in 25 mL dichloromethane, filtered, and adsorbed onto 2 grams of silica. The compound is purified by column chromatography on silica using toluene as an eluant, yielding 32.3 mg (16%) of the desired product. TLC: Rf=0.12 (silica plate: eluant = toluene).

1HNMR ($CDCl_3$, 500 MHz):

1.709 (d, 2H J=12.3 Hz)

1.817 (d, 2H J=12.3 Hz)

1.92652 (d, 1H J=12.7 Hz)

1.996 (d, 1H J=12.5 Hz)

2.099 (d, 2H J=12.2 Hz)

2.217 (s, 2H)
2.706 (d, 2H J=12.7 Hz)
3.886 (s, 3H)
3.986 (s, 3H)
4.379 (s, 1H)
6.988 (d, 1H, J=8.4 Hz)
7.577 (dd, 1H, J1=8.4 Hz, J2=2.2 Hz)
7.849 (d, 1H, J=7.8 Hz)
7.919 (d, 1H, J=8.7 Hz)
7.971 (d, 1H, J=8.7 Hz)
8.054 (dd, 1H, J1=11.1 Hz, J2=1.6 Hz)
8.076 (s, 1H)
8.079 (s, 1H)
8.600 (s, 1H)

EXAMPLE 10

Synthesis of methyl ester of 6-[3-(2-oxa-3-methyl-1-adamantyl)4-methoxyphenyl]-2-naphthoic acid

76.2 mg (0.26 mmoles) of the methyl ester of 6-(4-methoxyphenyl)naphthoic acid and 61.3 mg (0.25 mmoles) of the mesylate obtained in Example 5 are suspended in a mixture of 0.85 mL 1,2-dichloroethane and 80 microliters of cyclohexane. 30 microliters of concentrated trifluorosulfonic acid (0.339 mmoles) is added, and the suspension is stirred at 25°C for 5 days. The product is purified using preparative TLC on silica places with toluene as the eluant, yielding 4.5 mg (4%) of the desired product. TLC: Rf=0.38 (silica plate: eluant=toluene). ^{1}HNMR (DMSO-d6, 500 Mhz) 1.763 (s, 4H), 2.074 (s, 3H), 2.140 (s, 5H), 2.539 (s, 3H), 3.872 (s, 3H), 3.924(s, 3H), 7,128 (d, 1H, J=3.5 Hz), 7.584 (d, 1H, J=1.8 Hz), 7.664 (dd, 1H, J1=1.7 Hz), J2=8.7 Hz), 7.914 (dd, 1H, J1=1.5 Hz, J2=7.3 Hz), 7.988 (d, 1H, J=9.1Hz), 8.108 (d, 1H, J=9.1 Hz), 8.185 (d, 1H, J=3.6 Hz), 3.238 (s, 1H), 8.637 (s, 1H). MS 454 (M^{+}).

EXAMPLE 11

Synthesis of methyl ester of 6-[3-(3,5-dimethyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid

To a mixture of methyl ester of 6-(3,4-methylenedioxyphenyl)-2-naphthoic acid (see Example 6, 70 mg, 0.23 mmole), 3,5-dimethyl-1-adamantyl acetate (see Example 3, 63.4 mg, 0.285 mmole) in dichloroethane (1.2 mL) were added two drops of cyclohexane followed by addition of trifluoromethanesulfonic acid (0.030 mL, 0.34 mmole). The reaction mixture was stirred at room temperature for four days. Preparative TLC purification (10% ethyl acetate in hexanes) gave the desired product (44 mg, 40%.). Rf: 0.24 (10% ethyl acetate/hexane). ^{1}HNMR ($CDCl_3$, 500 Mhz) 0.899 (s, 6H), 1.233 (s, 2H), 1.395 (d, 2H, J=13.3 Hz), 1.463 (d, 2H, J=12.2 Hz), 1.681 (d, 2H, J=12.2 Hz), 1.741 (d, 2H, J=12.1 Hz), 1.929 (d, 2H, J=1.4 Hz), 2.18-2.20 (m, 1H), 3.990 (s, 3H), 6.012 (s, 2H), 7.078 (d, 1H, J=1.7 Hz), 7.099 (s, 1H), 7.743 (dd, 1H, J1=1.7 Hz, J2=3.5 Hz), 7.919 (d, 1H, J=8.7 Hz), 7.974 (s, 1H), 7.983 (d, 1H, J=9.2 Hz), 8.072 (d, 1H, J=7.8 Hz), 8.610 (s, 1H). MS 468 (M^+)

EXAMPLE 12

Synthesis of methyl ester of 6-[3-(3-methyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid

To a mixture of methyl ester of 6-(3,4-methylenedioxyphenyl)-2-naphthoic acid (see Example 6, 48.9 mg, 0.16 mmole), 3-methyl-1-adamantyl acetate (see Example 2, 40.2 mg, 0.193 mmole) in dichloroethane (1.2 mL) were added two drops of cyclohexane followed by the addition of trifluoromethanesulfonic acid (0.020 mL, 0.227 mmole). The reaction mixture was stirred at room temperature for four days. Preparative TLC purification (10% ethyl acetate in hexanes) gave the desired product (35 mg, 48%). Rf=0.27 (10% ethyl acetate in hexanes). ^{1}HNMR ($CDCl_3$, 500 Mhz), 0.87 (s. 3H), 1.520 (s, 4H),

1.661 (d, 1H, J=12.5 Hz), 1.737 (d, 1H, J=12.4 Hz), 1.787 (s, 2H), 1.984 (d, 2H, J=11.7 Hz), 2.049 (d, 2H, J=12.1 Hz), 2.154 (s, 2H), 3.990 (s, 3H), 6.012 (s, 2H), 7.084 (s, 1H), 7.105 (s, 1H), 7.745 (d, 1H, J=8.3 Hz), 7.914 (d, 1H, J=8.6 Hz), 7.974 (s, 1H), 7.982 (d, 1H, J=8.4 Hz), 8.071 (d, 1H, J=3.6 Hz), 8.610 (s, 1H). MS 454 (M^+)

EXAMPLE 13

Synthesis of methyl ester of 6-[3-[(2-oxa-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid

To a mixture of methyl ester of 6-(3,4-methylenedioxyphenyl)-2-naphthoic acid (see Example 6, 22.6 mg, 0.074 mmole), 2-oxa-1-adamantyl mesylate (see Example 4, 50 mg, 0.22 mmole) in dichloroethane (1.2 mL) were added two drops of cyclohexane followed by the addition of trifluoromethanesulfonic acid (0.020 mL, 0.227 mmole). The reaction mixture was stirred at room temperature for two days. Preparative TLC purification (10% ethyl acetate in hexanes) gave the desired product (5 mg, 15%). Rf=0.15 (silica 10% ethyl acetate, 90% hexanes). MS: 443 ($M+H^+$).

EXAMPLE 14

Synthesis of 6-[3-(3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid

10 mg (0.0226 mmoles) of the ester from Example 8 are dissolved in 0.5 mL of n-butanol and treated with 0.1 mL of 1 molar potassium hydroxide in n-BuOH (0.1 mmoles of potassium hydroxide). The solution is heated at 105°C for 110 minutes and cooled to 25°C. The reaction mixture is treated with 2.5 mL of water and 0.5 mL of acetic acid, and the volatiles are removed under vacuum. Washing with water to remove potassium acetate and drying under vacuum yields 6.6 mg (68.5%) of the desired product. ^{1}HNMR (DMSO-d6, 500 Mhz) 0.873 (s, 3H),

1.203 (s, 2H), 1.363 (d, 2H, J=11.9 Hz), 1.434 (d, 2H, J=11.3 Hz), 1.723 (d, 2H, J=12.0 Hz), 1.783 (d, 2H, J=11.9 Hz), 1.968 (s, 2H), 2.154 (s, 2H), 3.862 (s, 3H), 7.124 (d, 1H, J=3.7 Hz), 7.566 (d, 1H, J=2.2 Hz), 7.653 (dd, 1H, J1=1.8 Hz, J2=8.0 Hz), 7.88 (d, 1H, J1=1.4 Hz, J2=8.7 Hz), 7.987 (dd, 1H, J1=1.5 Hz, J2=8.8 Hz), 8.078 (d, 1H, J=8.6 Hz), 8.162 (d, 1H, 1=8.6 Hz), 8.199 (s, 1H), 8.599 (s, 1H).

EXAMPLE 15

Synthesis of 6-[3-(3,5-dimethyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid

The ester from example 7 is hydrolyzed as described in Example 14, yielding 35% of the desired product. M.p. 258-263°C.

EXAMPLE 16

Synthesis of 6-[3-(2-oxa-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid

The ester from Example 9 is hydrolyzed as described in Example 14, yielding 70% of the desired product. ^{1}HNMR (DMSO-d6, 500 MHz), 1.632 (s, 2H), 1.696 (s, 2H, J=11.8 Hz), 1.910 (s, 2H), 1.969 (d, 2H, J=11.6 Hz), 2.167 (s, 2H), 2.686 (s, 2H), 3.856 (s, 3H), 4.330 (s, 1H), 7.130 (d, 1H, J=8.6 Hz), 7.678 (dd, 1H, J1=7.3 Hz, J2=2.0 Hz), 7.827 (d, 1H, J=8.7 Hz), 7.975 (d, 1H, J=2.4 Hz), 7.984 (s, 1H), 8.0686 (d, 1H, J=8.5 Hz), 8.138 (d, 1H, J=8.7 Hz), 8.147 (s, 1H), 8.562 (s, 1H).

EXAMPLE 17

Synthesis of 6-[3-(2-oxa-3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid

The ester from Example 10 is hydrolyzed as described in Example 14, yielding the desired product. ^{1}HNMR (DMSO-d6, 500 MHz), 1.763 (s, 4H), 2.073 (s, 3H), 2.141 (s, 5H), 2.539 (s, 3H), 3.871 (s, 3H), 7.126 (d,

1H, J=7.6 Hz), 7.580 (d, 1H, J=1.8 Hz), 7.659 (dd, 1H, J1=8.1 Hz, J2=1.7 Hz), 7.895 (d, 1H, J=9.3 Hz), 7.974 (dd, 1H, J1=8.8, J2=1.4), 8.077 (d, 1H, J=8.7 Hz), 3.156 (d, 1H, J=8.6 Hz), 8.223 (s, 1H), 8.587 (s, 1H).

EXAMPLE 18

Synthesis of 6-[3-(3,5-dimethyl-1-adamantyl)-4,5-methyl-enedioxyphenyl]-2-naphthoic acid

The ester from Example 11 is hydrolyzed as described in Example 14, yielding 78% of the desired product. Rf: 0.23 (50% ethyl acetate in hexanes). ^{1}HNMR (DMSO-d6, 500 Mhz), 0.875 (s, 6H), 1.208 (s, 2H), 1.368 (d, 2H, J=11.5 Hz), 1.432 (d, 2H, J=12.0 Hz), 1.674 (d, 2H, J=12.0 Hz), 1.717 (d, 2H, J=12.0 Hz), 1.905 (s, 2H), 2.16-2.18 (m, 1H), 6.063 (s, 2H), 7.143 (s, 1H), 7.284 (s, 1H), 7.843 (d, 1H, J=8.5 Hz), 7.990 (d, 1H, J=9.0 Hz), 8.024 (d, 1H, J=9.0 Hz), 8.120 (d, 1H, J=8.5 Hz), 8.186 (s, 1H), 8.561 (s, 1H). MS 454 (M^+).

EXAMPLE 19

Synthesis of 6-[3-(3-methyl-1-adamantyl)-4,5-methylene-dioxyphenyl]-2-naphthoic acid

The ester from Example 12 is hydrolyzed as described in Example 14, yielding 59% of the desired product. Rf: 0.22 (50% ethyl acetate in hexanes). ^{1}HNMR (DMSO-d6, 500 Mhz): 0.861 (s, 3H), 1.485 (s, 4H), 1.622 (d, 1H, J=12.4 Hz), 1.692 (d, 1H, J=12.3 Hz), 1.766 (s, 2H), 1.962 (d, 2H, J=11.5 Hz), 2.009 (d, 2H, J=12.3 Hz), 2.117 (s, 2H), 6.065 (s, 2H), 7.156 (s, 1H), 7.297 (s, 1H), 7.877 (d, 1H, J=8.3 Hz), 7.981 (d, 1H, J=8.2 Hz), 8.060 (d, 1H, J=8.6 Hz), 8.147 (d, 1H, J=3.6 Hz), 8.221 (s, 1H), 8.601 (s, 1H). MS: 440 (M^+).

EXAMPLE 20

Synthesis of 6-[3-[(2-oxa-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid

The ester from Example 13 is hydrolyzed as described in Example 14, yielding 65% of the desired product. Rf: 0.16 (50% ethyl acetate in hexanes).

EXAMPLE 21

Preparation of the methyl ester of 6-[3-(3-methyl-1-adamantyl)-4-hydroxyphenyl]-2-naphthalenecarboxylic acid.

To a solution of the ester obtained in Example 8 (129 mg, 0.29 mmol) in anhydrous methylene chloride (5 mL) was added to 2M boron tribromide solution (2.1 mL, 2.1 mmol) slowly under argon at 0°C. The solution was stirred at 0°C for 90 minutes before adding methanol (20 mL). After 16 hours, the reaction solution was poured into aqueous solution of sodium hydrogen sulfate (0.48 g) and potassium carbonate (0.8 g). The mixture was extracted with ether (2 x 100 mL). The ether layer was dried over sodium sulfate and evaporated. Column chromatography with silica gel gave the desired product (83 mg, 65.6%), ^{1}NMR ($CDCL_3$ 500 MHz); 0.891 (s, 3H), 1.528 (s, 4H), 1.665 (d, 1H, J=12.4), 1.754 (d, 1H, J=12.0), 1.892 (s, 2H), 2.087 (d, 2H, J=11.2 Hz), 2.155 (d, 2H, J=11.1 Hz), 2.167 (s, 2H), 3.99 (s, 3H), 6.780 (d, 1H, J=8.2), 7.430(dd, 1H, J=2.0, 8.2), 7.585 (d, 1H, J=2.0), 7.774 (dd, 1H, J=1.4, 8.4), 7.918 (d, 1H, J=8.6), 7.988 (d, 1H, J=8.2), 7.996(s, 1H), 8,069(dd, 1H, J=1.6, 8.4), 8.612(s,1H).

EXAMPLE 22

Preparation of 6-[3-(3-methyl-1-adamantyl)-4-hydroxyphenyl]-2-naphthalenecarboxylic acid.

A solution of the ester from Example 24 (75 mg. 0.172 mmol) in 0.25 M potassium hydroxide in n-butanol

(10 mL) was refluxed under argon for 4 hours. A slightly excess of acetic acid was added and the whole was extracted with methylene chloride. The organic layer was washed with brine, dried over sodium sulfate and evaporated. Column chromatography with silica gel (1:15 methanol/methylene chloride) gave the desired product in almost quantitative yield. ^{1}NMR(DMSO-d_6, 500 MHz): .843 (s, 3H), 1.464 (s, 4H), 1.6109 (d, III), 1.668 (d, 1H), 1.844 (s, 2H), 2.06 (m, 6H), 6.91 (d, 1H, T=8.0 Hz), 7.49 (dd, 1H, J=2.5, 10.4), 7.85 (dd, 1H, J=1.5, 8.8), 7.96 (dd, 1H, J=0.6-7.6), 8.05 (d, 1H, J=8.7), 8.124 (d, 1H, J=8.7), 8.147 (s, 1H), 8.571 (s, 1H).

EXAMPLE 23

Preparation of N-(2-aminoethyl)-{6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthalenecarboxamide}.

To a suspension of 6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthalenecarboxylic acid (3 g, 7.27 mmoles) in dry toluene (20 mL) was added thionyl chloride (0.6 mL, 8.22 mmoles) and DMF (0.04 mL) under argon. The reaction mixture was heated to 100°C for ten minutes and another 0.04 mL of DMF was added. After 30 minutes, more thionyl chloride (0.1 mL, 1.37 mmoles) was added and the reaction mixture was heated to 110°C for 60 minutes. The solvent and excess thionyl chloride were removed in vacuo. The resulting solid was stirred with 100 mL dry methylene chloride under argon. This was added to a mixture of ethylene diamine (5.25 mL, 70 mmoles) in dry methylene chloride under argon at 0°C while stirring rapidly. The solution was allowed to warm to ambient temperature while stirring rapidly during one hour. The reaction mixture was poured carefully into 350 mL of 1N aqueous HCl while stirring, and the methylene chloride was removed in vacuo. The resulting precipitate (hydrochloride salt of the product) was

washed with 1N HCl, water, THF, and methylene chloride. Yield of hydrochloride salt: 2.76 g, 77%. The free base was generated by neutralizing with aqueous sodium bicarbonate and extracting the product into tetrahydrofuran, drying the organic layer over sodium sulfate, and removing the solvent. MS 455 ($M+H^+$).

EXAMPLE 24

Preparation of N-{6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthalenecarboxoyl}homopiperazide.

This amide was prepared from 6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthalenecarboxylic acid and homopiperazine using a procedure analogous to the one in Example 24. MS: 495 ($M+H^+$).

EXAMPLE 25

Preparation of N-{6-[3-(1-adamantyl)-4,5-methylenedioxy]-2-naphthalenecarboxoyl}piperazide.

This amide was prepared from 6-[3-(1-adamantyl)-4,5-methylenedioxy]-2-naphthalenecarboxylic acid and piperazine using a procedure analogous to the one in Example 24. MS: 495 ($M+H^+$)

EXAMPLE 26

N-{6-[3-(1-adamantyl)-4,5-methylenedioxy]-2-naphthalenecarboxoyl}homopiperazide.

This amide was prepared from 6-[3-(1-adamantyl)-4,5-methylenedioxy]-2-naphthalenecarboxylic acid and homopiperazine using a procedure analogous to the one in Example 24. MS: 509 ($M+H^+$).

EXAMPLE 27

N-(2-aminoethyl)-{6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthalenecarboxamide}.

This amide was prepared from 6-[3-(1-adamantyl)-4,5-methylenedioxy]-2-naphthalenecarboxylic acid and

ethylenediamine using a procedure analogous to the one in Example 24. MS: 469 ($M+H^+$)

EXAMPLE 28

N-(2-dimethylaminoethyl)-{6-[3-(1-adamantyl)-4,5-methylenedioxypehnyl]-2-naphthalenecarboxamide}.

This amide was prepared from 6-[3-(1-adamantyl)-4,5-methylenedioxy]-2-naphthalenecarboxylic acid and 2-dimethylaminoethylamine using a procedure analogous to the one in Example 24. MS: 495 ($M-H^-$)

EXAMPLE 29

The anti-cancer activity of various adamantyl retinoid compounds according to the invention was compared to all-trans-retinoic acid using cell-based high throughput screening assays. Specifically, the following compounds were tested in such assays: all-trans-retinoic acid, 6[3(1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid, 2-[3-(1-adamantyl)-4-methoxyphenyl]-5-benzimidazole carboxylic acid, 6-[3-(1-adamantyl)-4-hydroxy-5-methoxyphenyl]-2-naphthoic acid, 6-[3-(1-adamantyl)-4-acetoxymethylphenyl]-2-naphthoic acid and 6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid.

These compounds were tested against a panel of human tumor cell lines having a variety of tissue origins, and having distinct tumor characteristics. The tumor cell cultures were exposed to the above retinoid compounds for a specific duration. After such exposure, the percentage of surviving cells was then measured using standard assays. These results were then compared for different compounds, with an active compound being defined as one which results in a percentage survival of less than 80.

These results are contained in Figure 1. Based on these results, it can be seen that compounds according

to the invention were active against a number of distinct human cancers. By contrast, all-trans-retinoic acid did not give comparable results.

EXAMPLE 30

Based on the previous results, various active compounds according to the invention, in particular 2-[3-(1-adamantyl)-4-methoxyphenyl]-5-benzimidazole carboxylic acid, 6-[3-(1-adamantyl)-4-hydroxymethylphenyl]-2-naphthoic acid; 6-[3-(1-adamantyl)-4-hydroxy-5-methoxyphenyl]-2-naphthoic acid; 6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid, as well as all-trans-retinoic acid, were tested against various human cancer cell lines at retinoid concentrations ranging from 10^{-9} M to 10^{-5} M. These results are contained in Figures 2-4, and show that adamantyl compounds according to the invention exhibit significant anti-cancer activity. By contrast, all-trans-retinoic acid did not exhibit similar activity.

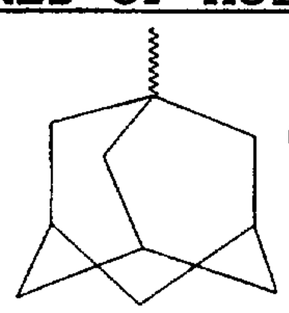
EXAMPLE 31

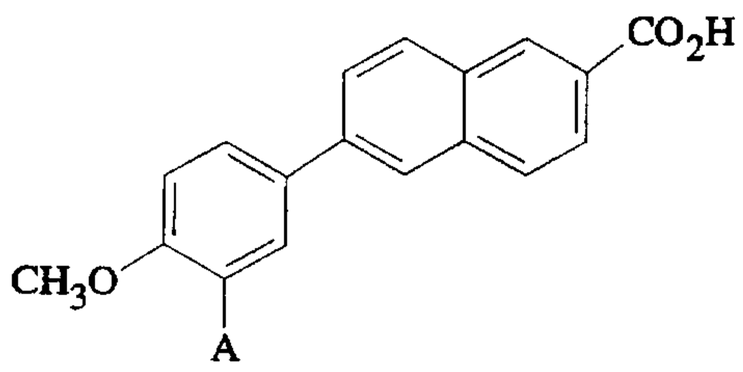
The anti cancer activity of a compound according to the invention, 6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid was also evaluated in a human xenograft mouse animal model containing human pancreatic cancer BxPC-3 tumor cells. Starting twenty-eight days after inoculation of tumor cells, said xenograft containing mice were administered the retinoid compound intraperitoneally at a dosage of 80 mg/kg body weight. Also, a control group of said mice was inoculated under similar conditions with the pharmaceutical vehicle used for formulation (but lacking the retinoid compound).

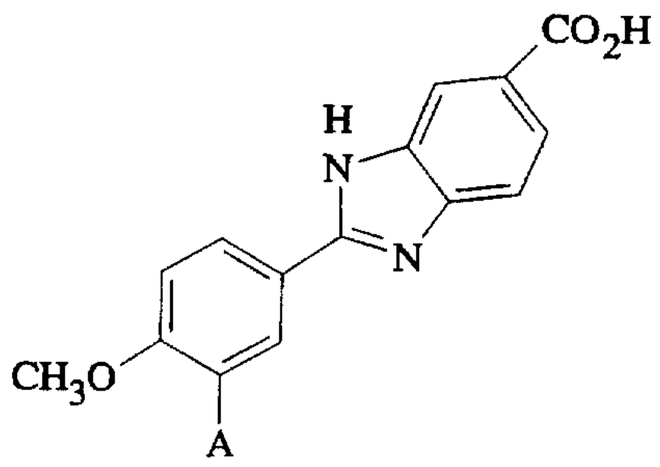
These results are contained in Figure 5 and show that the retinoid compound according to the invention, 6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic

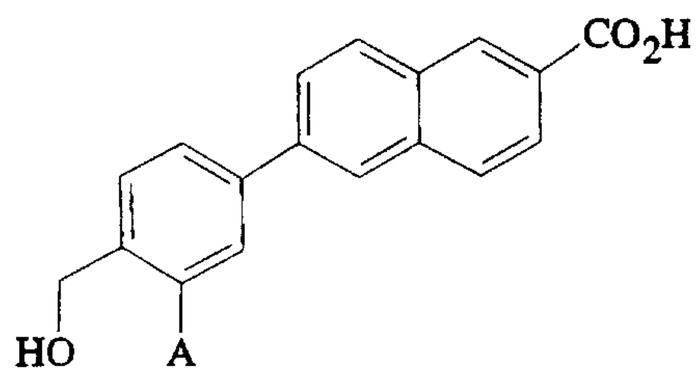
acid resulted in substantial reduction in tumor size compared to the control group which were not administered this retinoid compound. Therefore, based on these results, it is apparent that the anti-cancer activity of adamantyl compounds according to the invention, which is apparently attributable to apoptosis inducing activity, is observed both *in vitro* and *in vivo*.

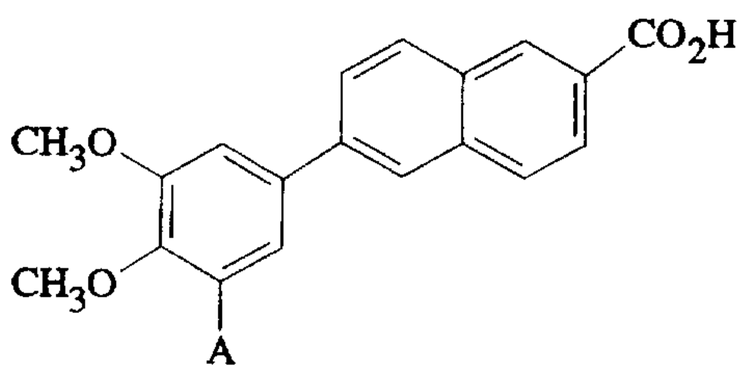
STRUCTURES OF ACTIVE COMPOUNDS

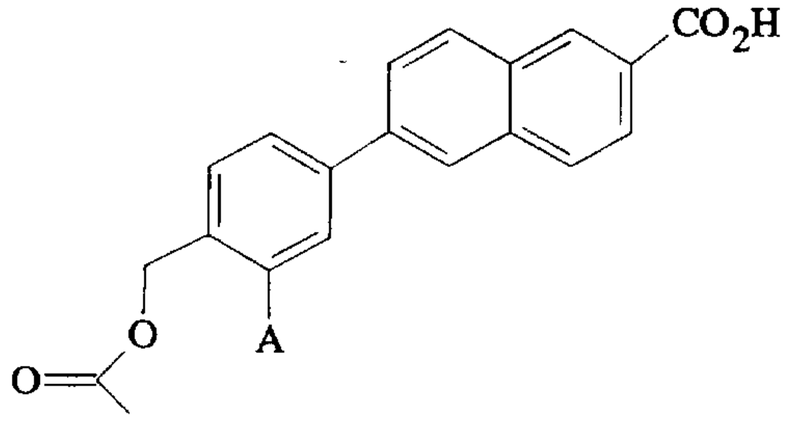
A=  (1-adamantyl)

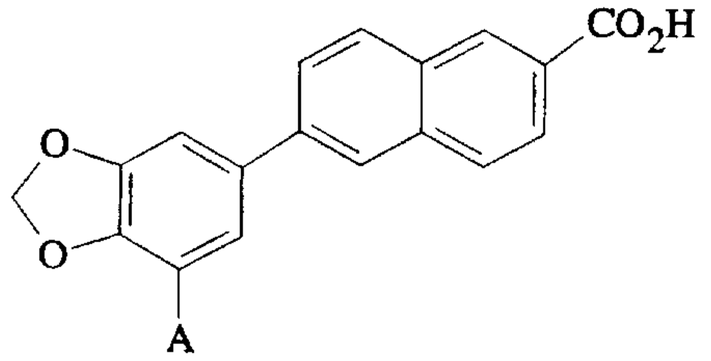
1. 

2. 

3. 

4. 

5. 

6. 

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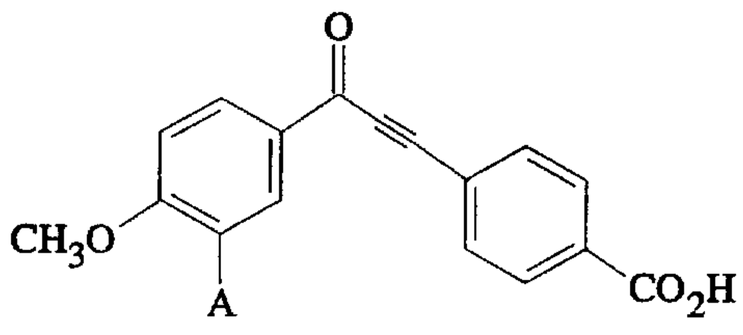
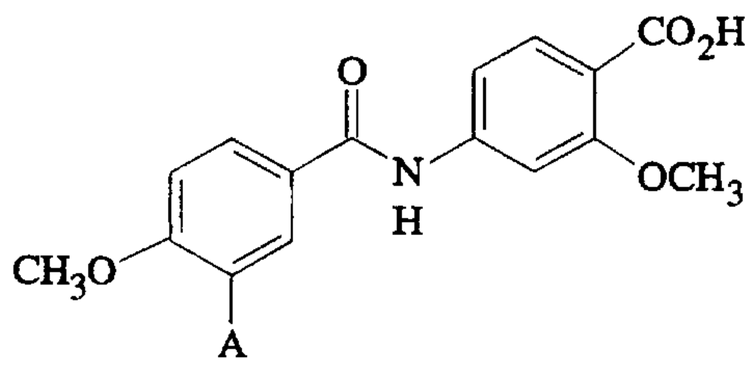
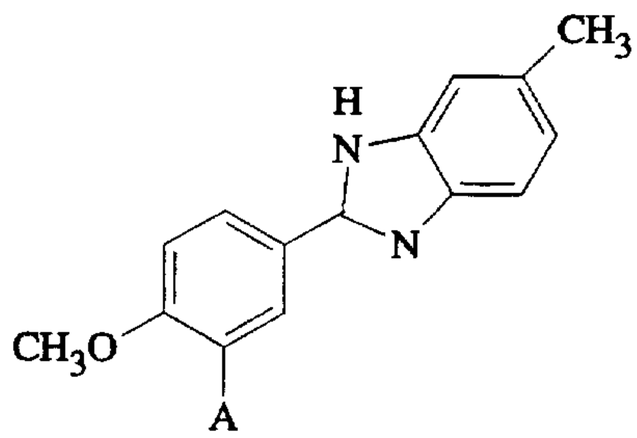
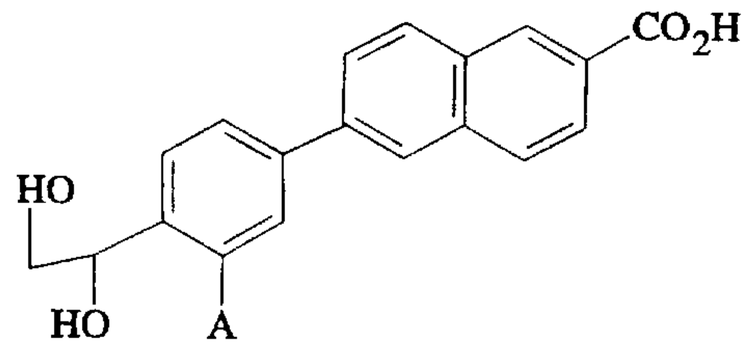
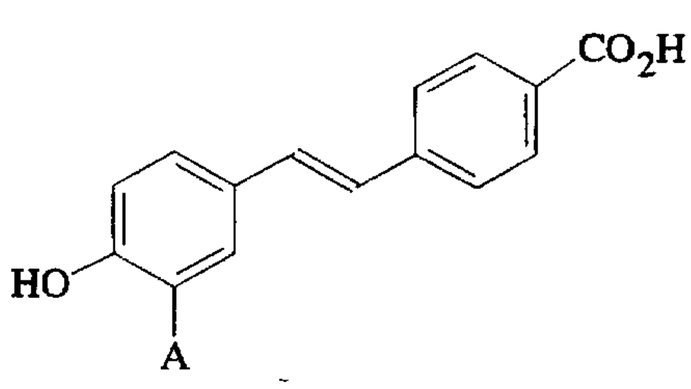
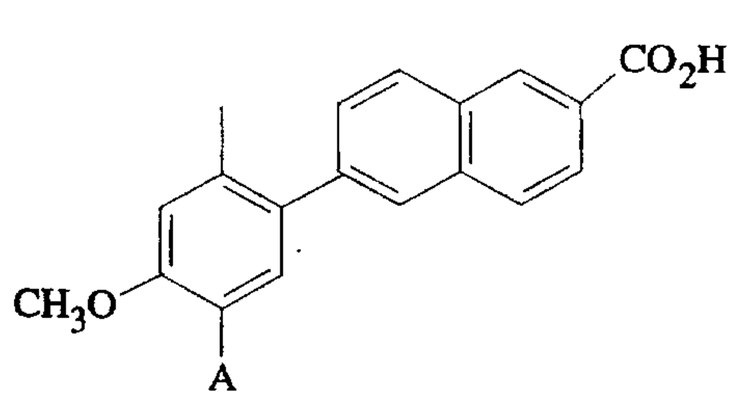
8. 

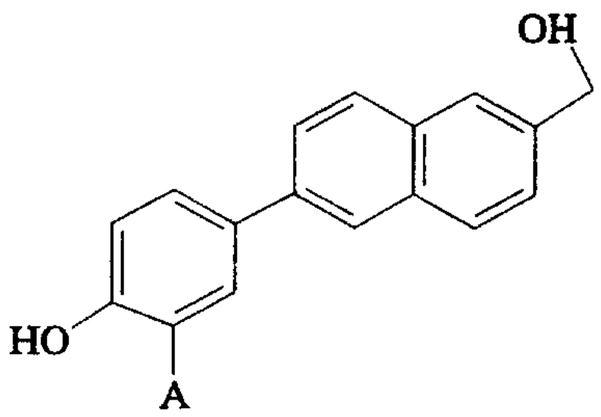
9. 

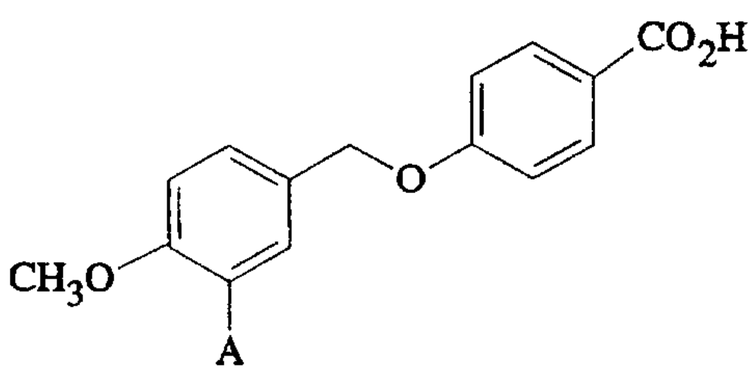
10. 

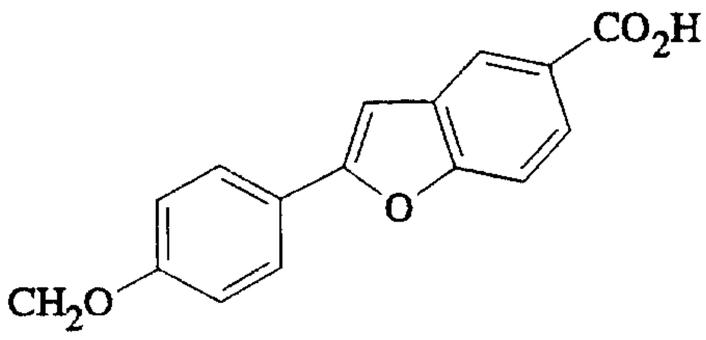
11. 

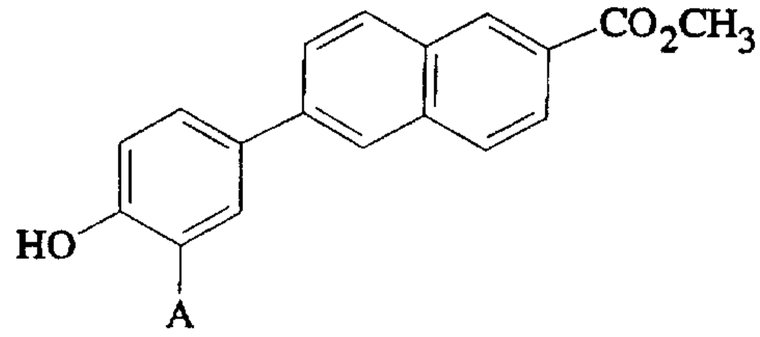
12. 

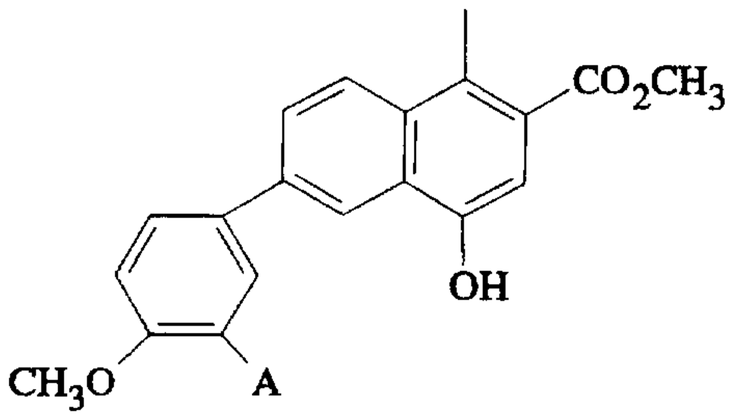
13. 

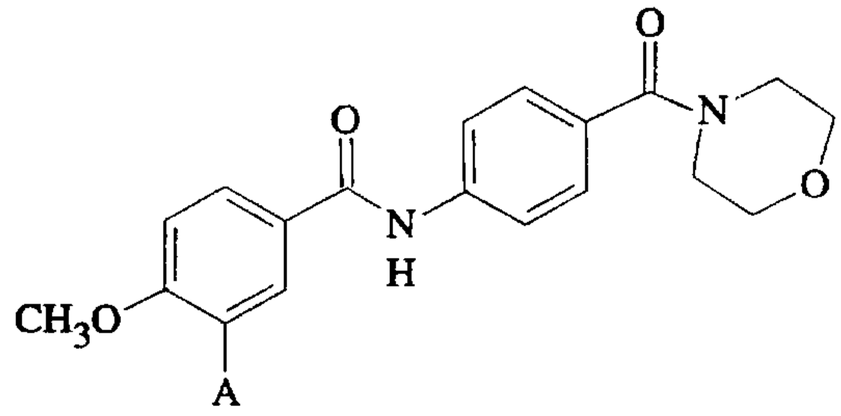
14. 

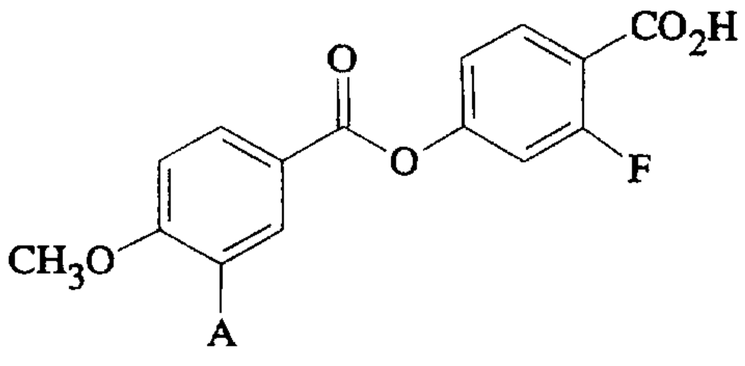
15. 

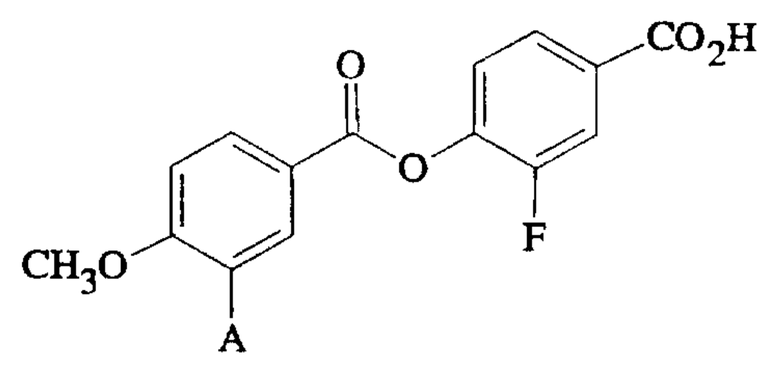
16. 

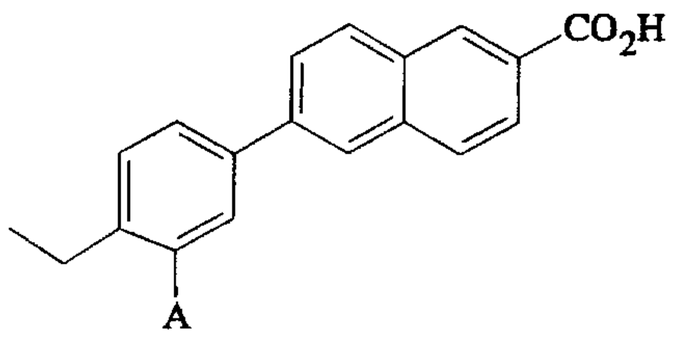
17. 

18. 

19. 

20. 

21. 

22. 

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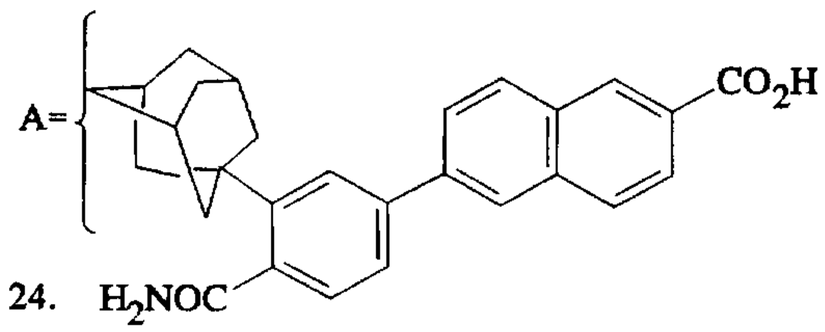

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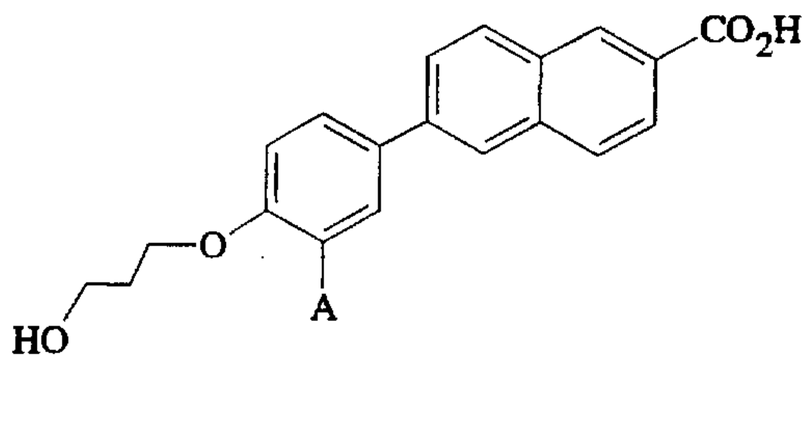
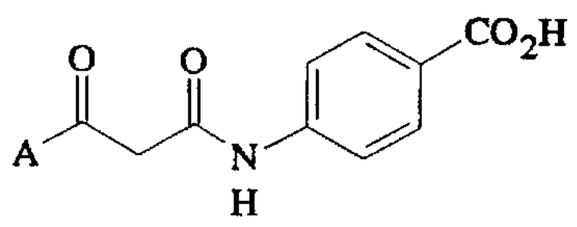
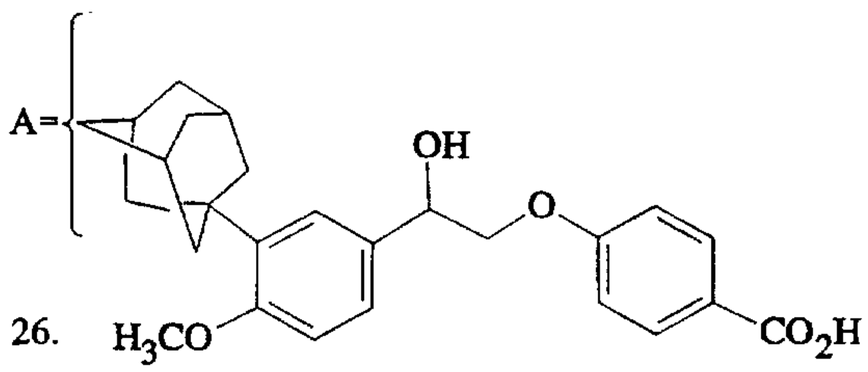
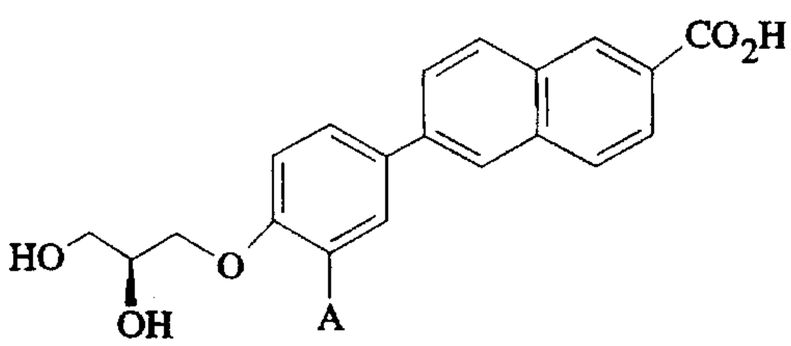
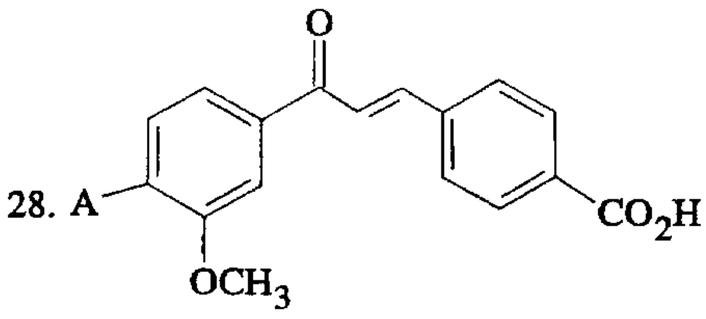
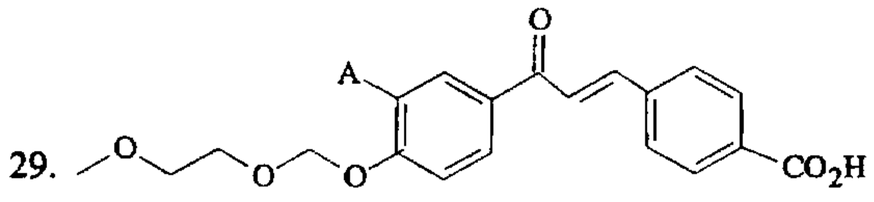
23. 

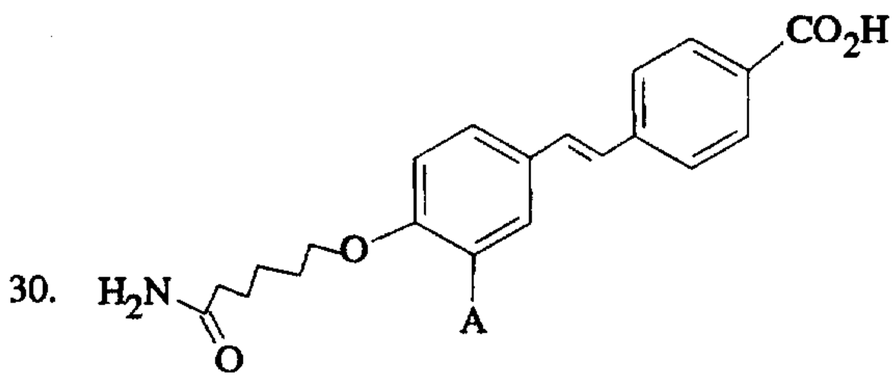
25. 

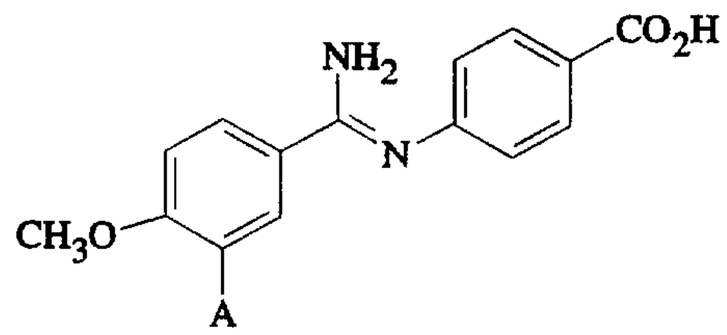
26. 

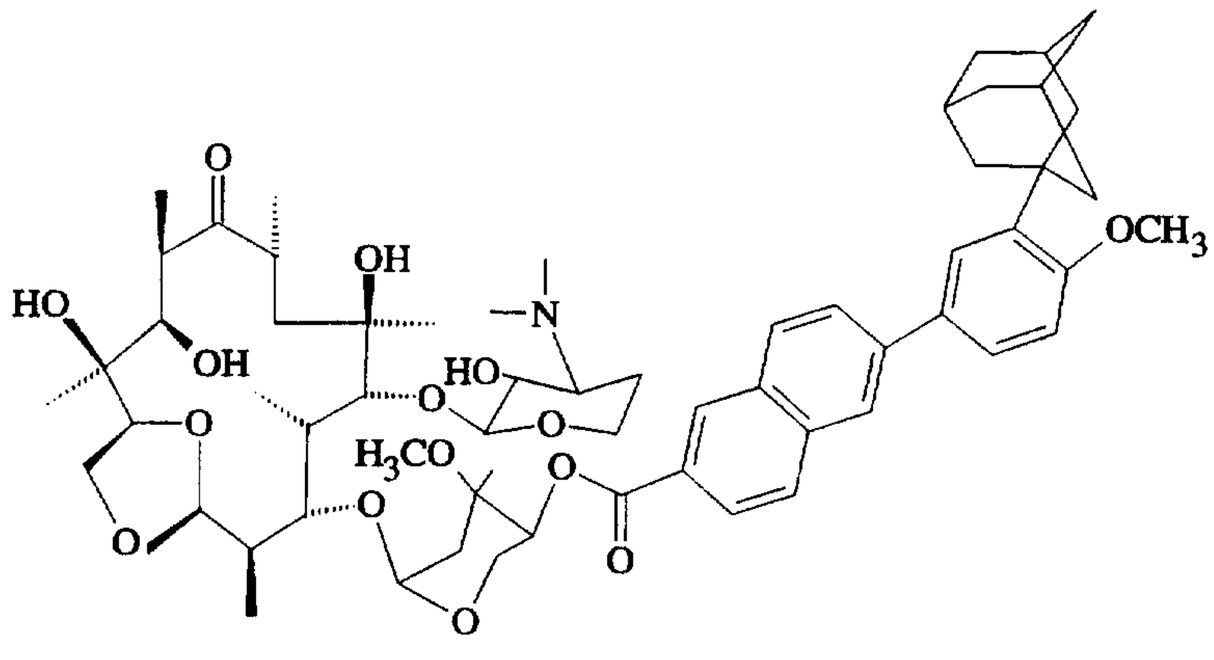
27. 

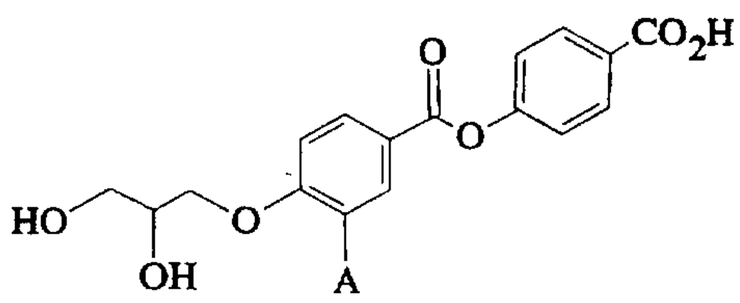
28. 

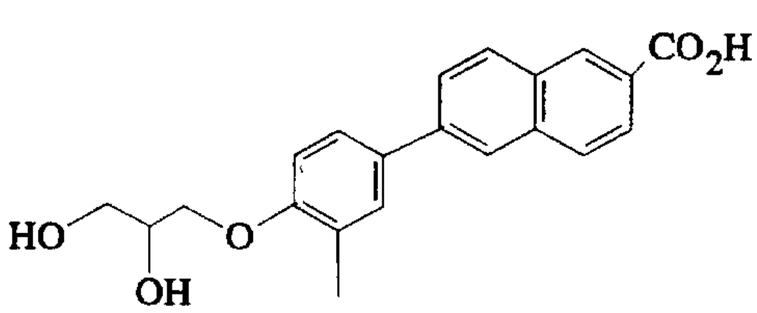
29. 

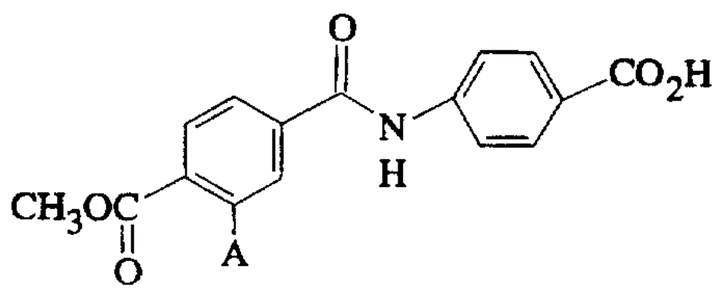
30. 

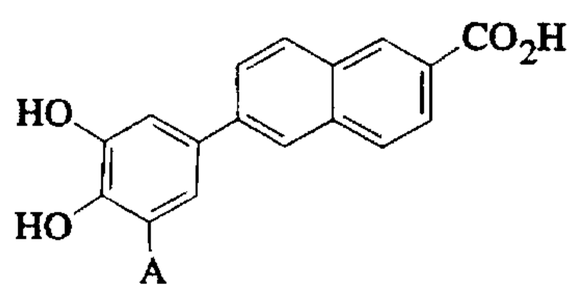
31. 

32. 

33. 

34. 

35. 

36. 

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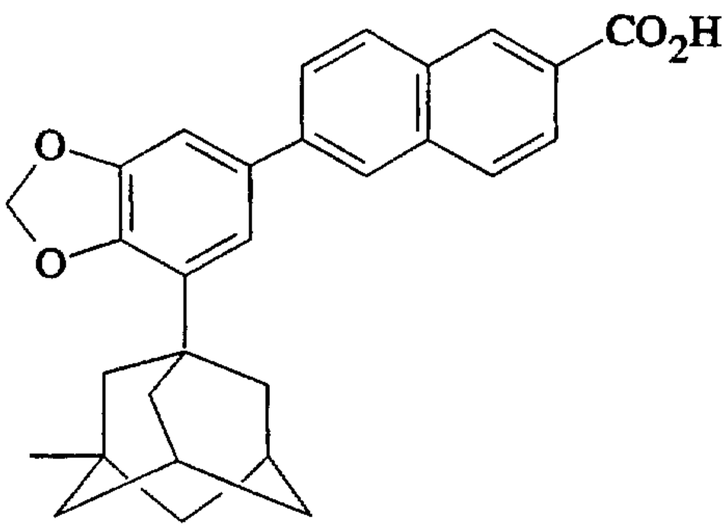

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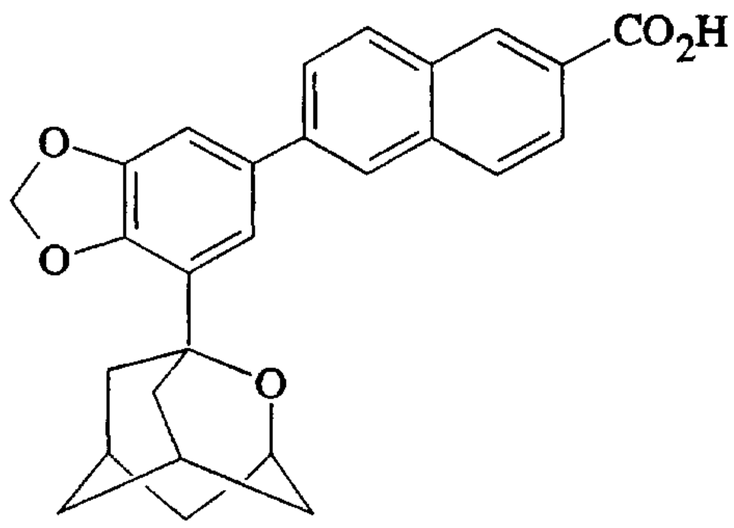

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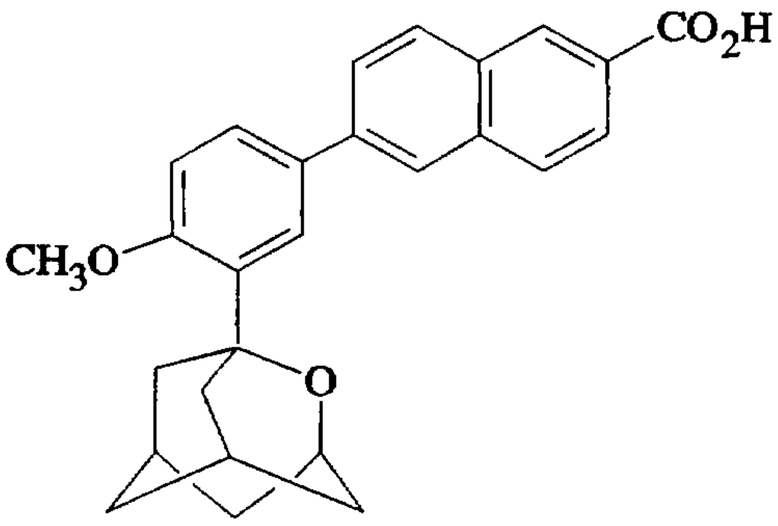

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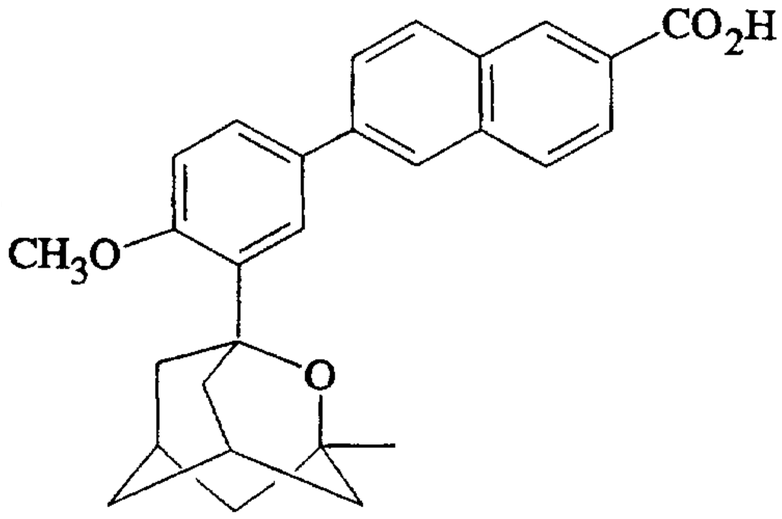

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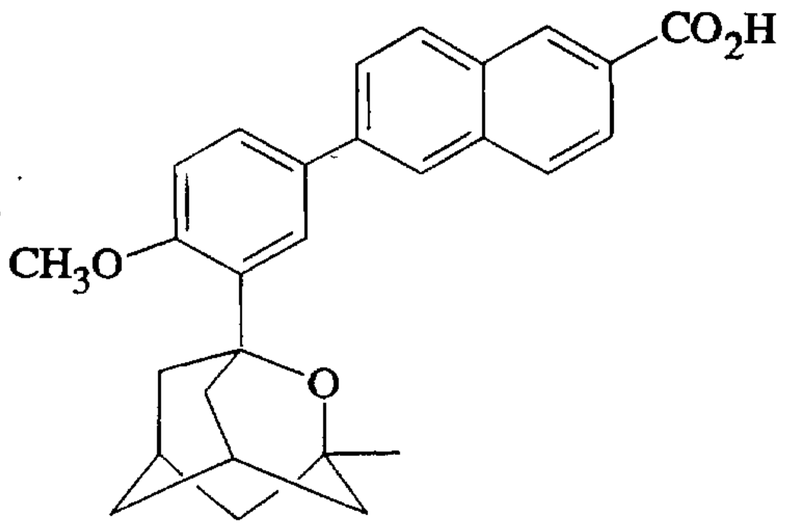

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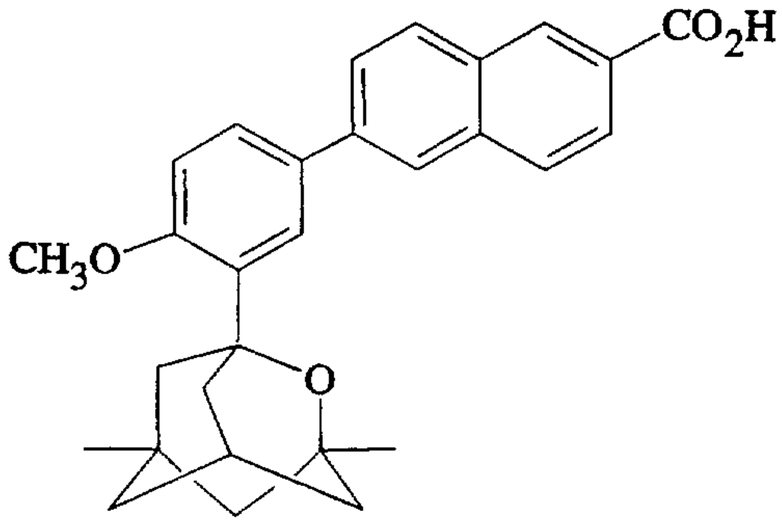

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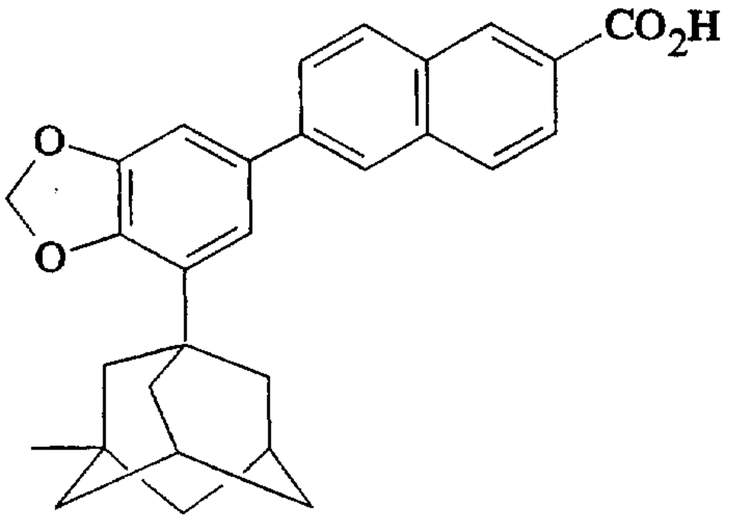
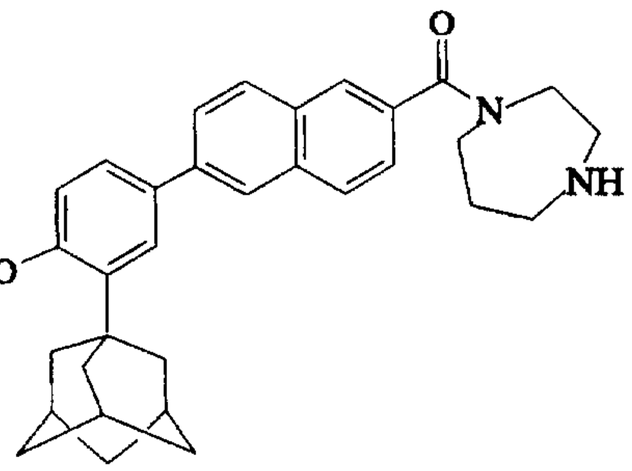
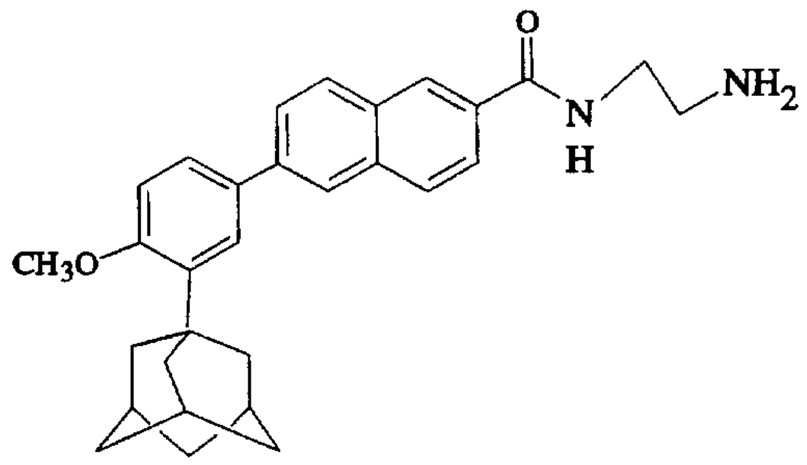
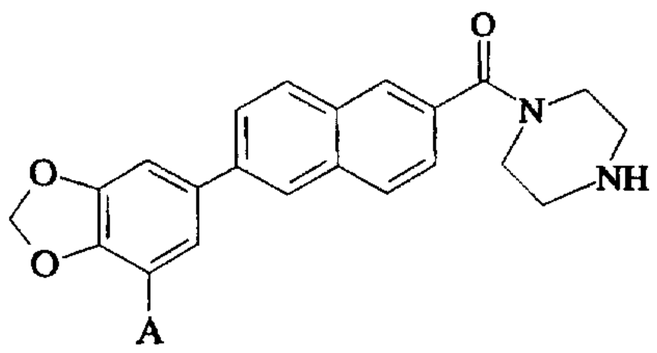
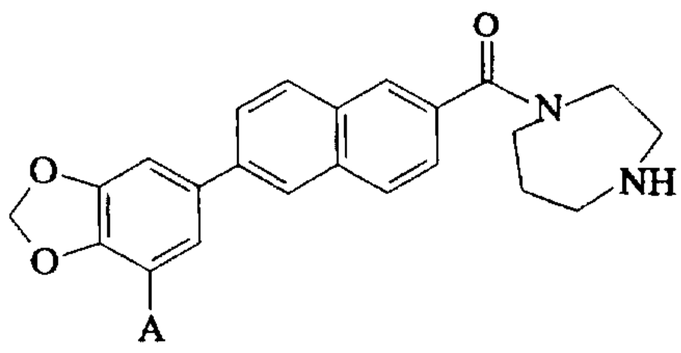
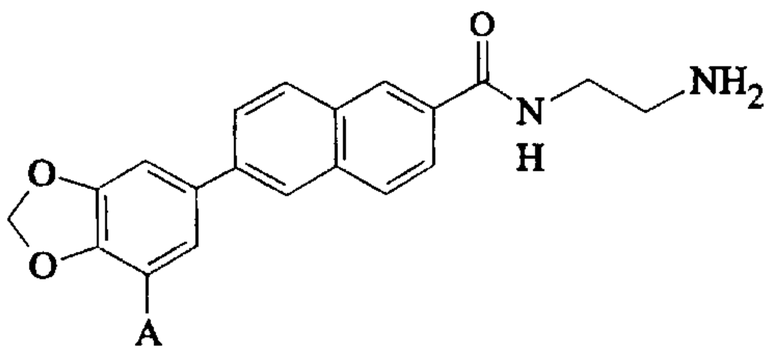


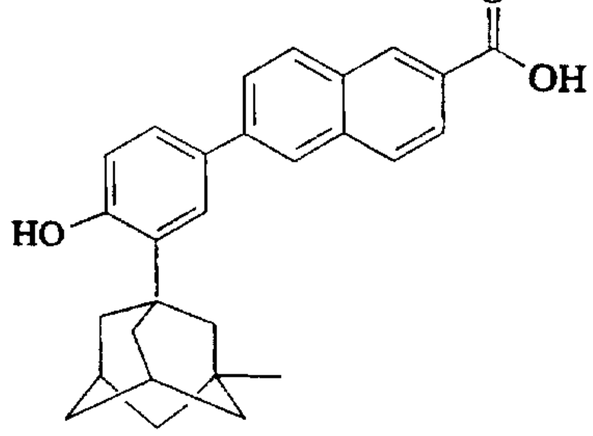
44. 

45. 

46. 

47. 

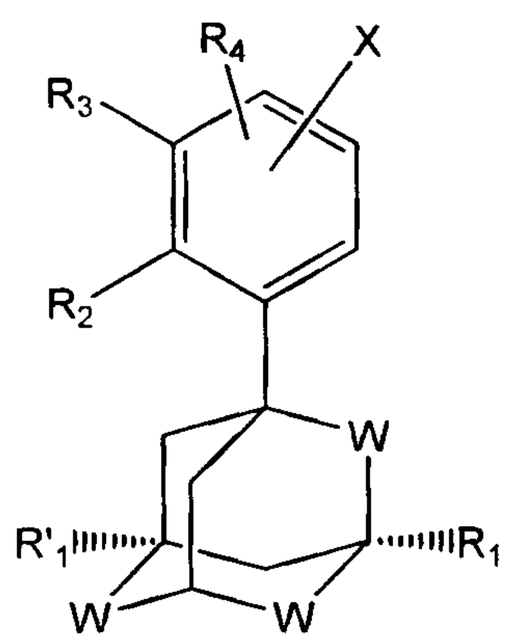
48. 

49. 

WHAT IS CLAIMED IS:

1. An adamantyl retinoid compound which is selected from the group consisting of:

– a compound of generic formula (I) or a pharmaceutically acceptable salt, geometric and/or optical isomer thereof:



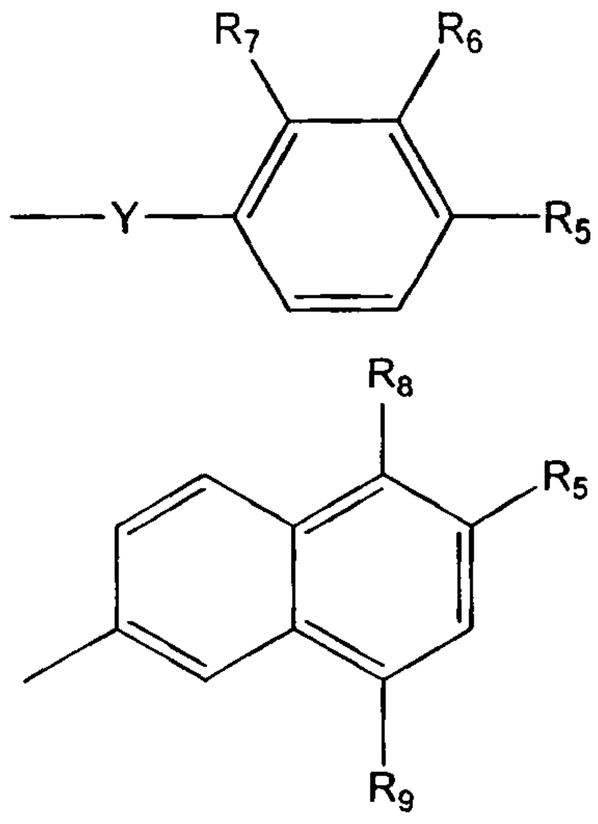
(I)

with the proviso that said retinoid of formula (I) is not an RAR-γ receptor-specific agonist ligand having a dissociation constant for RAR-α type receptor at least 10 times greater than the dissociation constant for RAR-γ type receptor

in which

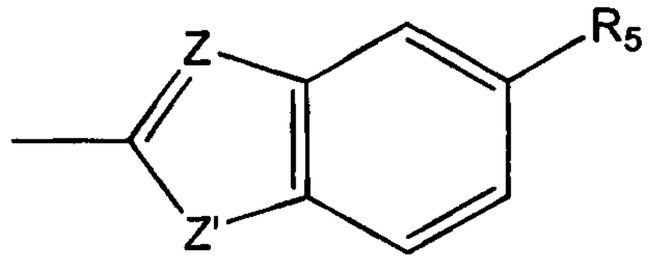
W is independently $-CH_2-$, -O-, -S-, -SO- or $-SO_2-$,

X is a radical selected from the group consisting of the following formulae (i)-(iii):



(i)

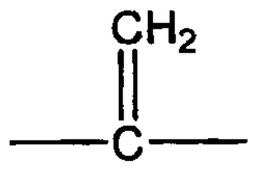
(ii)



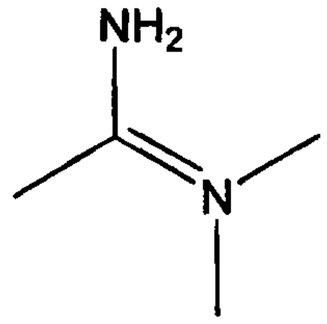
(iii)

wherein

Y is a radical -CO-V-, -CH=CH-, -(CH_3)C=CH-, -HC=C(CH_3)-, or



, -CHOH-CH_2-O-, or



V is an oxygen atom (-O-), an aza radical (-NH-), a radical -CH=CH- or -C≡C-;

Z is a radical -CH- and Z' is an oxygen atom, or

Z is a nitrogen atom (N) and Z' is an aza radical (-NH-);

R_1 is a hydrogen atom, halogen atom, or a lower alkyl radical;

R'_1 is a hydrogen atom, halogen atom, or a lower alkyl radical;

R_2 is a hydroxyl radical, an alkyl radical, optionally substituted by one or more hydroxyl or acyl groups, an alkoxyl radical, optionally substituted by one or more hydroxyl, alkoxyl or aminocarbonyl groups, and/or optionally interrupted by one or more oxygen atoms, an acyl radical, an aminocarbonyl radical or a halogen;

R_3 is a hydrogen atom, a halogen atom, a hydroxyl radical, an alkyl radical, or an alkoxyl radical;

R_4 is a hydrogen atom, an alkyl radical, an alkoxyl radical, or a halogen;

with the proviso that at least one of R_3 and R_4 is not an hydrogen;

R_5 is a radical -CO-R_{10}, an alkyl radical, optionally substituted by one or more hydroxyl groups, or a halogen;

R_6 is a hydrogen atom, a halogen atom, an alkoxyl radical, or a hydroxyl group;

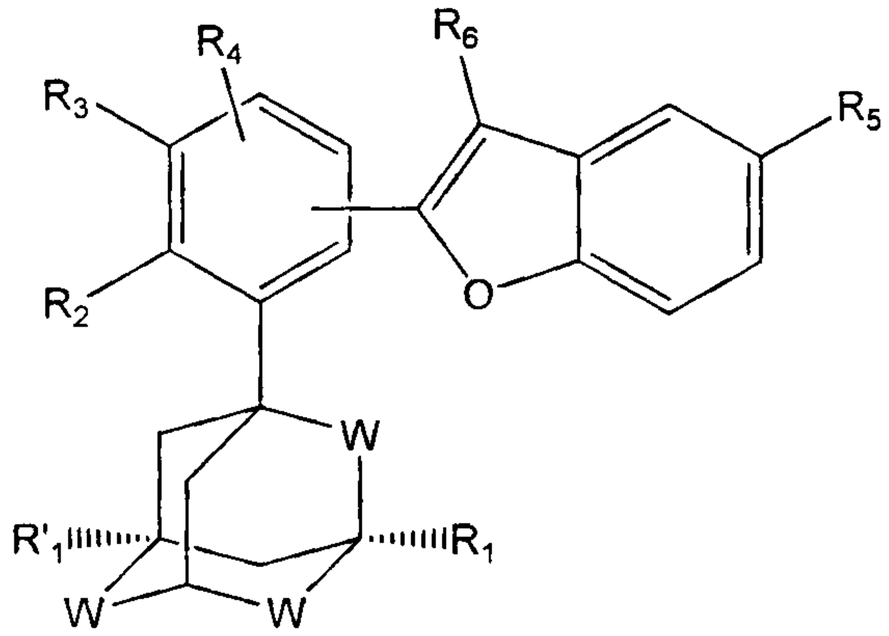
R_7 is a hydrogen atom or a halogen;

R_8 is a hydrogen atom, a halogen atom or an alkyl radical;

R_9 is a hydrogen atom, a hydroxyl radical or a halogen atom;

R_{10} is a hydroxyl radical, an alkoxyl radical, a radical of formula -Nr'r", wherein r' and r" represent a hydrogen atom, an aminoalkyl radical wherein the amino residue is optionally substituted by at least one alkyl radical, a mono- or polyhydroxyalkyl radical, a phenyl radical optionally substituted by at least one halogen, a hydroxyl or a nitro functional group, or an amino acid or sugar residue, or alternatively, r' and r" together, form a heterocycle; and

– a compound having generic formula (III) or a pharmaceutically acceptable salt, geometric and/or optical isomer thereof:



(III)

wherein W, R'_1, R_1, R_2, R_3, R_4, R_5, R_6 are as defined for compounds of formula (I), and

wherein said lower alkyl radicals contain from 1 to 6 carbon atoms.

2. The adamantly retinoid of formula (I) of claim 1, a pharmaceutically acceptable salt, geometric and/or optical isomer thereof, wherein at least one of W is -O-, -S-, -SO-, or $-SO_2-$, and/or at least one of R_1 and R_1' is halogen or a lower alkyl radical.

3. The adamantly retinoid of formula (I) of claim 1, or a pharmaceutically acceptable salt, geometric and/or optical isomer thereof, wherein R_5 is -CO-R_{10}, and R_{10} is a radical of formula -Nr'r", wherein one of r' and r" is hydrogen and the other is an aminoalkyl radical wherein the amino residue is optionally

substituted by at least one alkyl radical or alternatively r' and r", taken together, form a heterocycle.

4. The adamantyl retinoid compound of claim 1, which is of formula (I), or a pharmaceutically acceptable salt or geometric and/or optical isomer thereof.

5. The adamantyl retinoid compound of claim 1, which is of formula (III), or a pharmaceutically acceptable salt or geometric and/or optical isomer thereof.

6. The adamantyl retinoid compound of formula (I) according to claim 1, wherein R_5 is -CO-R_{10} and R_{10} is a radical of formula -Nr'r", wherein one of r' and r" is hydrogen and the other is an aminoalkyl radical wherein the amino residue is optionally substituted by at least one alkyl radical, or alternatively r' and r" together form a heterocycle.

7. The compound of claim 6, wherein r' and r" together form a piperazino group, or a homolog thereof.

8. The compound of claim 6, which is selected from the group consisting of N-(2-dimethylaminoethyl)-{6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphtalenecarboxamide}; N-{6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthalenecarboxoyl}homopiperazide; N-(2-aminoethyl)-{6-[3-(1-adamantyl)-4-methoxyphenyl]-2-naphthalenecarboxamide]; N-{6-[3-(1-adamantyl)-4,5-methylenedioxyl]-2-naphthalenecarboxoyl}piperazide; N-{6-[3-(1-adamantyl)-4,5-methylenedioxyl]-2-naphthalenecarboxoyl}homopiperazide; and N-(2-aminoethyl)-{6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthalenecarboxamide}.

9. The adamantyl retinoid compound of formula (I) according to claim 1, wherein at least one of W is -O-, -S-, -SO- or -SO_2- and/or at least one of R_1 and R_1' is halogen or a lower alkyl radical.

10. The adamantyl retinoid compound according to claim 9, which is selected from the group consisting of methyl ester of 6-[3-(3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; methyl ester of 6-[3-(2-oxa-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; methyl ester of 6-[3-(2-oxa-3-methyl-1-adamantyl)4-methoxyphenyl]-2-naphthoic acid; methyl ester of 6-[3-(3,5-dimethyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; methyl ester of 6-[3-(3-methyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; methyl ester of 6-[3-[(2-oxa-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; 6-[3-(3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; 6-[3-(3,5-dimethyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; 6-[3-(2-oxa-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; 6-[3-(2-oxa-3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; 6-[3-(3,5-dimethyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; 6-[3-(3-methyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; 6-[3-[(2-oxa-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; 6-[3-(3-methyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; 6-[3-(2-oxa-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; 6-[3-(2-oxa-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; 6-[3-(2-oxa-3-methyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; 6-[3-(3-methyl-1-adamantyl)-4-methoxy-phenyl]-2-naphthoic acid; 6-[3-(3,5-dimethyl-1-adamantyl)-4-methoxyphenyl]-2-naphthoic acid; 6[3-(3,5-dimethyl-1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid; and 6-[3-(3-methyl-1-adamantyl)-4-hydroxyphenyl]-2-naphtalene-carboxylic acid.

11. The adamantyl retinoid compound according to claim 9, wherein at least one W is -O- and/or R_1 is a lower alkyl radical and/or R_1' is a lower alkyl radical.

12. The compound according to claim 11, wherein X is of formula (ii).

13. The compound of claim 12, wherein R_8 is hydrogen and/or R_9 is hydrogen, and/or R_5 is $-COR_{10}$.

14. The adamantyl retinoid compound of formula (I) according to claim 1, wherein R_2 is an alkoxyl radical or hydroxyl group and/or R_3 or R_4 is hydrogen.

15. The adamantyl compound according to claim 5, wherein said compound is 2-[3-(1-adamantyl)-4-methoxyphenyl)-5-benzofurancarboxylic acid.

16. The adamantyl retinoid of formula (I) of claim 1, wherein at least one of W is -O-, -S-, -SO-, -SO_2, and/or at least one of R_1 and R_1' is halogen or a lower alkyl radical; or

wherein R_5 is -CO-R_{10}, R_{10} is a radical of formula -Nr'r", wherein one of r' and r" is hydrogen, and the other is an aminoalkyl radical wherein the amino residue is optionally substituted by at least one alkyl radical, or alternatively r' and r" together form a heterocycle,

or a pharmaceutically acceptable salt or geometric and/or optical isomer thereof.

17. The adamantyl retinoid compound according to claim 16, wherein at least one of W is -O-, -S-, -SO- or -SO_2 and/or at least one of R_1 and R_1' is halogen or a lower alkyl radical.

18. The compound of claim 17, wherein at least one W is -O- and/or R_1 is a lower alkyl radical and/or R_1' is a lower alkyl radical.

19. The adamantyl retinoid compound according to claim 16, wherein X is of formula (ii).

20. The compound of claim 19, wherein R_8 is hydrogen and/or R_9 is hydrogen and/or R_5 is -CO-R_{10}.

21. The adamantyl compound according to claim 16, wherein R_5 is -CO-R_{10} and R_{10} is a radical of formula -Nr'r", wherein one of r' and r" is hydrogen and the other is an aminoalkyl radical wherein the amino residue is optionally

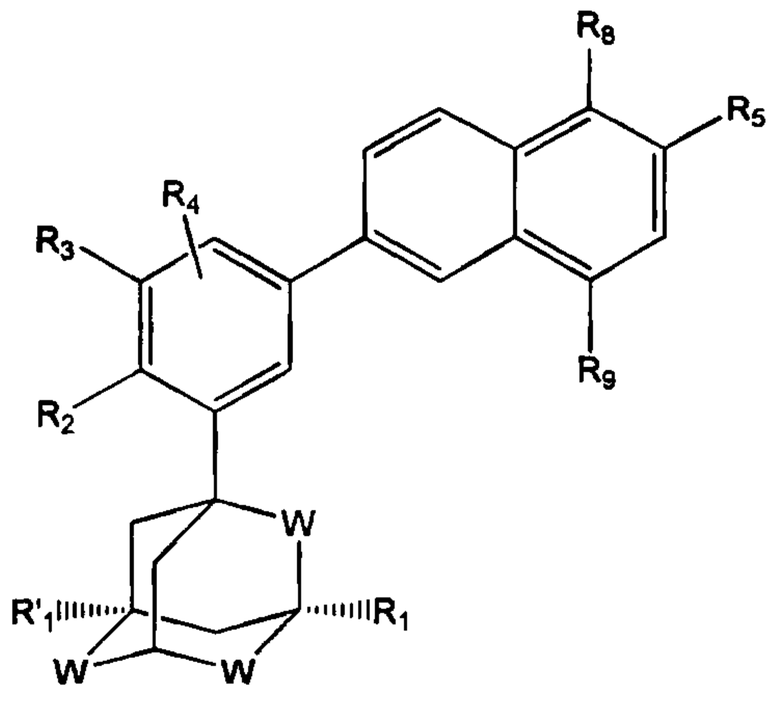
substituted by at least one alkyl radical or alternatively r' and r" together form a heterocycle.

22. The compound according to claim 21, wherein r' and r" together form a piperazino group, or a homolog thereof.

23. The adamantyl compound according to claim 21, wherein R_2 is an alkoxyl radical or hydroxyl group and/or R_3 or R_4 is hydrogen.

24. The compound according to claim 16, which is selected from the group consisting of 6-[3-(1-adamantyl)-4-hydroxy-5-methoxyphenyl]-2-naphthoic acid; 6-[3-(1-adamantyl)-4-hydroxy-6-methylphenyl]-2-naphthoic acid; 6-[3-(1-adamantyl)-4-methoxy-6-methylphenyl]-2-naphthoic acid; and 6-[3-(1-adamantyl)-4,5-dihydroxyphenyl]-2-naphthoic acid.

25. The adamantyl retinoid compound according to claim 1, corresponding to a compound of the generic formula (V):



(V)

wherein at least one of R_3 and R_4 is not hydrogen, and/or a pharmaceutically acceptable salt or geometric and/or optical isomer thereof.

26. The compound of claim 25, wherein at least two of the W moieties are $-CH_2-$.

27. The compound of claim 26, wherein R_1' and R_1 are both hydrogen.

28. The compound according to claim 25, wherein at least one of W is -O-, -S-, -SO- or $-SO_2-$, and/or at least one of R_1 and R_1' is halogen or lower alkyl radical.

29. A pharmaceutical or cosmetic composition comprising the adamantyl retinoid compound according to any one of claims 1 to 28, and at least one pharmaceutically or cosmetically acceptable vehicle, carrier or diluent.

30. A composition according to claim 29, which is adapted for topical, systemic, enteral, parenteral, or ocular administration, and which comprises a tablet, a capsule, a syrup, a dragee, a suspension, an elixir, a solution, a powder, granules, an emulsion, microspheres, nanospheres, lipid vesicles, polymeric vesicles, or an injectable or which is in the form of an ointment, a cream, a milk, a salve, an impregnated pad, a gel, a spray or a lotion.

31. A composition according to claim 29 or 30, further comprising another retinoid compound, a D vitamin or derivative thereof, a corticosteroid, an anti-free radical agent, a α-hydroxy or α-keto acid or derivative thereof, or combination thereof.

32. Use of the adamantyl retinoid compound according to any one of claims 1 to 28, in the manufacture of a medicament for:

(a) treating or preventing a dermatological condition associated with a keratinisation disorder related to differentiation and/or proliferation;

(b) treating or preventing dermal or epidermal proliferations which may be benign or malignant, and optionally of viral origin;

(c) treating bullous dermatoses and/or a collagen disease;

(d) repairing or controlling aging of the skin, whether photoinduced or chronologic, actinic keratoses and pigmentations, and other pathologies associated with chronologic or actinic aging;

(e) preventing or treating the stigmata of epidermal and/or dermal atrophy induced by local or systemic corticosteroids, or other forms of cutaneous atrophy;

(f) preventing and/or treating healing disorders or preventing and/or repairing stretch marks;

(g) controlling disorders of the sebaceous function; or

(h) preventing or treating alopecia.

33. Use of the adamantyl compound according to any one of claims 1 to 28 in the manufacture of a medicament for:

(a) preventing of cancerous or precancerous conditions;

(b) treating of a condition associated with inflammation;

(c) treating of viral associated conditions;

(d) treating of dermatological or general conditions including an immunological component;

(e) treating of a cardiovascular system associated ailment; or

(f) treating or prevention of osteoporosis.

FIG. 1

Experimental Data Output for Lead Identification

Chemical Name	Bre	Cor	Col	Fib	Gli	HN	Lu	Mel	Neu	Ov	Pan	Pro
all-*trans*-retinoic acid	97	91	124	114	91	79	82	111	122	103	94	115
6 (3 (1 adamantyl) 4 methoxyphenyl) 2 naphthoic acid	6	79	103	105	81	70	63	87	43	107	84	77
2 (3 (1 adamantyl) 4 methoxyphenyl) 5 benzimidazole carboxylic acid	9	61	104	103	97	39	48	80	88	104	52	48
6 (3 (1 adamantyl) 4 hydroxymethylphenyl) 2 naphthoic acid	4	70	1	31	69	10	30	43	26	4	40	12
6 (3 (1 adamantyl) 4 hydroxy 5 methoxyphenyl) 2 naphthoic acid	33	81	103	76	41	23	42	68	64	81	56	26
6 (3 (1 adamantyl) 4 acetoxymethylphenyl) 2 naphthoic acid	81	92	103	87	83	83	77	101	115	85	101	49
6 (3 (1 adamantyl) 4,5 methylenedioxyphenyl) 2 naphthoic acid	31	95	99	74	87	25	36	17	6	56	68	100

SUBSTITUTE SHEET (RULE 26)

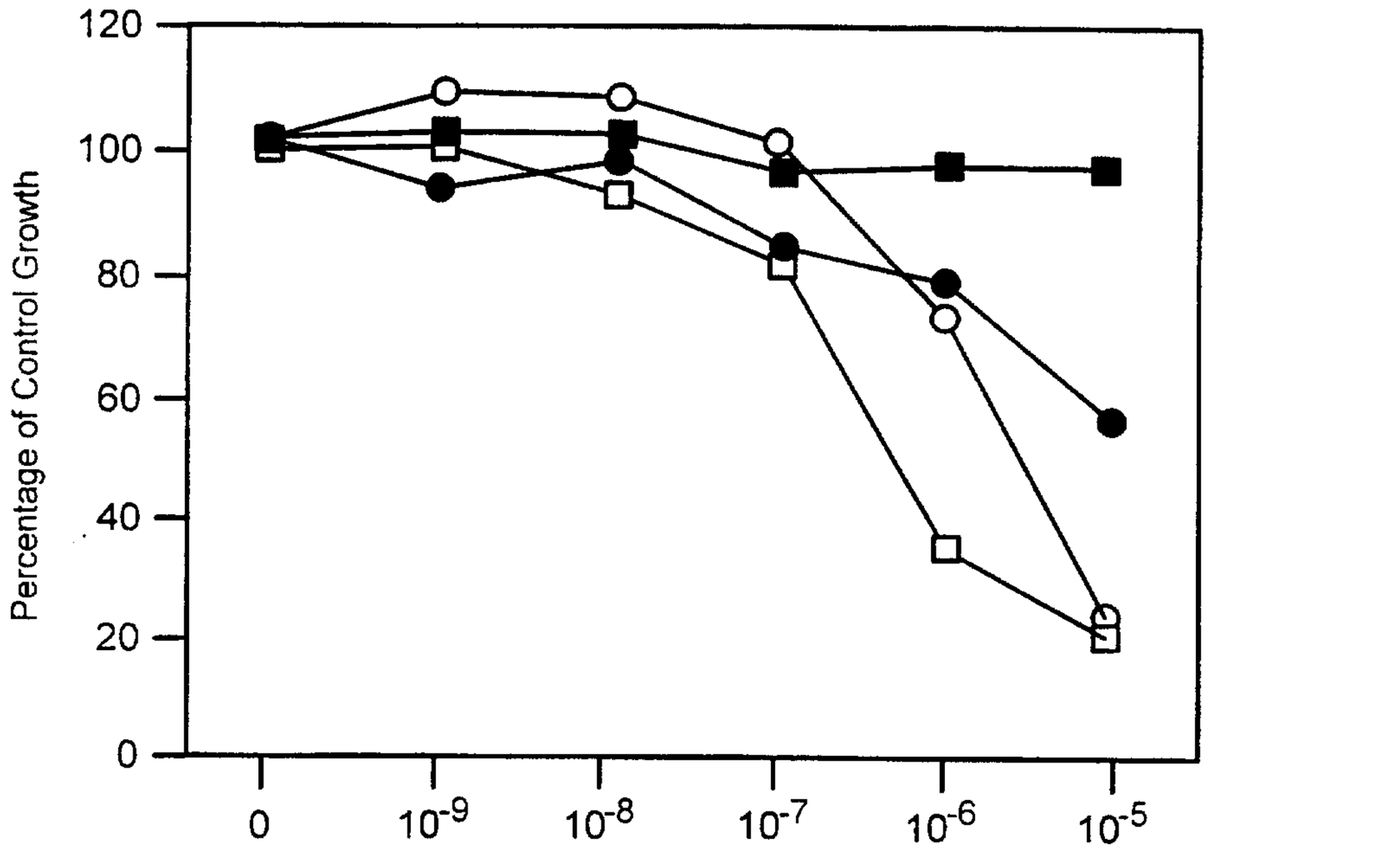
PCT/US97/11564

CA 02259936 1999-01-07

FIG. 2

Non-Small Cell Lung Carcinoma

Human Lung Carcinoma Cell Line NCI-H292 (Pulmonary Mucoepiderma Lung Carcinoma)



- all-*trans*-retinoic acid
- 2-[3-(1-adamantyl)-4-methoxyphenyl]-5-benzimidazole carboxylic acid
- 6-[3-(1-adamantyl)-4-hydroxymethylphenyl]-2-naphthoic acid
- 6-[3-(1-adamantyl)-4-hydroxy-5-methoxyphenyl]-2-naphthoic acid

PROSTATE CANCER

FIG. 3A

Human Prostate Adenocarcinoma Cell Line PC-3

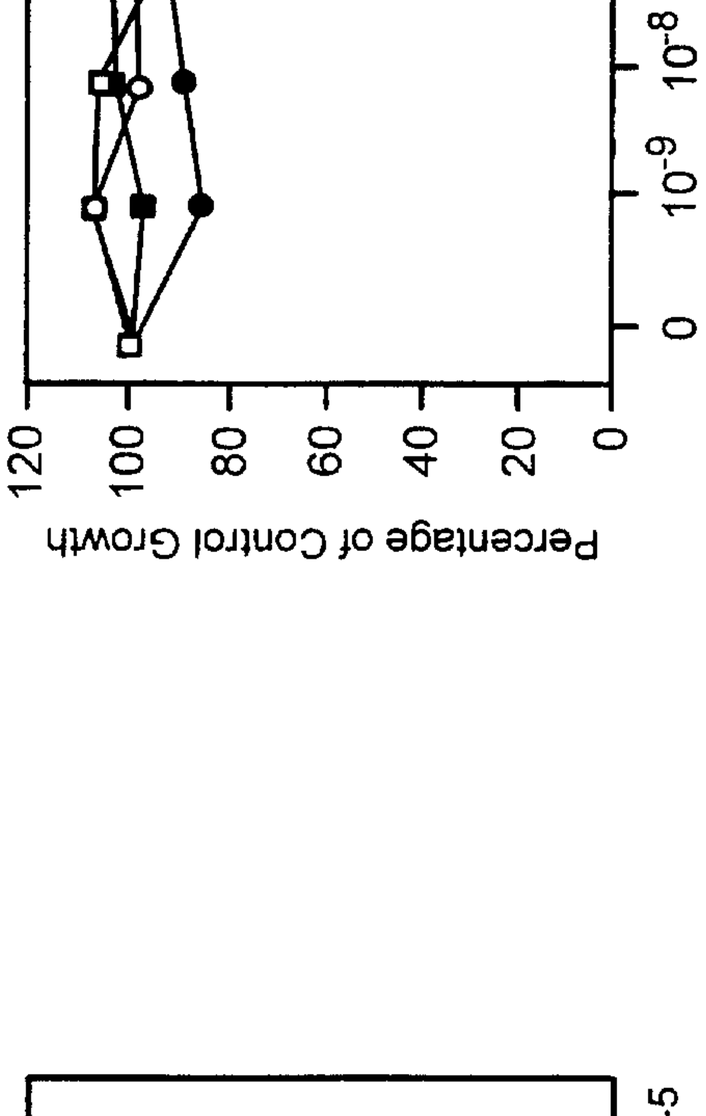
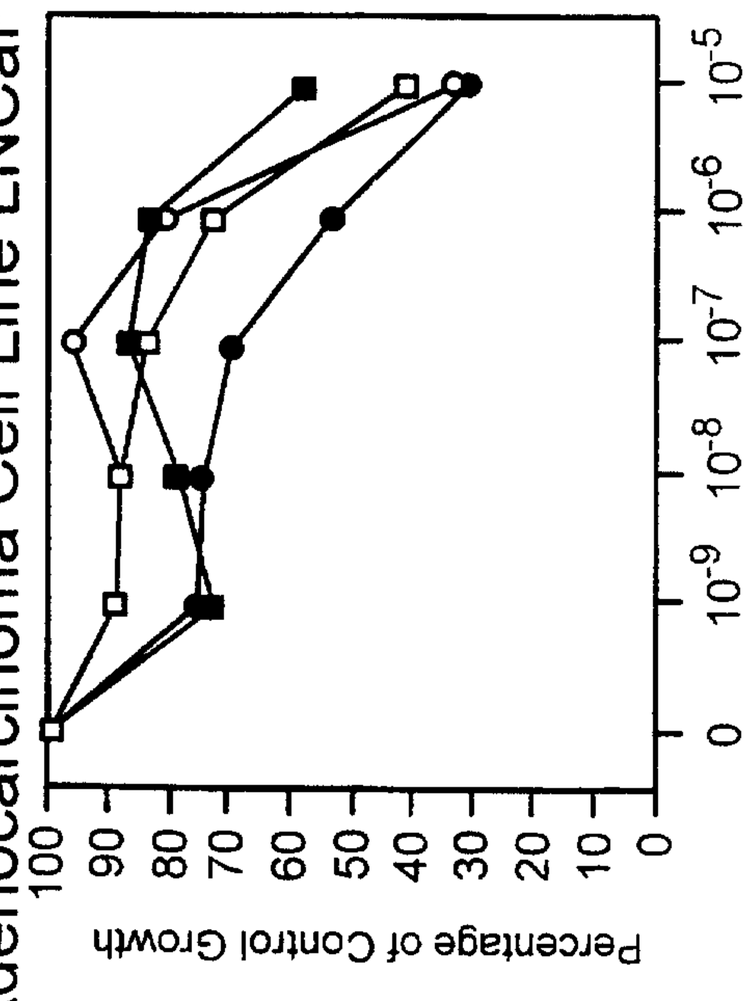


FIG. 3B

Human Prostate Carcinoma Cell Line DU-145

FIG. 3C

Human Metastatic Prostate Adenocarcinoma Cell Line LNCaP.FGC



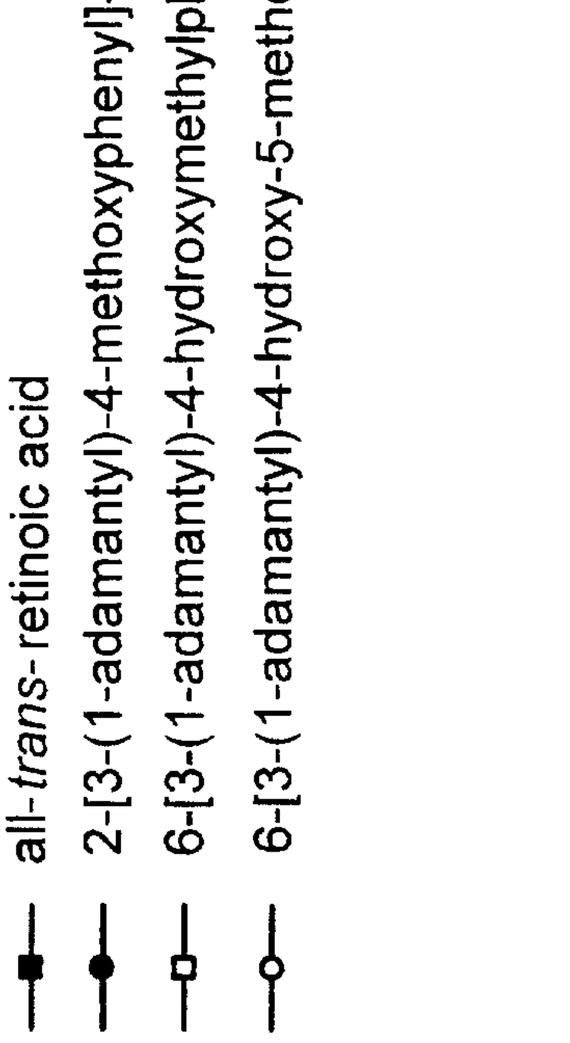
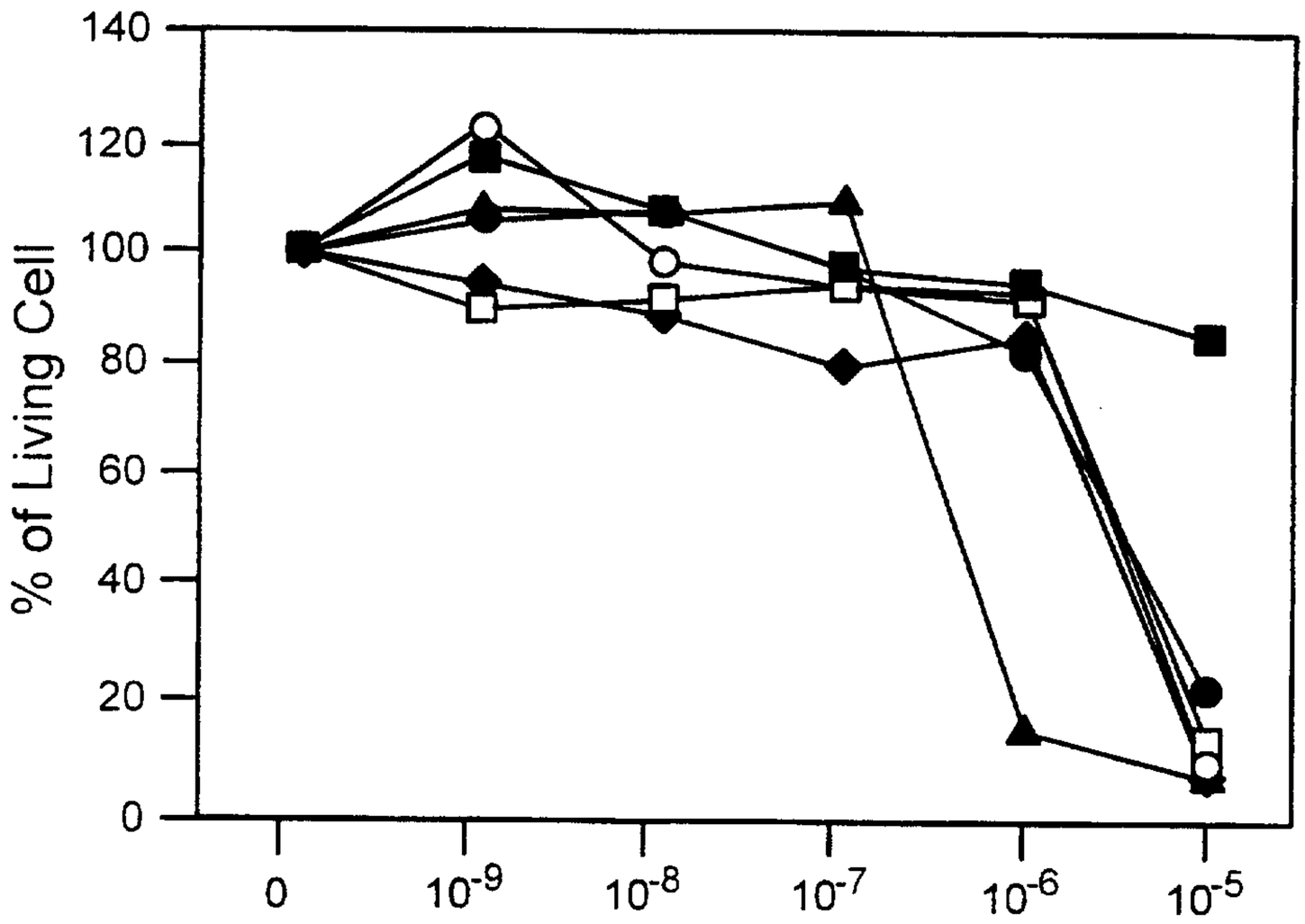


FIG. 4

Liver Cancer

Human Liver Cancer Cell Line SK-Hep-1



all-*trans*-retinoic acid

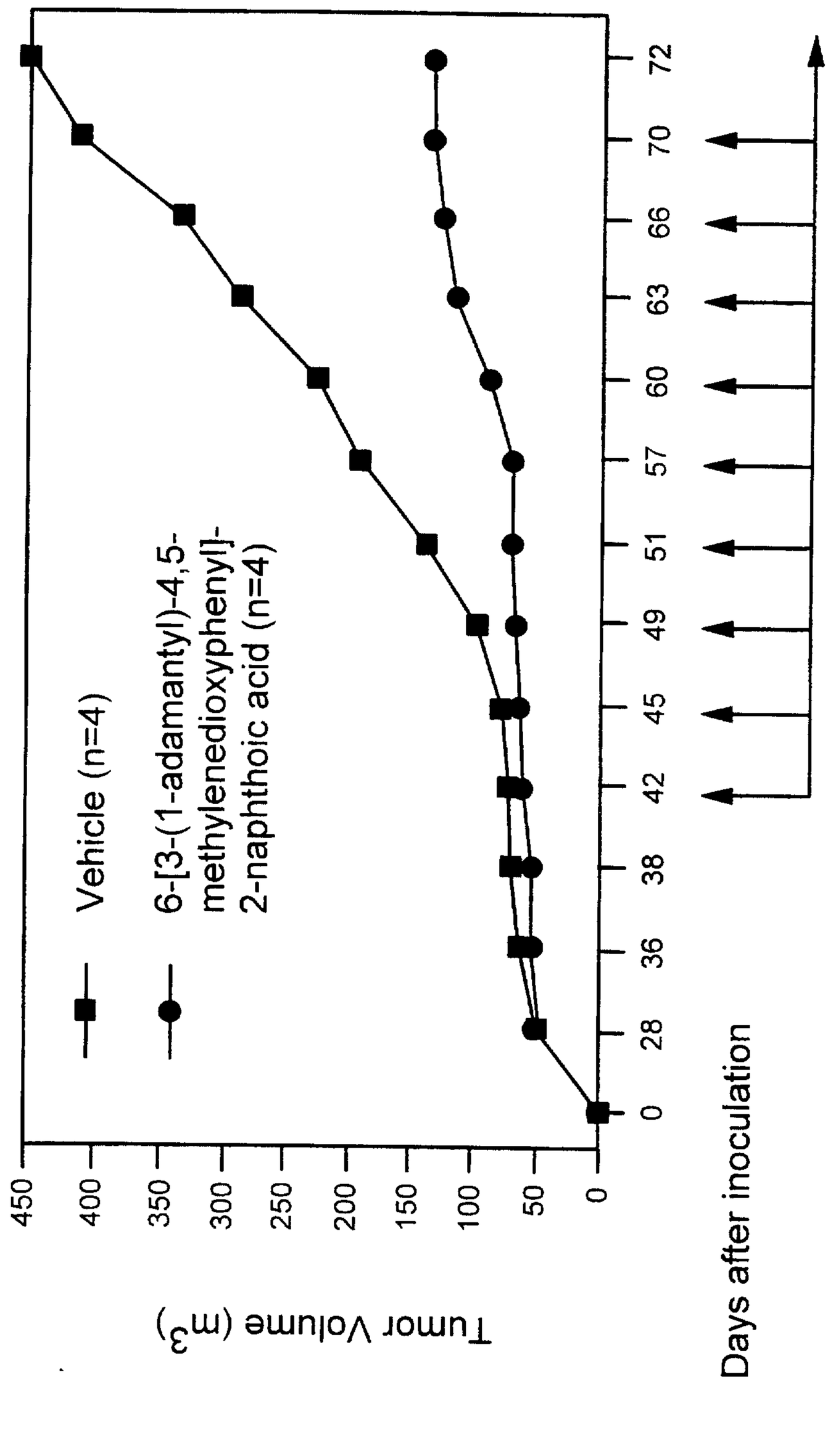
2-[3-(1-adamantyl)-4-methoxyphenyl]-5-benzimidazole carboxylic acid

6-[3-(1-adamantyl)-4-hydroxymethylphenyl]-2-naphthoic acid

6-[3-(1-adamantyl)-4-hydroxy-5-methoxyphenyl]-2-naphthoic acid

6-[3-(1-adamantyl)-4-acetoxymethylphenyl]-2-naphthoic acid

6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid

FIG. 5

Effect of 6-[3-(1-adamantyl)-4,5-methylenedioxyphenyl]-2-naphthoic acid on Human Pancreatic Cancer BxPC-3 Animal Mode *in vivo*