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CA 2462998 C 2008/12/09

(11)(21) **2 462 998**

(12) **BREVET CANADIEN
CANADIAN PATENT**

(13) **C**

(22) Date de dépôt/Filing Date: 2004/04/01

(41) Mise à la disp. pub./Open to Public Insp.: 2004/10/04

(45) Date de délivrance/Issue Date: 2008/12/09

(30) Priorité/Priority: 2003/04/04 (US10/407,509)

(51) Cl.Int./Int.Cl. *C07J 41/00* (2006.01),
A61K 31/56 (2006.01), *A61K 31/565* (2006.01),
A61K 31/566 (2006.01), *A61P 5/00* (2006.01),
C07J 1/00 (2006.01), *C07J 31/00* (2006.01)

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(54) Title: NOVEL ESTROGENIC COMPOUNDS

(57) **Abrégé/Abstract:**

The present invention relates to novel estrogenic compounds. The present invention also relates to methods of treating estrogen deprivation in a subject comprising administering novel estrogenic compounds. Additionally, the present invention relates to methods of synthesizing novel estrogenic compounds.



ABSTRACT

The present invention relates to novel estrogenic compounds. The present invention also relates to methods of treating estrogen deprivation in a subject comprising administering novel estrogenic compounds. Additionally, the present invention relates to methods of synthesizing novel estrogenic compounds.

NOVEL ESTROGENIC COMPOUNDS

[0001] Field of the Invention

[0002] The present invention relates to the field of estrogenic compounds.

[0003] Background of the Invention

[0004] Women, particularly menopausal and post-menopausal women, often experience a wide variety of conditions and disorders attributable to estrogen deprivation. Estrogen deprivation is often associated with the loss of ovarian function. This may result in hot flashes, dryness of the vagina, including discomfort during intercourse, loss of bone mass, increased heart disease and the like.

[0005] Providing dosages of estrogen is an effective agent for the control or prevention of such conditions, particularly in controlling or preventing hot flashes and vaginal atrophy, along with retarding or preventing osteoporosis. Estrogen is typically administered alone or in combination with a progestin.

[0006] As detailed in U.S. Patent No. Re. 36,247 to Plunkett et al., estrogen alone, given in small doses, on a continuous basis, is effective in most patients for the control of the above symptoms and problems associated therewith. However, although the vast majority of women taking continuous low-dose estrogen will not have bleeding for many months or even years, there is a distinct risk posed by this routine of developing "hyperplasia of the endometrium". This phrase refers to an overstimulation of the lining of the uterus which can become pre-malignant, coupled with the possibility that the patient may eventually develop cancer of the uterine lining even under such a low-dose regimen (Gusberg et al., Obstetrics and Gynaecology, 17, 397-412, 1961).

[0007] Estrogen alone may be given in cycles, usually 21-25 days on treatment and 5-7 days off treatment. When small doses of estrogen are required to control the symptoms generally only about 10% of women experience withdrawal bleeding between the cycles of actual treatment. However, the risk of developing endometrial hyperplasia and the increased relative risk of developing cancer of the uterus may still be present with this method (Research on the Menopause: Report of a W.H.O. Scientific Group, 53-68, 1981).

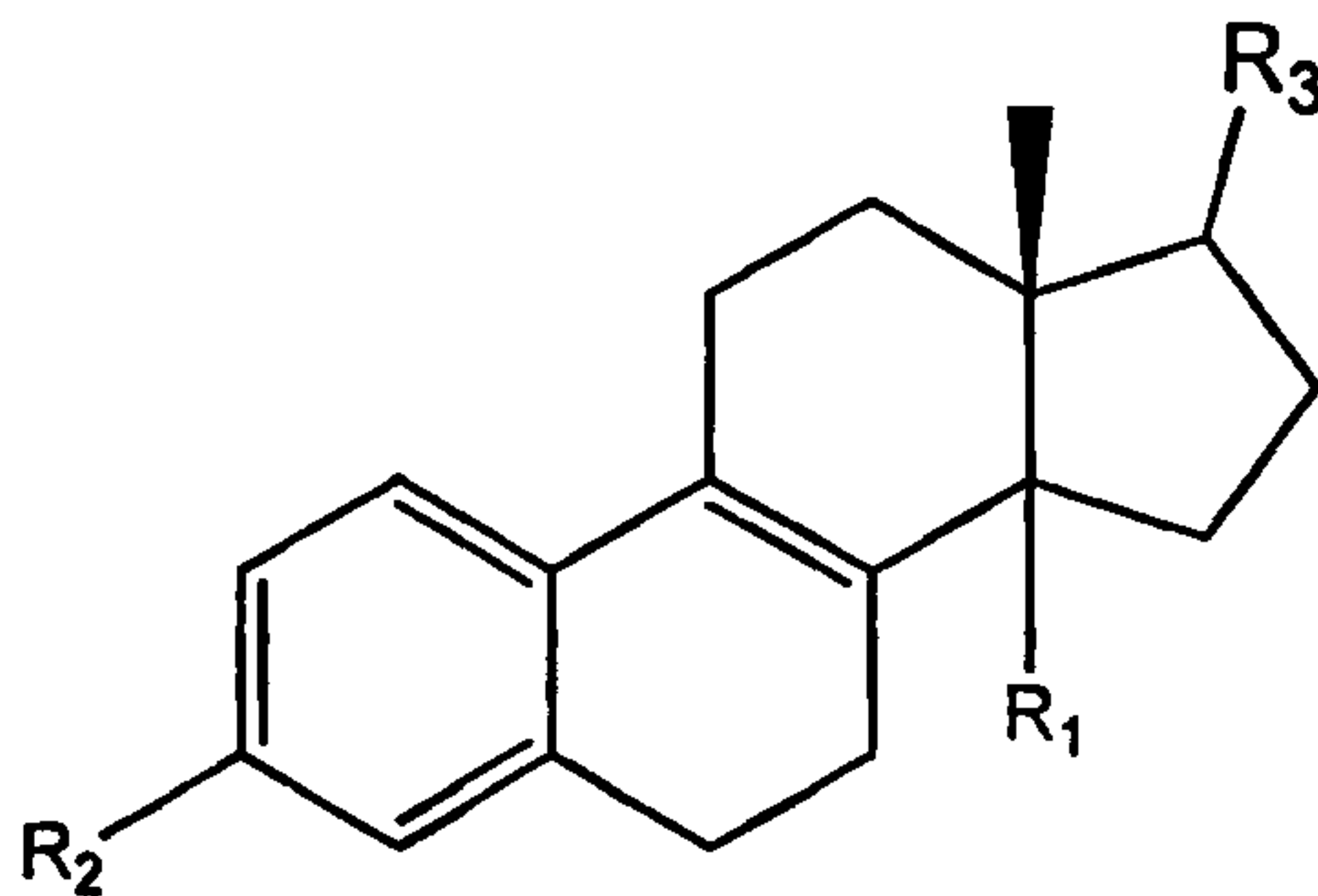
[0008] The addition of a progestin for the last 7-10 days of each estrogen cycle helps to reduce concerns about developing endometrial hyperplasia and/or also reduce the risk of

developing endometrial carcinoma below that of the untreated general population. However, withdrawal bleeding may occur regularly in this routine and this is generally not preferable to most older women (Whitehead, Am. J. Obs/Gyn., 142,6, 791-795, 1982).

[0009] Another routine for estrogen administration may involve a formulation such as those found in birth control pills which contain relatively small doses of estrogen over the full 20-21 day treatment cycle, plus very substantial doses of potent progestins over the same period of time. This routine, of course not only produces withdrawal bleeding on each cycle, but is also generally unacceptable because such formulations have been shown to carry an increased risk of developing arterial complications, such as stroke or myocardial infarction in
10 older women about the age of 35-40. This is especially true if the individual is a smoker of cigarettes (Plunkett, Am. J. Obs/Gyn. 142,6, 747-751, 1982). Thus, there remains a need for novel isolated estrogenic compounds.

[0010] Summary of the Invention

[0011] The present invention relates to novel estrogenic compounds comprising the formula:



wherein R₁ is selected from the group consisting of peroxy, hydroxy, halogen, and thiol;

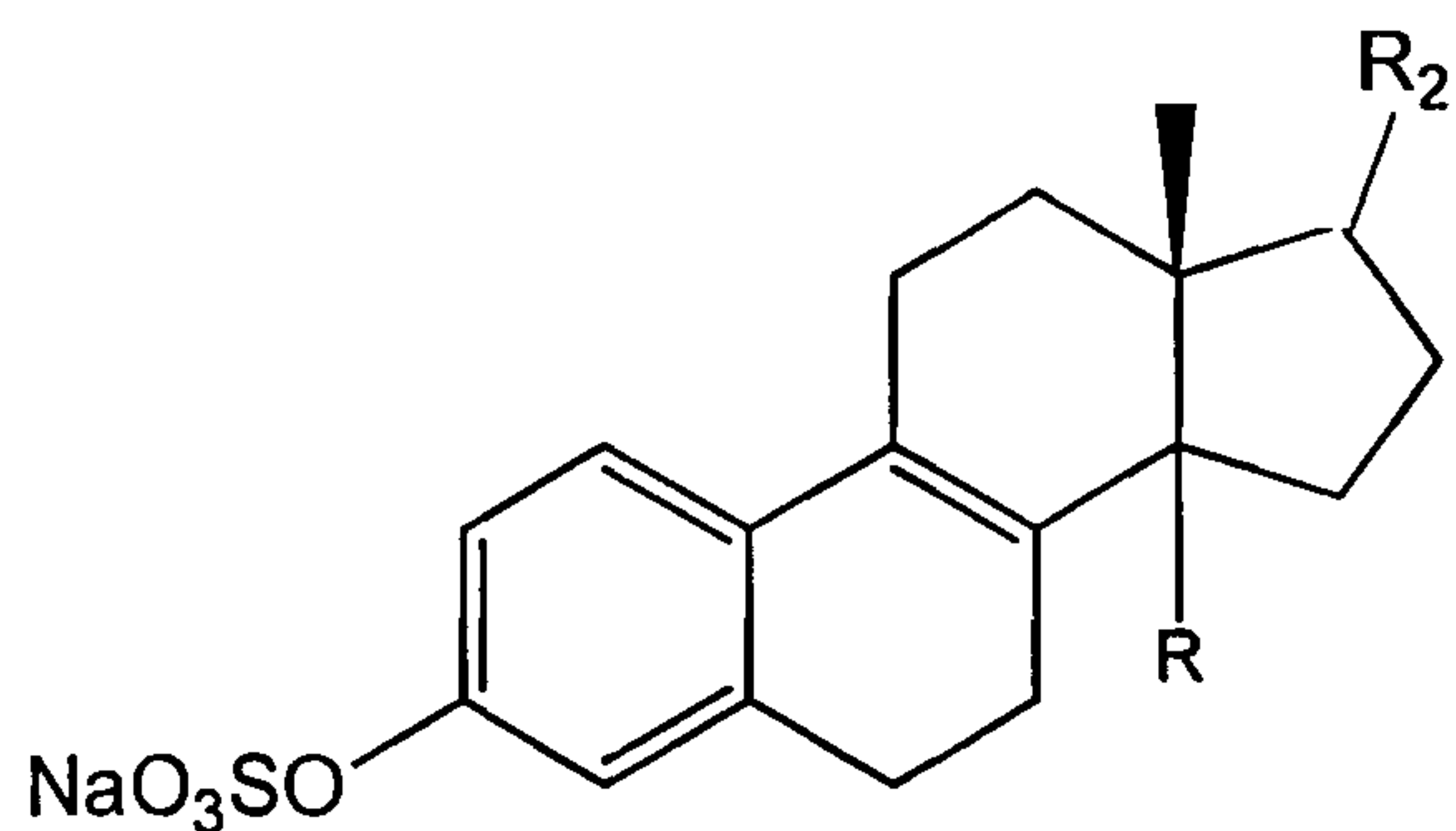
R₂ is selected from the group of glucuronide, sulfate, phosphate, pyrophosphate
20 and thiol; and

R₃ is selected from the group consisting of hydroxy, O-acyl, and oxo; or a pharmaceutically acceptable salt of said compound.

The present invention also relates to methods of treating estrogen deprivation in a subject comprising administering the novel estrogenic compounds.

Additionally, the present invention relates to methods of synthesizing novel estrogenic compounds.

Finally, the invention relates to the use of a compound in the manufacture of a medicament for the treatment of estrogen deprivation comprising the
30 formula:



wherein R is selected from the group consisting of peroxy, hydroxy, halogen, and thiol; and

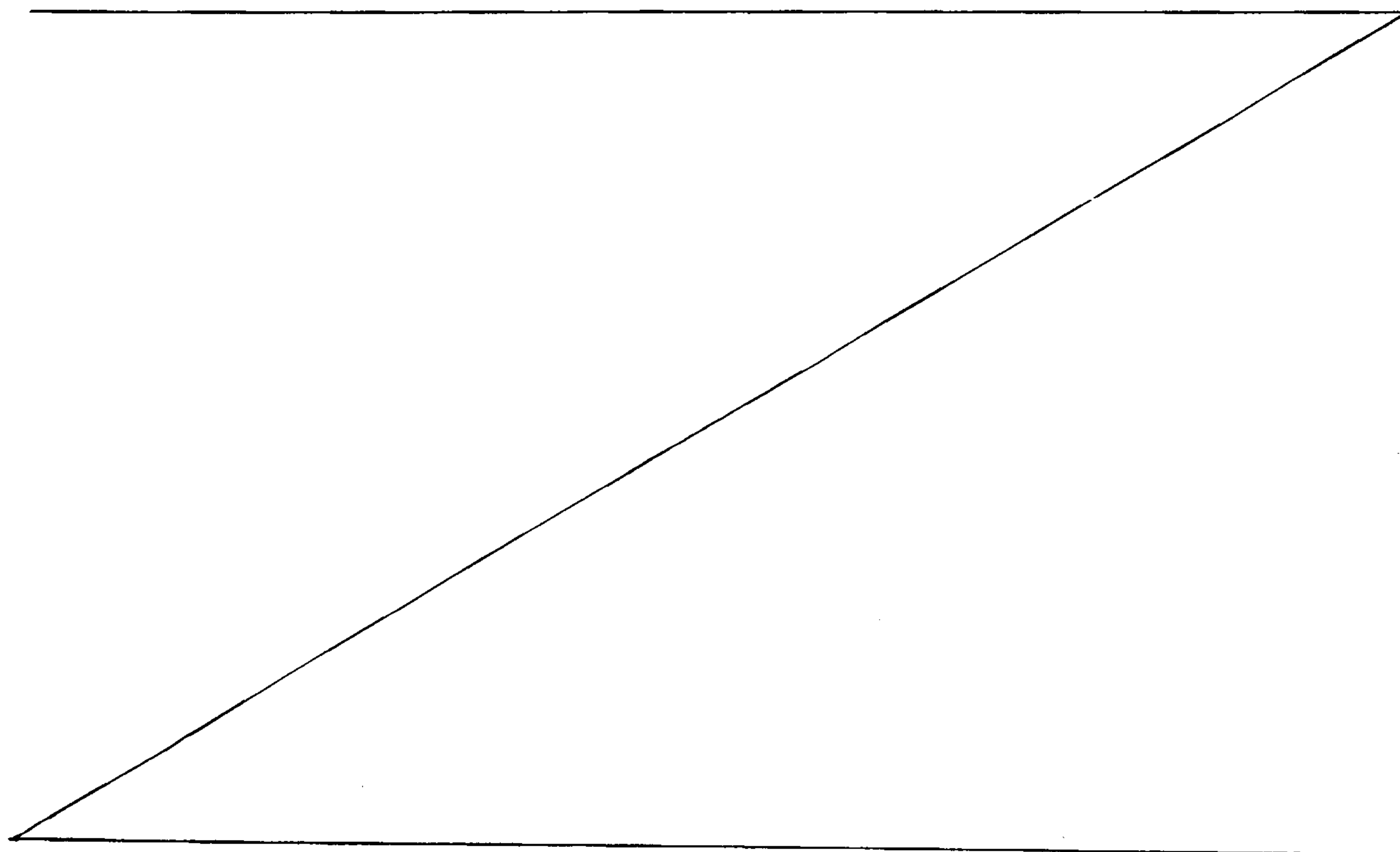
R₂ is selected from the group consisting of hydroxy, O-acyl, and oxo, or a pharmaceutically acceptable salt thereof.

[0012] Brief Description of the Figures of the Invention

[0013] FIG. 1A illustrates a UV chromatogram of components C, D, E and $\Delta^{8,9}$ -dehydroestrone sulfate;

[0014] FIG. 1B illustrates the diode array UV spectrum of component C;

[0015] FIG. 1C illustrates the diode array UV spectrum of component D;



- [0016] FIG. 1D illustrates the diode array UV spectrum of component E;
- [0017] FIG. 1E illustrates the diode array UV spectrum of $\Delta^{8,9}$ -dehydroestrone sulfate;
- [0018] FIG. 2 depicts a UV chromatogram of a sample containing components C, D, and E;
- [0019] FIG. 3 illustrates a mass spectrum of component C;
- [0020] FIG. 4 depicts a single ion trace at m/z equal to 363 for the spectrum set forth in FIG. 3;
- [0021] FIG. 5 shows a mass spectrum of component D;
- [0022] FIG. 6 illustrates a single ion trace at m/z equal to 448 for the spectrum set forth in FIG. 5;
- [0023] FIG. 7 depicts a mass spectrum of component E; and
- [0024] FIG. 8 illustrates a single ion trace at m/z equal to 379 for the spectrum set forth in FIG. 7.

[0025] Detailed Description of the Invention

[0026] In one aspect, the invention relates to a method of synthesizing an estrogenic composition. For the purposes of the invention, the estrogenic composition may encompass various compounds. Preferably, the estrogenic composition includes at least one conjugated estrogen. The conjugates may be various conjugates understood by those skilled in the art, including, but not limited to, sulfate and glucuronide. The most preferred estrogen conjugates are estrogen sulfates. The estrogenic compounds may also be present as salts of estrogen conjugates. The salts may be various salts understood by those skilled in the art, including, but not limited to, sodium salts, calcium salts, magnesium salts, lithium salts, and piperazine salts. The most preferred salts are sodium salts.

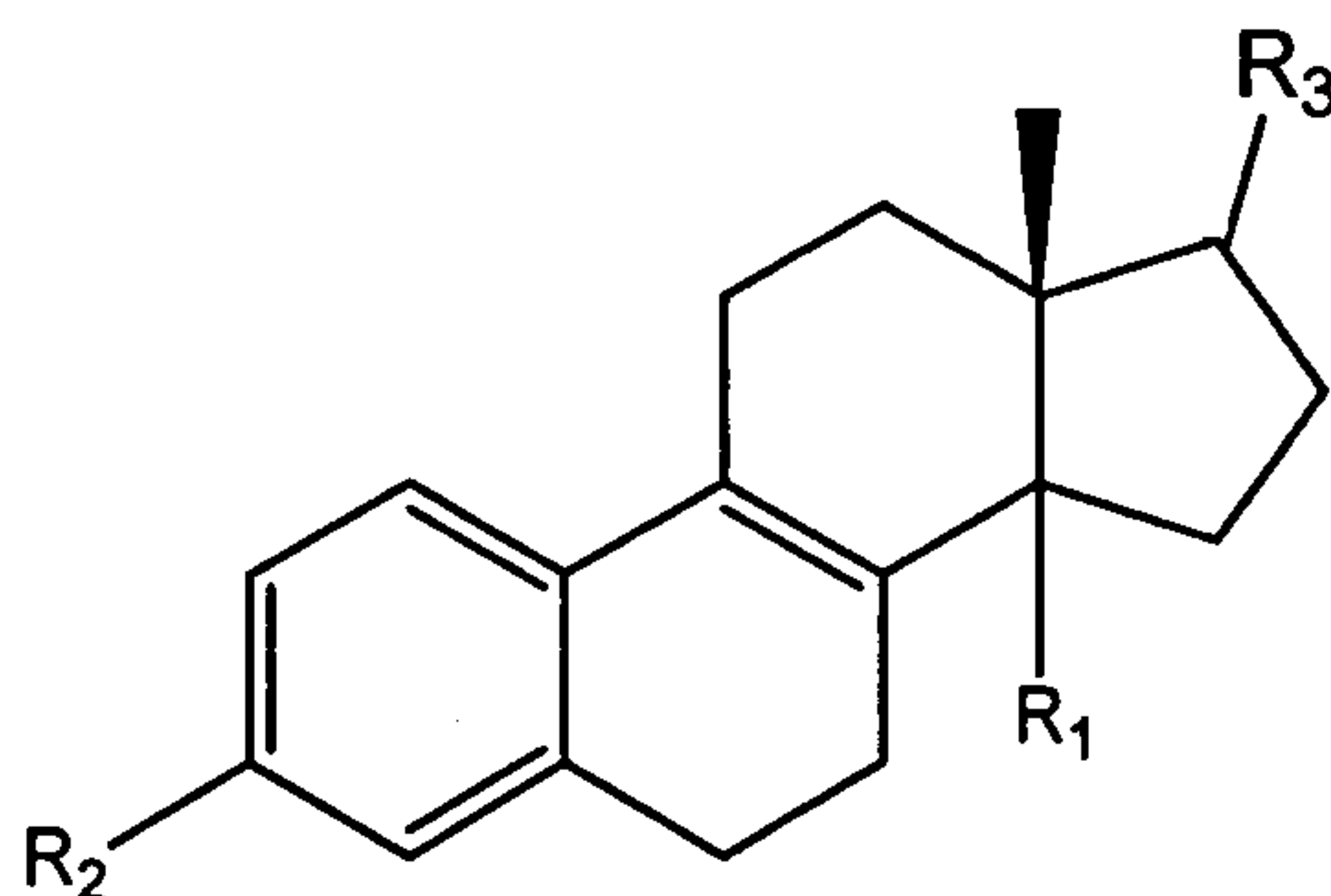
[0027] The present invention may act as an agonist, partial agonist or antagonist. The term "antagonist" may be generally defined as a substance that tends to nullify the action of another, *i.e.*, as a drug that binds to a cell receptor without eliciting a biological response. The term "agonist" is known in the art, and, as used herein, generally refers to a drug that has affinity for and stimulates physiologic activity at cell receptors normally stimulated by naturally occurring substances, thus triggering a biochemical response. A "partial agonist" may itself cause agonist effects, but because they can displace through competitive action a full agonist from its receptor, the net effect is a reduction in drug effect. As a result, a partial agonist, depending on circumstance, can act as either an agonist or an antagonist.

[0028] In one embodiment of the present invention, the estrogenic composition of the invention may include at least one additional pharmaceutically active ingredient, including, but are not limited to, androgens, progestins, calcium salts, and vitamin D and its derivatives such as calcitriol, and mixtures and blends thereof.

[0029] Pharmaceutically acceptable salts, solvates, hydrates, and polymorphs may be formed of any of the active ingredients employed in the estrogenic composition of the invention. The invention also encompasses embodiments in which the composition defined herein is included in various quantities in combination with known pharmaceutically accepted formulations. For example, the composition of matter of the invention may be incorporated into various known estrogen-containing drug products such as, Premarin* made commercially available by Wyeth-Ayerst Laboratories of Philadelphia, PA. The composition of matter of the invention may also be employed as part of a continuous estrogen-progestogen therapy regimen such as that described by U.S. Pat. No. Re. 36,247 to Plunkett et al. and is present commercially as Prempro* and Premphase* made available by Wyeth-Ayerst Laboratories.

[0030] Various estrogen-containing samples may be evaluated by LC-MS and accurate mass analyses and UV spectra. In general, certain peaks are first characterized by mass spectrometric response (nominal mass) during LC-MS. Such peaks are then analyzed by direct infusion, and high-resolution electrospray mass spectrometry in order to attempt to obtain accurate mass measurements.

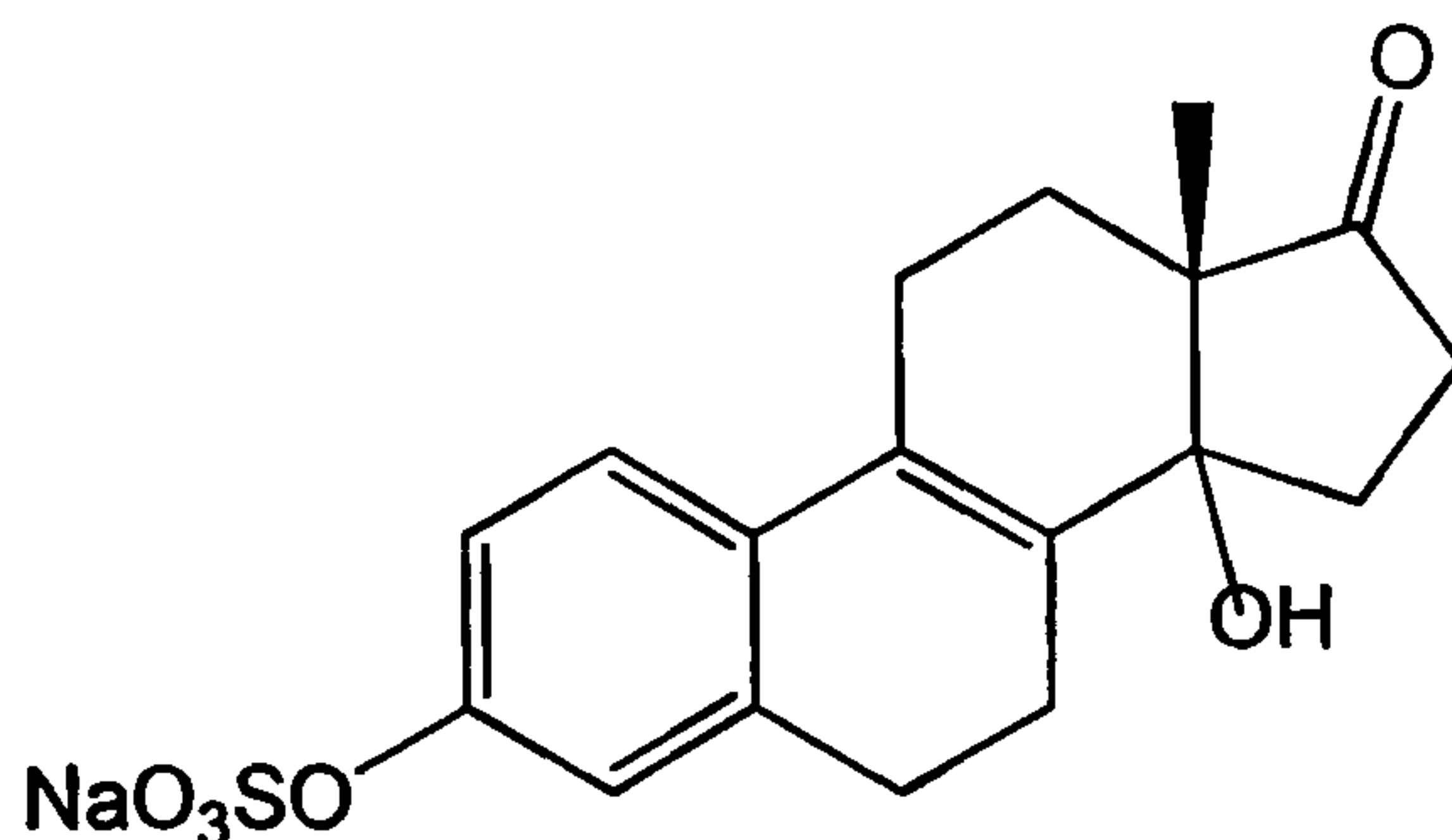
[0031] In one aspect of the present invention, a compound represented by Formula I is provided.



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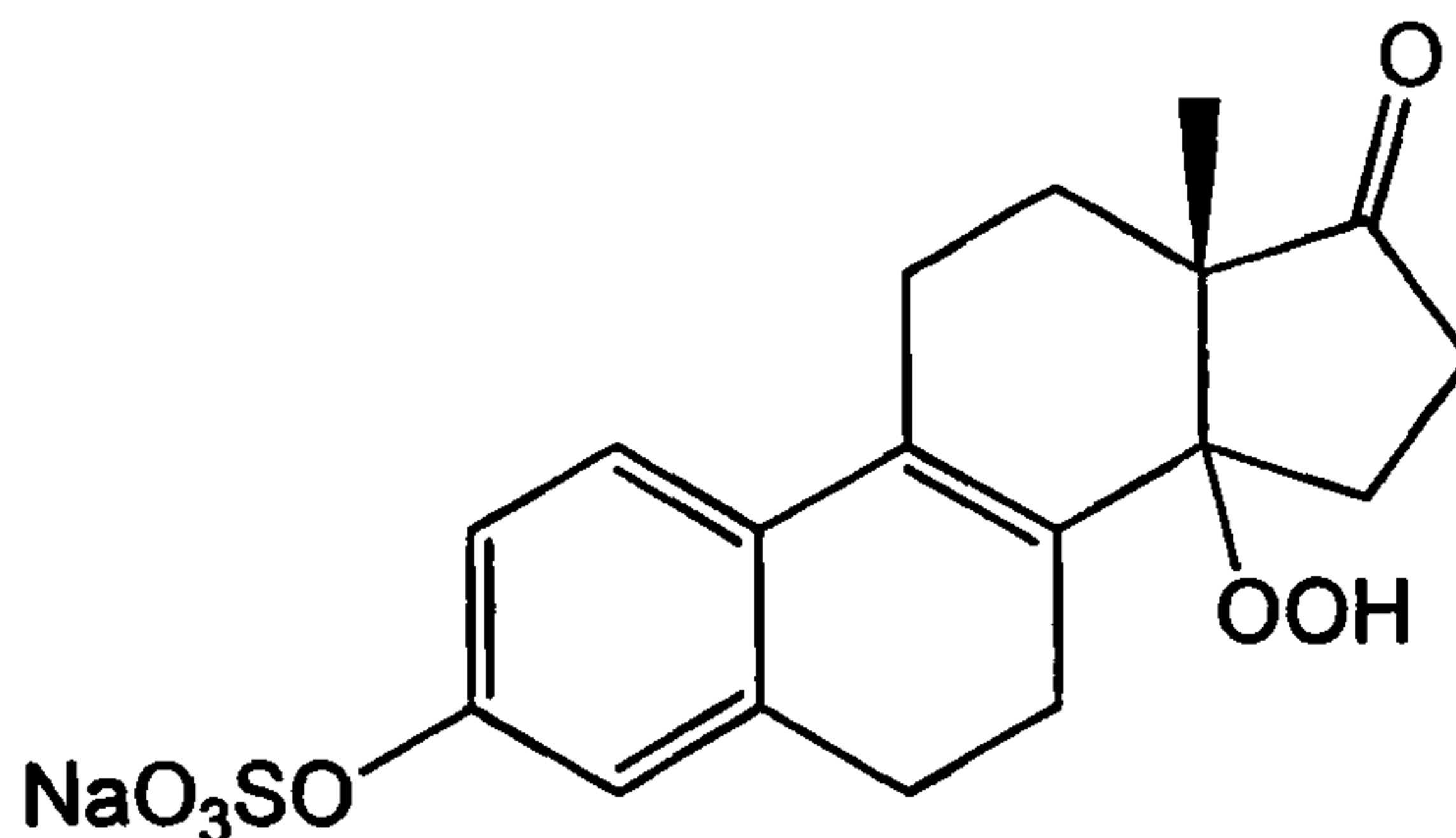
[0032] wherein R_1 is selected from the group consisting of peroxy, hydroxy, halogen, and thiol groups, ester, R_2 is selected from the group of glucuronide, sulfate, phosphate, pyrophosphate and thiol, and R_3 is selected from the group consisting of hydroxy, O-acyl, and oxo. The compound represented by Formula I is preferably greater than about 99% pure. The base compound, wherein R_1 is hydrogen and R_2 is sulphate, has the chemical compound $C_{18}H_{19}NaO_5S$, a mass of 370.41 amu and is known as $\Delta^{8,9}$ -Dehydroestrone Sodium Sulfate.

10 [0033] A preferred compound is illustrated in Formula II (referred to herein as Compound "C"):



wherein the above compound has the name 14-hydroxy- $\Delta^{8,9}$ -Dehydroestrone Sodium Sulfate with the formula $C_{18}H_{19}NaO_6S$ and has a mass of approximately 386.41 amu.

[0034] Another preferred compound is illustrated in Formula III (referred to herein as Compound "E"):



20 [0035] wherein the above compound has the name 14-hydroperoxy- $\Delta^{8,9}$ -Dehydroestrone Sodium Sulfate with the formula $C_{18}H_{19}NaO_7S$ and has a mass of approximately 402.41 amu. Compounds of the present invention may

be present in a conjugated form, wherein the most preferred conjugate is sulfate.

[0036] Compounds of the present invention may also be present as various pharmaceutically acceptable salts including salts of the conjugated compound. The salts may be various salts understood by those skilled in the art, including, but not limited to, sodium salts, calcium salts, magnesium salts, lithium salts, and amine salts such as piperazine salts. The most preferred salts are sodium salts.

[0037] Examples of estrogenic compounds and compositions are set forth in U.S. No. 6,855,703 (Hill et al) granted on February 15, 2005, which is commonly assigned to the present invention. Suitable estrogenic compounds include estrone, 17 α -estradiol, 17 β -estradiol, equilin, 17 α -dihydroequilin, 17 β -dihydroequilin, equilenin, 17 α -dihydroequilenin, 17 β -dihydroequilenin, $\Delta^{8,9}$ -dehydroestrone, 17- $\Delta^{8,9}$ -dehydroestradiol, 17- $\Delta^{8,9}$ -dehydroestradiol ethinyl estradiol, estradiol valerate, 6-OH equilenin, 6-OH 17- α dihydroequilenin, 6-OH 17- β dihydroequilenin, and mixtures, conjugates and salts thereof, and the estrogen ketones and their corresponding 17 α - and 17 β -hydroxy derivatives. The estrogenic compounds may also be present as conjugated estrogens. The conjugates may be various conjugates understood by those skilled in the art, including, but not limited to, sulfate and glucuronide. The most preferred estrogen conjugates are estrogen sulfates. The estrogenic compounds may also be present estrogen conjugates. In one embodiment, the estrogenic compounds are present as salts of estrogen conjugates. The salts may be various salts understood by those skilled in the art, including, but not limited to, sodium salts, calcium salts, magnesium salts, lithium salts, and piperazine salts. The most preferred salts are sodium salts. The estrogenic compounds can be derived from natural and synthetic sources.

[0038] Examples of androgens include, without limitation, methyltestosterone; fluoxymesterone; oxandrolone; oxymetholone; stanozolol; 7 α -methyl-19-nortestosterone; testosterone; testosterone cypionate; testosterone enanthate; testosterone propionate; danazol; 5 α -androstan-3 α -ol-16-one; 5 α -androstan-3 β ,16 β -diol; 5 α -androstan-3 β ,16 α -diol; and 5 α -

androstan-3 β ,17 α -diol. Examples of progestins are set forth in U.S. Patent No. Re. 36,247 to Plunkett et al. Examples include, but are not limited to, desogestrel; dydrogesterone; ethynodiol diacetate;

medroxyprogesterone acetate; levonorgestrel; medroxyprogesterone acetate; hydroxyprogesterone caproate; norethindrone; norethindrone acetate; norethynodrel; allylestrenol; 19-nortestosterone; lynoestrenol; quingestanol acetate; medrogestone; norgestrienone; dimethisterone; ethisterone; cyproterone acetate; chlormadinone acetate; megestrol acetate; norgestimate; norgestrel; desogestrel; trimegestone; gestodene; nomegestrel acetate; progesterone; 5 α -pregnan-3 β ,20 α -diol sulfate; 5 α -pregnan-3 β ,20 β -diol sulfate; 5 α -pregnan-3 β -ol-20-one; 16,5 α -pregnen-3 β -ol-20-one; and 4-pregnen-20 β -ol-3-one-20-sulfate, and pharmaceutically acceptable esters and salts thereof, and combinations of any of the foregoing.

[0039] Suitable vasodilation compounds include alpha andrenergic antagonists. Exemplary α -adrenergic compounds include phentolamine, phenoxybenzalamine, tolazoline, doxazosin, dibenamine, prazosin, prazosin hydrochloride, phenoxybenzamine and the like. Preferably, phentolamine is used and can form pharmaceutically acceptable salts with organic and inorganic acids, as described, for example, in U.S. Pat. No. 6,001,845 to Estok. Preferably phentolamine mesylate or phentolamine hydrochloride is used. Other vasodilation compounds include phosphodiesterase type 5 inhibitors (e.g., sildenafil), prostaglandin E compounds (e.g., alprostadil), thymoxamine, bromocriptine, yohimbine, papaverine, apomorphine, organic nitrates, imipramine, verapamil, naftidrofuryl, and isoxsuprine. Combinations of the various vasodilation compounds may be used.

[0040] Examples of progestins are set forth in U.S. Pat. No. Re. 36,247 to Plunkett et al. Suitable progestin compounds include desogestrel, dydrogesterone, ethynodiol diacetate, medroxyprogesterone, levonorgestrel, medroxyprogesterone acetate, hydroxyprogesterone caproate, norethindrone, norethindrone acetate, norethynodrel, allylestrenol, 19-nortestosterone, lynoestrenol, quingestanol acetate, medrogestone, norgestrienone, dimethisterone, ethisterone, cyproterone acetate, chlormadinone acetate, megestrol acetate, norgestimate, norgestrel, desogestrel, trimegestone,

gestodene, nomegestrol acetate, progesterone, 5 α -pregnan-3 β ,20 α -diol sulfate, 5 α -pregnan-3 β ,20 α -diol sulfate, 5 α -pregnan-3 β -ol-20-one, 16, 5 α -pregnen-3 β -ol-20-one, 4-pregnen-20 β -ol-3-one-20-sulfate and mixtures thereof.

[0041] Calcium salts may include, without limitation, organic acid salts of calcium such as calcium citrate, calcium lactate, calcium fumarate, calcium acetate, and calcium glycerophosphate, as well as inorganic salts such as calcium chloride, calcium phosphate, calcium sulphate, and calcium nitrate.

[0042] The present invention also encompasses pharmaceutically acceptable drug products comprising a composition of matter of the present invention and at least one
10 pharmaceutically acceptable carrier, diluent, or excipient, the selection of which are known to the skilled artisan. The drug product formulations can be in various forms such as, for example, tablets; effervescent tablets; pills; powders; elixirs; suspensions; emulsions; solutions; syrups; soft and hard gelatin capsules; transdermal patches; topical gels, creams and the like; suppositories; sterile injectable solutions; and sterile packaged powders, sublingual tablets, buccal tablets, and buccal adhesive systems.

[0043] In certain embodiments, the drug product is present in a solid pharmaceutical composition that may be suitable for oral administration. A solid estrogenic composition according to the present invention may be formed and may be mixed with an excipient, diluted by an excipient or enclosed within such
20 a carrier which can be in the form of a capsule, sachet, tablet, paper, or other container. When the excipient serves as a diluent, it may be a solid, semi-solid, or liquid material which acts as a vehicle, carrier, or medium for the composition of matter.

[0044] Various suitable excipients will be understood by those skilled in the art and may be found in the National Formulary 19, pages 2404-2406 (2000). Examples of suitable excipients include, but are not limited to, starches, gum arabic, calcium silicate, microcrystalline cellulose, methacrylates, shellac, polyvinylpyrrolidone, cellulose, water, syrup, and methylcellulose. The drug product formulations can additionally include lubricating agents such as, talc,
30 magnesium stearate and mineral oil; wetting agents; emulsifying agents; suspending agents; preserving agents such as methyl- and propyl

hydroxybenzoates; sweetening agents; and/or flavoring agents. Polyols, buffers, and inert fillers may also be used. Examples of polyols include, but are not limited to, mannitol, sorbitol, xylitol, sucrose, maltose, glucose, lactose, dextrose, and the like. Suitable buffers encompass, but are not limited to, phosphate, citrate, tartarate, succinate, and the like. Other inert fillers which may be used encompass those which are known in the art and are useful in the manufacture of various dosage forms. If desired, the solid formulations may include other components such as bulking agents and/or granulating agents, and the like. The drug products of the invention may be formulated so as to
10 provide quick, sustained, or delayed release of the active ingredient after administration to the patient by employing procedures well known in the art.

[0045] To form dosage units for oral administration, the estrogenic composition of the present invention may be mixed with a solid, pulverant carrier such as, for example, lactose, saccharose, sorbitol, mannitol, starch, amylopectin, cellulose derivatives or gelatin, as well as with an antifriction agent such as, for example, magnesium stearate, calcium stearate, and polyethylene glycol waxes. The mixture may then be pressed into tablets. Tablets for oral use are typically prepared in the following manner, although other techniques may be employed. The solid substances are ground or sieved to a desired particle size, and the binding agent is homogenized and suspended in a suitable solvent. The active ingredient and auxiliary agents are
20 mixed with the binding agent solution. The resulting mixture is moistened to form a uniform suspension. The moistening typically causes the particles to aggregate slightly, and the resulting mass is pressed through a stainless steel sieve having a desired size. The layers of the mixture are then dried in controlled drying units for a determined length of time to achieve a desired particle size and consistency. The granules of the dried mixture may then be sieved to remove any powder. To this mixture, disintegrating, antifriction, and anti-adhesive agents may be added. Finally, the mixture is pressed into tablets using a machine with the appropriate punches and dies to obtain the desired tablet size. The operating parameters of the machine may be selected by the skilled artisan.

[0046] If coated tablets are desired, the above prepared core may be coated with a concentrated solution of sugar, which may contain gum arabic, gelatin, talc, titanium dioxide, or
30 with a lacquer dissolved in volatile organic solvent or mixture of solvents. To this coating various dyes may be added in order to distinguish among tablets with different active

compounds or with different amounts of the active compound present. In a particular embodiment, the active ingredient may be present in a core surrounded by one or more layers including an enteric coating layers.

[0047] Soft gelatin capsules may be prepared in which capsules contain a mixture of the active ingredient and vegetable oil. Hard gelatin capsules may contain granules of the active ingredient in combination with a solid, pulverulent carrier, such as, for example, lactose, saccharose, sorbitol, mannitol, potato starch, corn starch, amylopectin, cellulose derivatives, or gelatin.

[0048] In one preferred embodiment, the formulation is in the form of orally-administered tablets which contain the estrogenic composition of the present invention as set
10 forth herein along with the following inactive ingredients: calcium phosphate tribasic, calcium sulfate, carnauba wax, cellulose, glyceryl monooleate, lactose, magnesium stearate, methylcellulose, pharmaceutical glaze, polyethylene glycol, stearic acid, sucrose, and titanium dioxide. Such ingredients may be present in amounts similar to those present in Premarin^{*} (conjugated estrogens tablets, USP) made commercially available by Wyeth-Ayerst Laboratories of Philadelphia, Pennsylvania. Tablets employing the active ingredients of the invention may contain excipients similar to those contained in the 0.3 mg., 0.625 mg., and 1.25 mg tablets of Premarin^{*} (conjugated estrogens tablets, USP).

[0049] Liquid preparations for oral administration may be prepared in the form of syrups or suspensions, e.g., solutions containing an active ingredient, sugar, and a mixture of ethanol, water, glycerol, and propylene glycol. If desired, such liquid preparations may contain coloring
20 agents, flavoring agents, and saccharin. Thickening agents such as carboxymethylcellulose may also be used.

[0050] In the event that the above formulations are to be used for parenteral administration, such a formulation may comprise sterile aqueous injection solutions, non-aqueous injection solutions, or both comprising the estrogenic composition of the present invention. When aqueous injection solutions are prepared, the estrogenic composition may be present as a water soluble pharmaceutically acceptable salt. Parenteral preparations may contain anti-oxidants, buffers, bacteriostats, and solutes which render the formulation isotonic with the blood of the intended recipient. Aqueous and non-aqueous sterile suspensions may include suspending agents and thickening agents. The formulations may be presented in unit-dose or multi-dose containers, for example sealed ampules and vials. Extemporaneous injection
30 solutions and suspensions may be prepared from sterile powders, granules and tablets of the kind

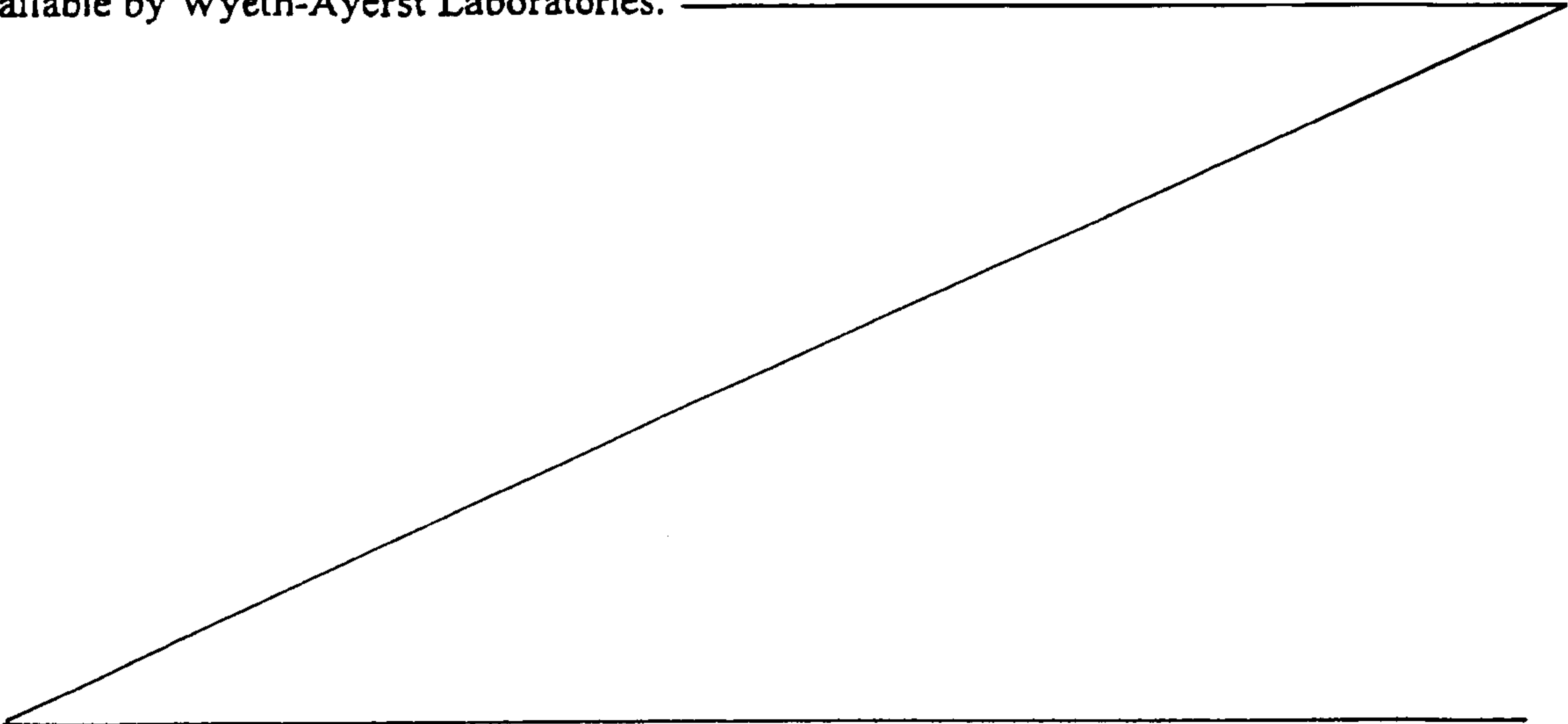
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previously described.

[0051] In a specific embodiment, the drug product of the present invention is in the form of an injectable solution containing a predetermined amount (e.g., 25 mg) of the estrogenic composition in a sterile lyophilized cake which also contains lactose, sodium citrate, and simethicone. The pH of a solution containing the above ingredients may be adjusted using a suitable buffer (e.g., sodium hydroxide or hydrochloric acid). Reconstitution may be carried out according to known methods, e.g., using a sterile diluent (5 mL) containing 2 percent benzyl alcohol in sterile water. A preferred injectable solution is similar to Premarin^{*} Intravenous made commercially available by Wyeth-Ayerst Laboratories.

[0052] The estrogenic composition also may be formulated such that it is suitable for
10 topical administration (e.g., vaginal cream). These formulations may contain various excipients known to those skilled in the art. Suitable excipients may include, but are not limited to, cetyl esters wax, cetyl alcohol, white wax, glyceryl monostearate, propylene glycol, monostearate, methyl stearate, benzyl alcohol, sodium lauryl sulfate, glycerin, mineral oil, water, carbomer, ethyl alcohol, acrylate adhesives, polyisobutylene adhesives, and silicone adhesives.

[0053] In a preferred embodiment, the drug product is in the form of a vaginal cream containing the estrogenic composition as set forth herein present in a nonliquefying base. The nonliquefying base may contain various inactive ingredients such as, for example, cetyl esters wax, cetyl alcohol, white wax, glyceryl monostearate, propylene glycol, monostearate, methyl stearate, benzyl alcohol, sodium lauryl sulfate, glycerin, and mineral oil. Such
20 composition may be formulated similar to Premarin^{*} Vaginal Cream made commercially available by Wyeth-Ayerst Laboratories.



***Trademarks**

[0054] Dosage units for rectal administration may be prepared in the form of suppositories which may contain the estrogenic composition in a mixture with a neutral fat base, or they may be prepared in the form of gelatin-rectal capsules which contain the active substance in a mixture with a vegetable oil or paraffin oil.

[0055] In another aspect, the present invention relates to methods of treating mammals (e.g., man) in need of treatment for estrogen deprivation. These include the symptoms of hot flashes, dryness of the vagina, loss of bone mass, increased heart disease and the like. The methods include administering an effective amount of an estrogenic composition as defined herein to a mammal. The methods may be used for a number of treatments such as, but not limited to, vasomotor symptoms; atrophic vaginitis; osteoporosis; hypoestrogenism due to hypogonadism, castration, or primary ovarian failure; breast cancer in selected persons with metastatic disease; advanced androgen-dependent carcinoma of the prostate, abnormal uterine bleeding, and kraurosis vulvae. The administration may be cyclic, occurring for one or more short periods of time or courses of treatment (i.e. short-term use). Alternatively, the administration may be continuous, occurring over extended periods of time (i.e. long-term use). One example of long-term use would be from the onset of menopause until death. Cyclic and continuous administration may be either uninterrupted or interrupted. Uninterrupted administration occurs one or more times daily such that there is no break in treatment. Interrupted administration occurs other than daily, for example one or more times every other day.

[0056] In another aspect, the invention relates to a method of synthesizing an estrogenic composition. The method comprises subjecting an estrogenic composition comprising at least one estrogenic compound to thermal energy of high humidity that promotes the generation of at least one additional estrogenic compound in a final estrogenic composition that was not present in the initial estrogenic composition. The high humidity may be retained at 50% to 90% relative humidity. Additionally, the temperature during the synthesis step may be maintained between 30° to 60°C.

[0057] The present invention is explained in greater detail in the Examples that follow. These examples are intended as illustrative of the invention and are not to be taken as limiting thereof.

[0058] Examples

[0059] The present invention will now be described in greater detail with respect to the following numbered examples. In the examples, "mL" means milliliter, "°C" means degrees

Celcius, "mM" means millimoles/liter, "M" means moles/liter, "Å" means angstrom, "µm" means micrometer, "nm" means nanometer, "mm" means millimeter, "mg" means milligram, and "m/z" means mass to charge ratio. These examples are for illustrating the invention and are not intended to limit the invention as set forth by the claims.

[0060] A list of instruments and equipment employed in the examples are as follows:

1. HPLC Chromatographic Procedures
 - a. Analytical scale chromatographic system
 1. HP1100 Diode-array detector
 2. HP1100 Quaternary HPLC pump
 3. HP1100 Thermostatically controlled column compartment
2. Fraction Collection, Purification, and Crystallization
 - a. ISCO Foxy Jr., Fraction Collector
 - b. Büchi, Model R-124 rotary evaporator
3. Mass Spectral Analyses
 - a. Liquid Chromatography (LC-MS)
 1. Instrument: Sciex Q-Star/Pulsar: quadrupole-tof
 2. Mode: Negative ionization
 3. Solvent: LC Matrix
 - b. High Resolution Mass Spectrometer (HR-MS)
 1. Instrument: Sciex Q-Star/Pulsar: quadrupole-tof
 2. Sample input: Nanospray needle
 3. Solvent: Methanol
 4. Matrix: PEG 300 & PEG 400
- B. Chemicals, Reagents, and Analytical Materials
 1. Chemicals and Reagents
 - a. Acetonitrile (ACN), HPLC grade
 - b. Methanol (MeOH), HPLC grade
 - c. Milli-Q water
 - d. Ammonium acetate, AR grade
 - e. Glacial Acetic Acid, USP grade
 - f. Nitrogen gas, zero grade

[0061] Example 1

[0062] Synthesis Utilizing $\Delta^{8,9}$ -dehydroestrone sulfate

[0063] 500 mg of $\Delta^{8,9}$ -dehydroestrone sulfate is placed into a glass petri dish with the top loosely attached. This is then placed into a chamber set at 40°C and 75% RH for 20 hrs. Upon removal the sample is chromatographed as given in Example 2. Individual components are then fraction collected and brought to dryness in a roto-evaporator.

[0064] Example 2**[0065] HPLC Chromatographic Separation with UV DAD detection**

[0066] An Agilent*1100 system consisting of a gradient pump, auto sampler, column heater, and UV DAD, was employed as the chromatographic system. Two mobile phases were employed in gradient mode as follows:

[0067] Mobile phase A containing 10mM ammonium acetate and acetonitrile: water in a 12:88 ratio can be prepared as follows by combining 120 mL acetonitrile, 880 mL water and 10 mL 1M ammonium acetate buffer. The ammonium acetate buffer may be prepared by dissolving approximately 7.7 mg of NH_4 acetate into 90 ml of water and adjusting the combination to a pH of 6.0 by adding in glacial acetic acid. The solution may then be
10 transferred into a 100 mL flask and dilute with H_2O .

[0068] Mobile phase B containing 10mM ammonium acetate and acetonitrile: water in a 60:40 ratio can be prepared as follows by combining 600 mL acetonitrile, 400 mL water and 10 mL 1M ammonium acetate buffer.

[0069] The gradient elution was performed by starting at 0% B and raising to 51% B in 30 minutes with a 0.83ml/min flow rate. A YMC ODS-A C_{18} 4.6 x 150 mm column was used at a temperature of 25°C. UV detection was performed using the DAD set to 220 nm and collecting UV spectral information from 200-400 nm. The sample is prepared by dissolving a suitable amount of sample in mobile phase A and injecting a suitable volume. Fig. 1 illustrates a UV chromatogram and diode array UV spectra of components C, D, E and $\Delta^{8,9}$ -dehydroestrone sulfate.

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[0070] Example 3**[0071] HPLC Chromatographic Separation with MS detection**

[0072] An Agilent 1100 system consisting of a gradient pump, autosampler, column heater, and UV variable wavelength detector, was employed as the chromatographic system. MS detection is achieved using a Sciex* Q-Star/Pulsar quadrupole time of flight mass spectrometer operating in the negative ion electrospray ionization mode.

[0073] Two mobile phases were employed in gradient mode as follows:

1) Mobile phase A containing 10mM ammonium acetate and acetonitrile: water in a 12:88 ratio can be prepared as follows by combining 120 mL acetonitrile, 880 mL water and 10 mL 1M ammonium acetate buffer, as described
30 in the previous example; and

***Trademarks**

2) Mobile phase B containing 10mM ammonium acetate and acetonitrile: water in a 60:40 ratio can be prepared as follows by combining 600 mL acetonitrile, 400 mL water and 10 mL 1M ammonium acetate buffer.

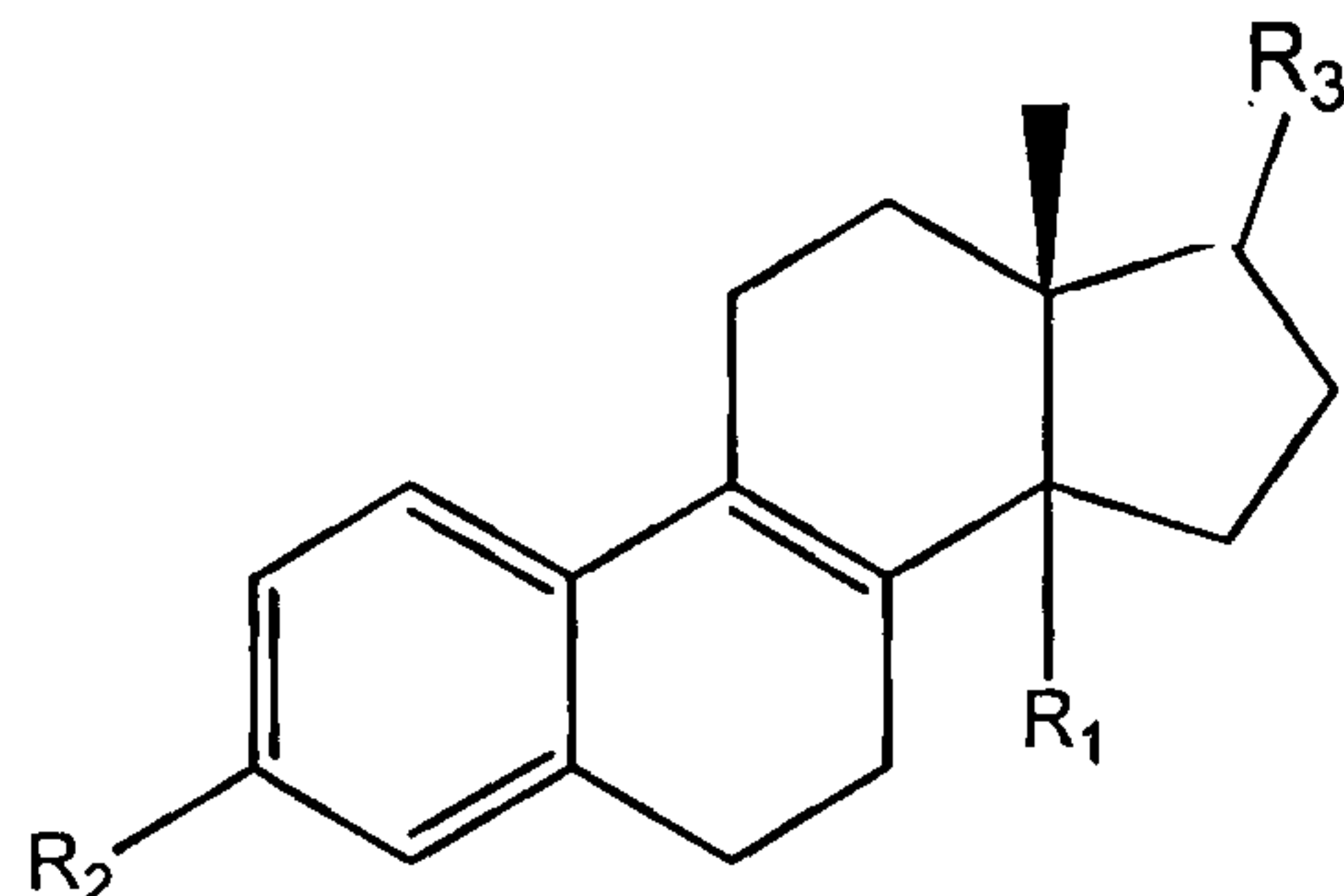
[0074] The gradient elution was performed by starting at 0% B and raising to 51% B in 30 minutes with a 0.83ml/min flow rate. A YMC ODS-A C₁₈ 4.6 x 150 mm column was used at a temperature of 25°C. UV detection was performed using the variable wavelength detector set to 220 nm. The sample is prepared by dissolving a suitable amount of sample in mobile phase A and injecting a suitable volume. Fig. 1 illustrates a UV chromatogram and FIGs 3-8 illustrate MS spectra and single ion traces of components C, D and E. Fractions of components C, D and E were collected from the HPLC separation and dried under a stream of nitrogen. The fraction were then analyzed by HR ESI-MS to produce accurate masses, which were then used to predict the most probable empirical formulas.

[0075]	<u>Component accurate mass (amu) EF</u>		
C	363.0889	C ₁₈ H ₁₉ O ₆ S	
D	448.1459	C ₂₂ H ₂₆ N ₇ O ₇ S	
E	379.0851	C ₁₈ H ₁₉ O ₇ S	

[0076] The present invention has been described herein with reference to its preferred embodiments. These embodiments do not serve to limit the invention, but are set forth for illustrative purposes. The scope of the invention was defined by the claims that follow.

WHAT IS CLAIMED IS:

1. A compound comprising the formula



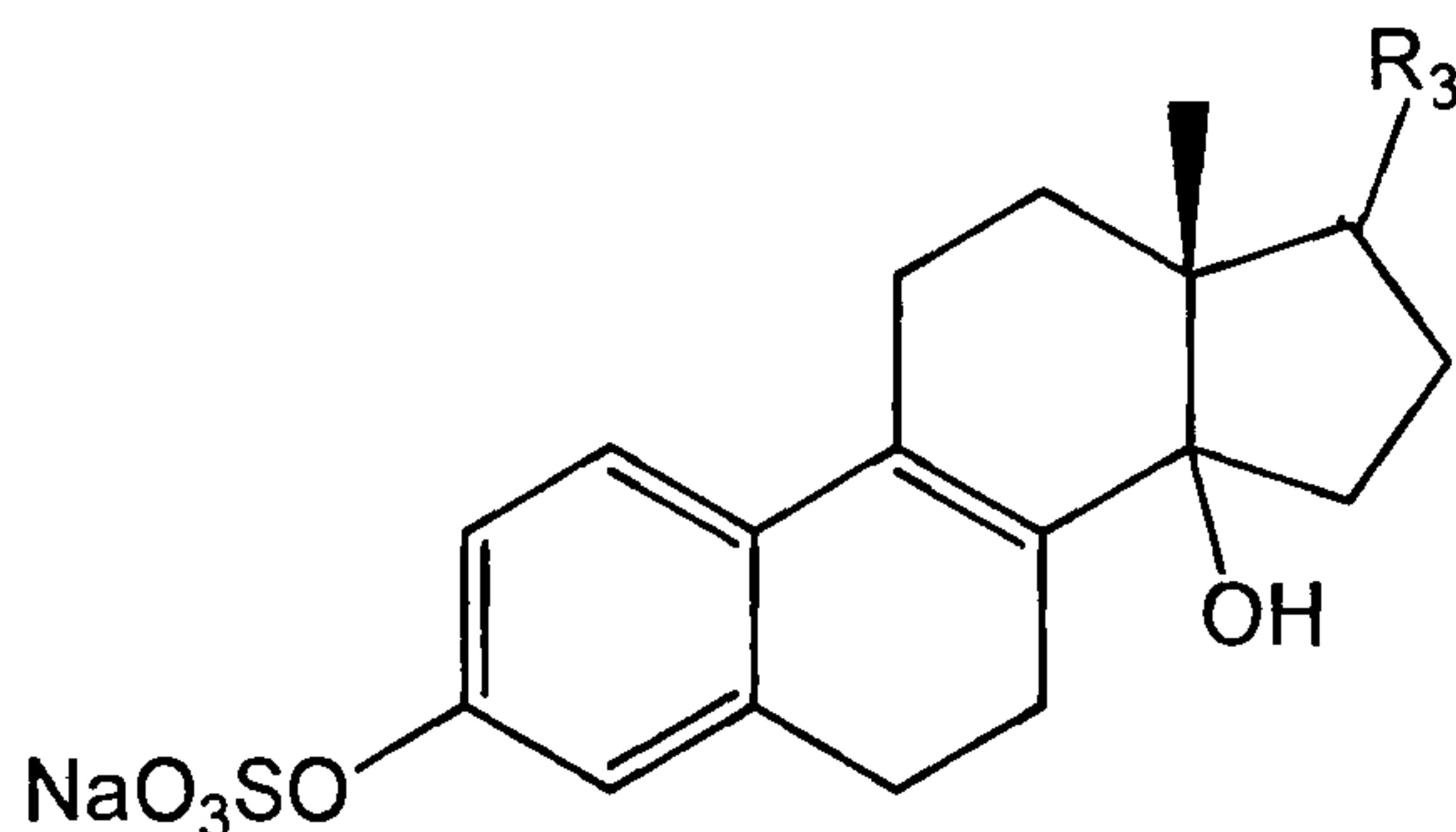
wherein R₁ is selected from the group consisting of peroxy, hydroxy, halogen, and thiol;

R₂ is selected from the group of glucuronide, sulfate, phosphate, pyrophosphate and thiol; and

R₃ is selected from the group consisting of hydroxy, O-acyl, and oxo; or a pharmaceutically acceptable salt of said compound.

10

2. The compound of claim 1, wherein said compound is:



with R₃ is as defined in claim 1,

or a pharmaceutically acceptable salt thereof.

3. The compound of claim 2, wherein said compound has a chromatographic retention time of 16 to 17.5 minutes, wherein said retention time is measured with:

- a mobile phase A containing 10 mM ammonium acetate and a acetonitrile : water mixture in a 12:88 ratio;

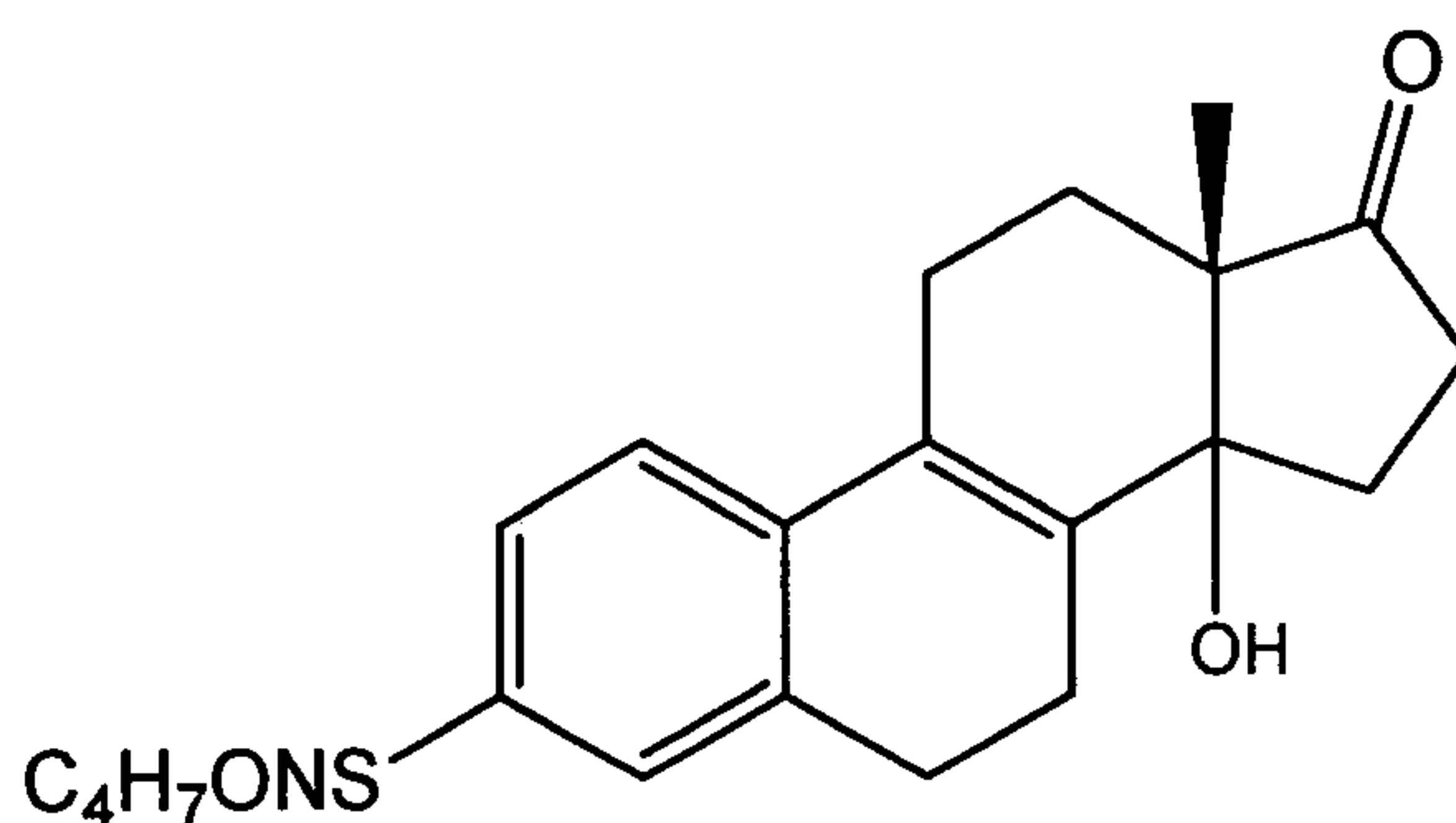
- a mobile phase B containing 10 mM ammonium acetate and a acetonitrile : water mixture in a 60:40 ratio;
- a gradient elution performed by starting at 0% of mobile phase B and raising to 51% of mobile phase B in 30 minutes with a 0.83 ml/min flow rate on a YMC ODS-A C₁₈ 4/6 x 150 mm column at 25°C, and
- a UV detection performed using a DAD set to 220 nm and collecting UV spectral information from 200 to 400 nm.

4. The compound of claim 2, wherein R₃ is oxygen, having the
10 characteristics:

Mass spectrum: M/Z 363.09 (M⁺) in the mass spectrum using ESI-MS.

5. The compound of claim 2, wherein said compound has a UV spectrum as defined in FIG. 1B.

6. The compound of claim 1, wherein said compound is:



or a pharmaceutically acceptable salt thereof, wherein said compound has a chromatographic retention time of 17.6 to 19 minutes, wherein said retention time is measured with:

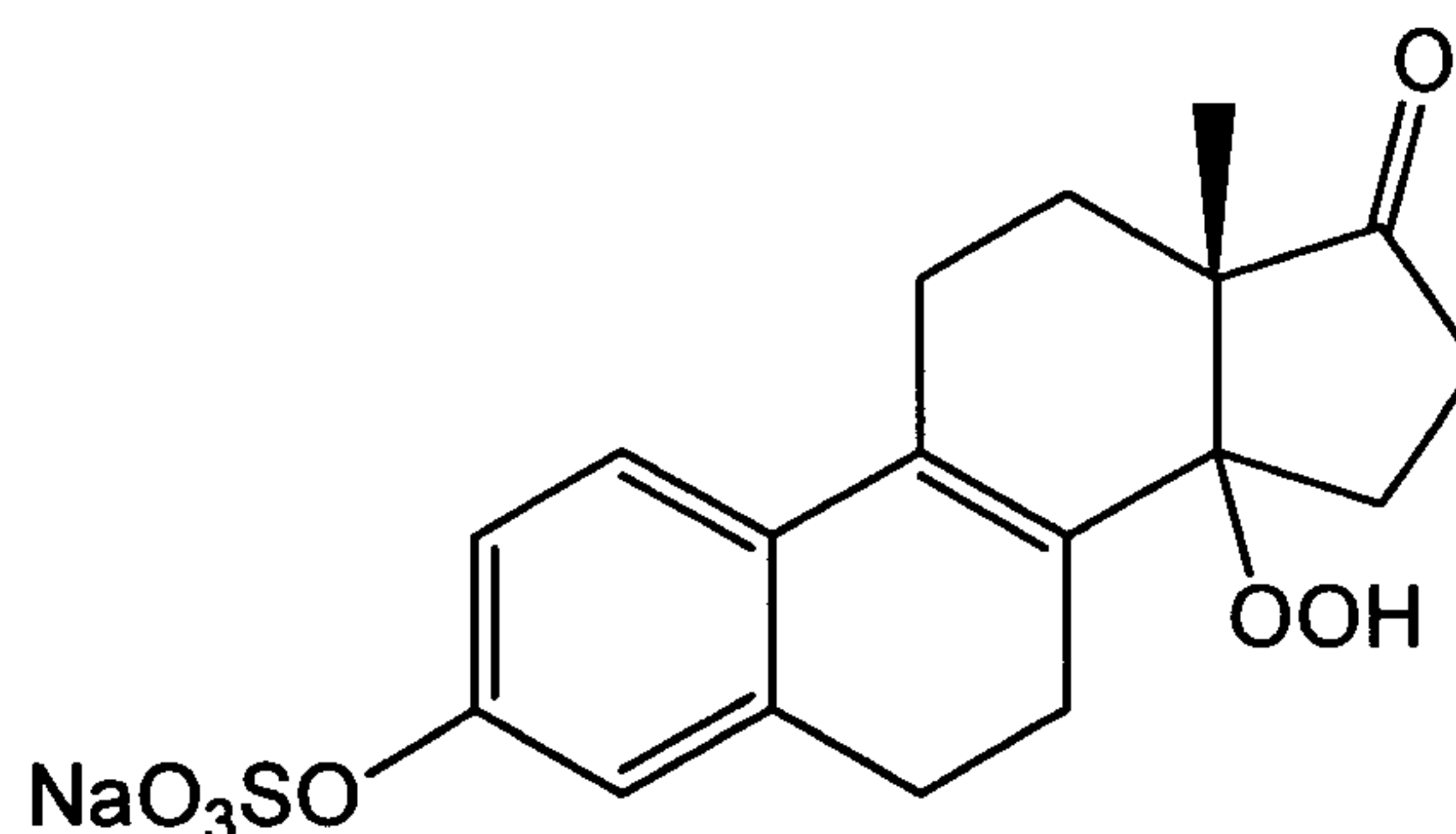
- 20
- a mobile phase A containing 10 mM ammonium acetate and a acetonitrile : water mixture in a 12:88 ratio;
 - a mobile phase B containing 10 mM ammonium acetate and a acetonitrile : water mixture in a 60:40 ratio;

- a gradient elution performed by starting at 0% of mobile phase B and raising to 51% of mobile phase B in 30 minutes with a 0.83 ml/min flow rate on a YMC ODS-A C₁₈ 4/6 x 150 mm column at 25°C, and
- a UV detection performed using a DAD set to 220 nm and collecting UV spectral information from 200 to 400 nm.

7. The compound of claim 6, having
- a mass spectrum: M/Z 448.14 (M⁺) in the mass spectrum using ESI-MS.

- 10 8. The compound of claim 6, wherein said compound has a UV spectrum as defined in FIG. 1C.

9. The compound of claim 1, wherein said compound is:



or a pharmaceutically acceptable salt thereof.

10. The compound of claim 9, wherein said compound has a chromatographic retention time of 19.5 to 21 minutes, when said retention time is measured with:

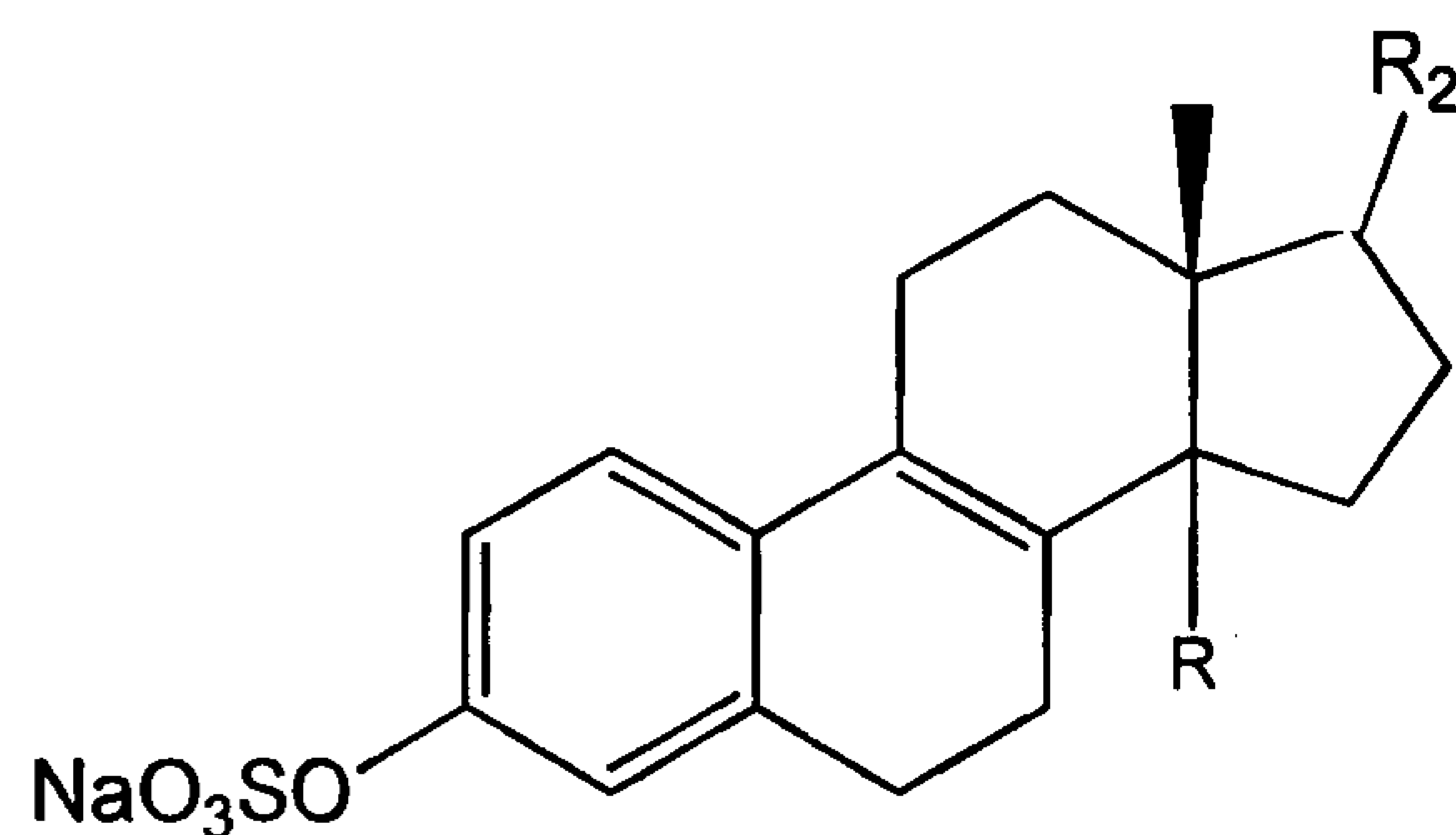
- a mobile phase A containing 10 mM ammonium acetate and a acetonitrile : water mixture in a 12:88 ratio;
- a mobile phase B containing 10 mM ammonium acetate and a acetonitrile : water mixture in a 60:40 ratio;

- a gradient elution performed by starting at 0% of mobile phase B and raising to 51% of mobile phase B in 30 minutes with a 0.83 ml/min flow rate on a YMC ODS-A C₁₈ 4/6 x 150 mm column at 25°C, and
- a UV detection performed using a DAD set to 220 nm and collecting UV spectral information from 200 to 400 nm.

11. The compound of claim 9, having
- a mass spectrum: M/Z 379.09 (M⁺) in the mass spectrum using ESI-MS.

- 10 12. The compound of claim 9, wherein said compound has a UV spectrum as defined in FIG. 1D.

13. Use of a compound in the manufacture of a medicament for the treatment of estrogen deprivation comprising the formula:



wherein R is selected from the group consisting of peroxy, hydroxy, halogen, and thiol; and

R₂ is selected from the group consisting of hydroxy, O-acyl, and oxo, or a pharmaceutically acceptable salt thereof.

14. The use in the manufacture of a medicament for the treatment of
 20 estrogen deprivation according to claim 13, wherein said compound is 14-hydroxy- $\Delta^{8,9}$ -dehydroestrone sodium sulfate.

15. The use according to claim 13, wherein said compound is 14-hydroperoxy- $\Delta^{8,9}$ -dehydroestrone sodium sulfate.

16. A method of synthesizing an estrogenic composition, said method comprising:

subjecting an estrogenic composition comprising at least one estrogenic compound to thermal energy and high humidity that promotes the generation of at least one additional estrogenic compound in a final estrogenic composition that was not present in the initial estrogenic composition.

17. The method according to claim 16, wherein the composition is
10 maintained at a temperature between 30° to 60° C.

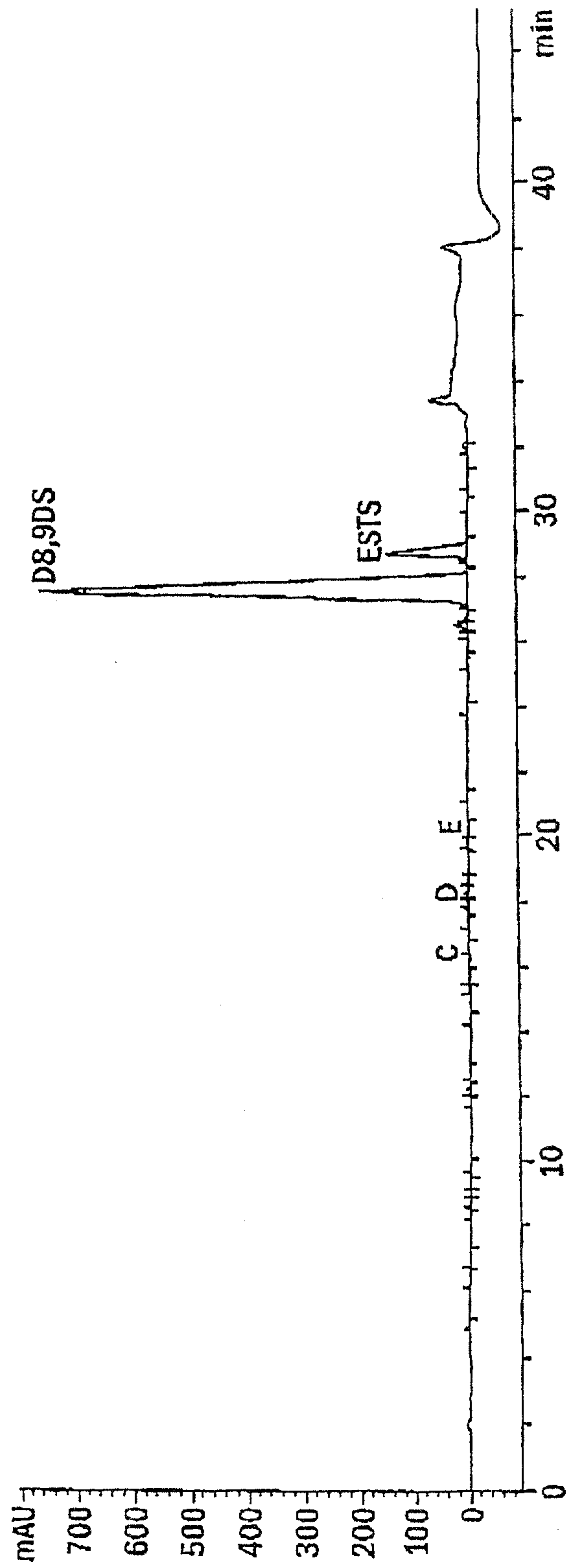
18. The method according to claim 16, wherein the composition is kept at 50% to 90% relative humidity.

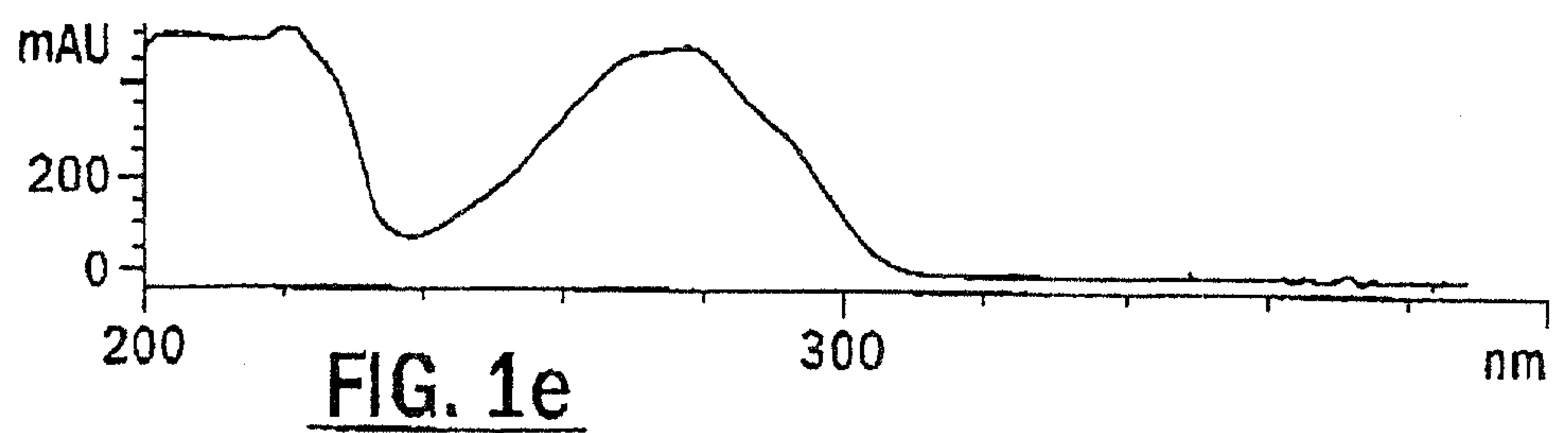
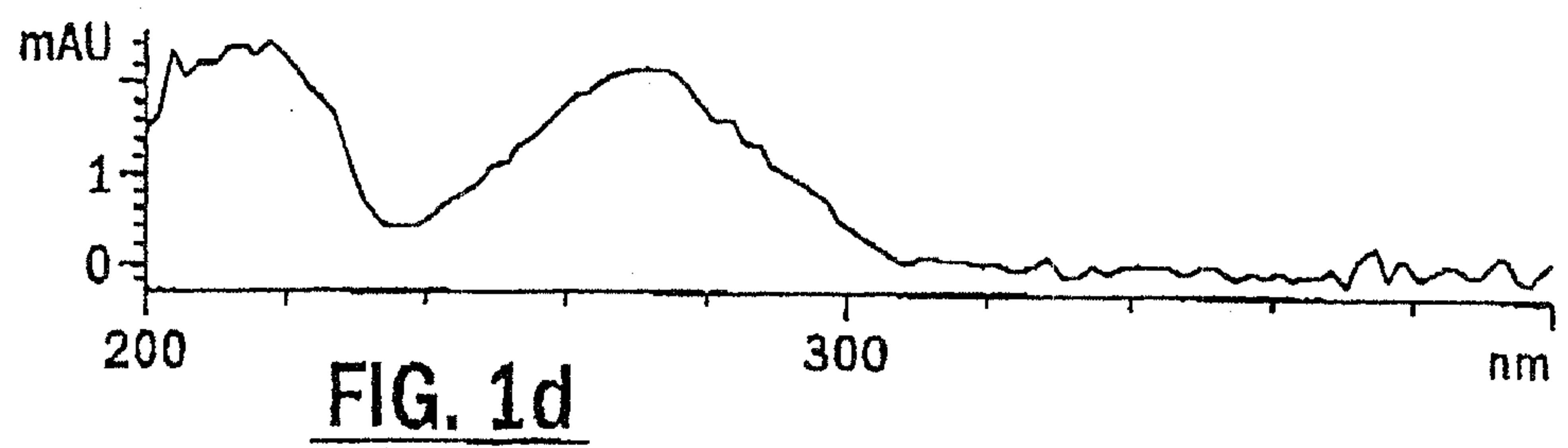
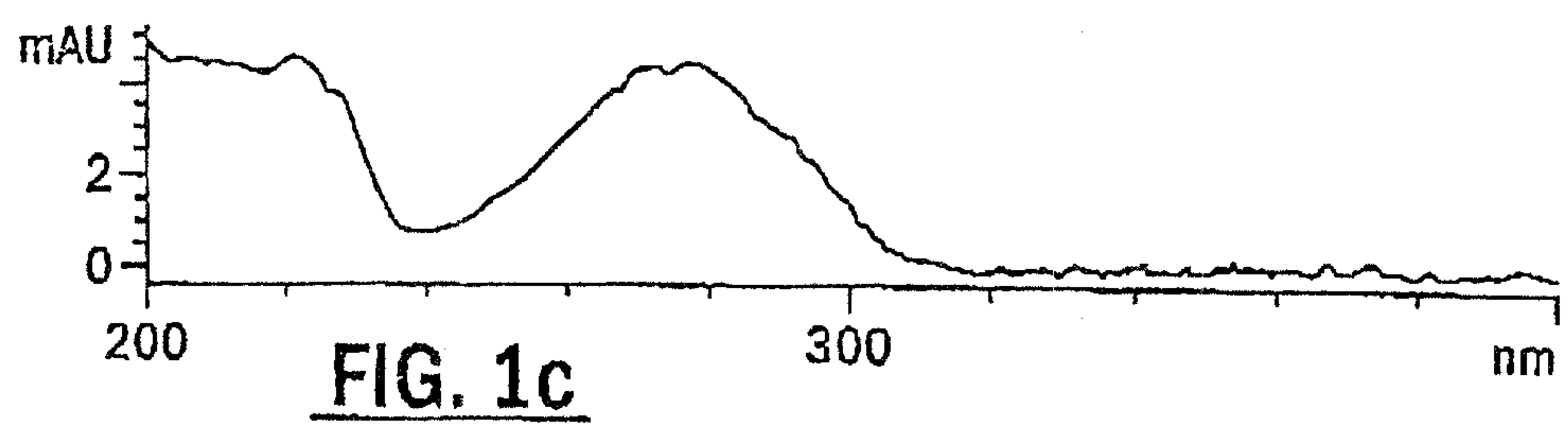
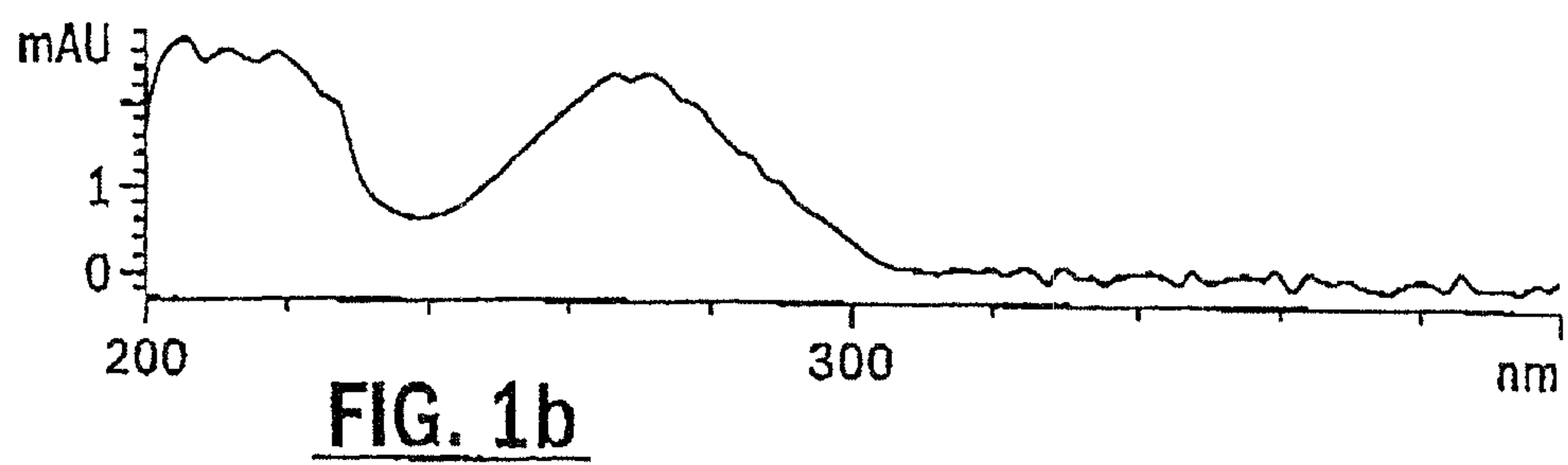
19. The method according to claim 16, wherein said subjecting step is carried out from about 3 to about 72 hours.

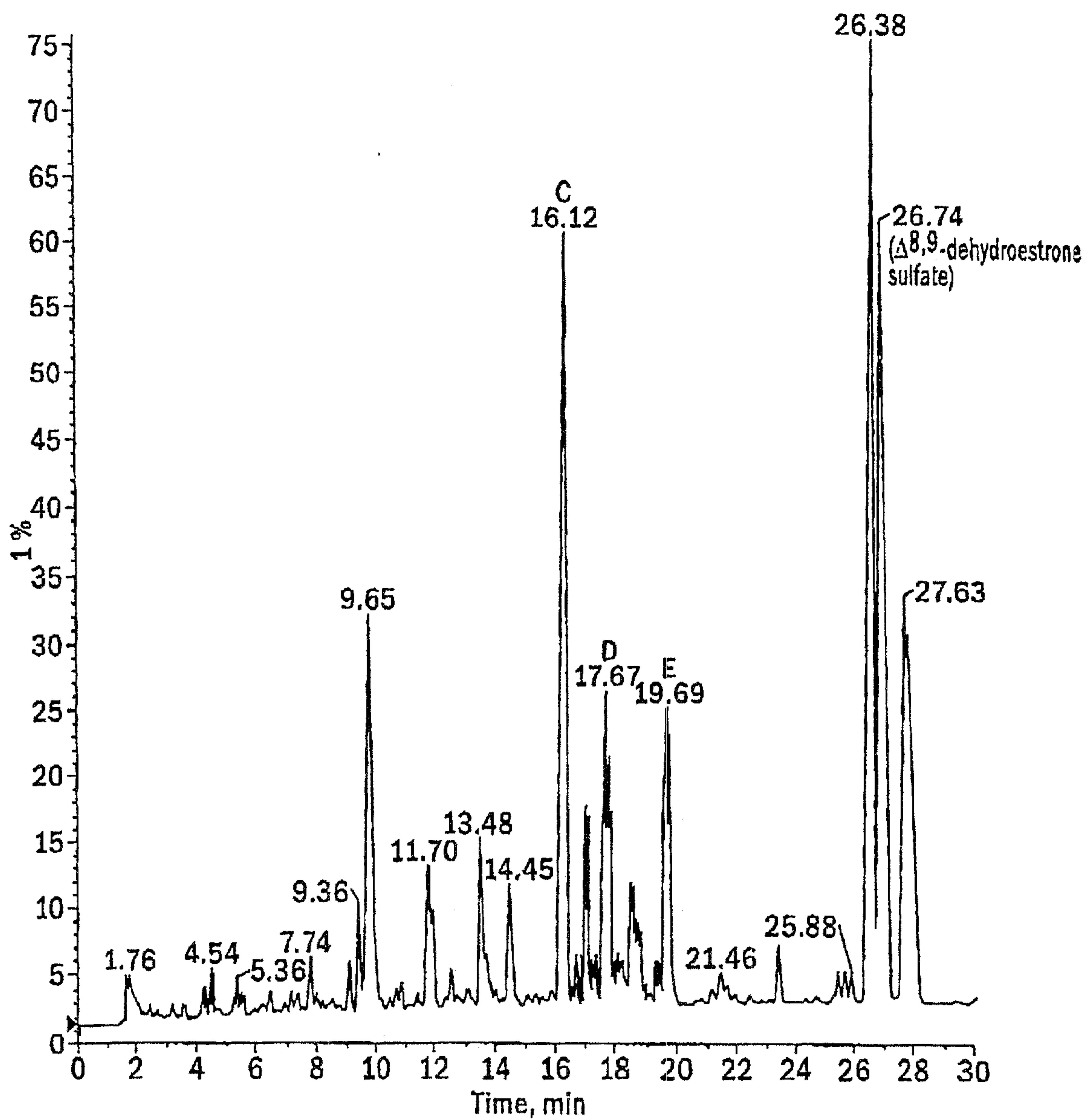
20. The method according to claim 16, wherein the estrogenic composition comprises a conjugated estrogen selected from the group consisting of a sulfate of an estrogen, a glucuronide of an estrogen, and mixtures thereof.

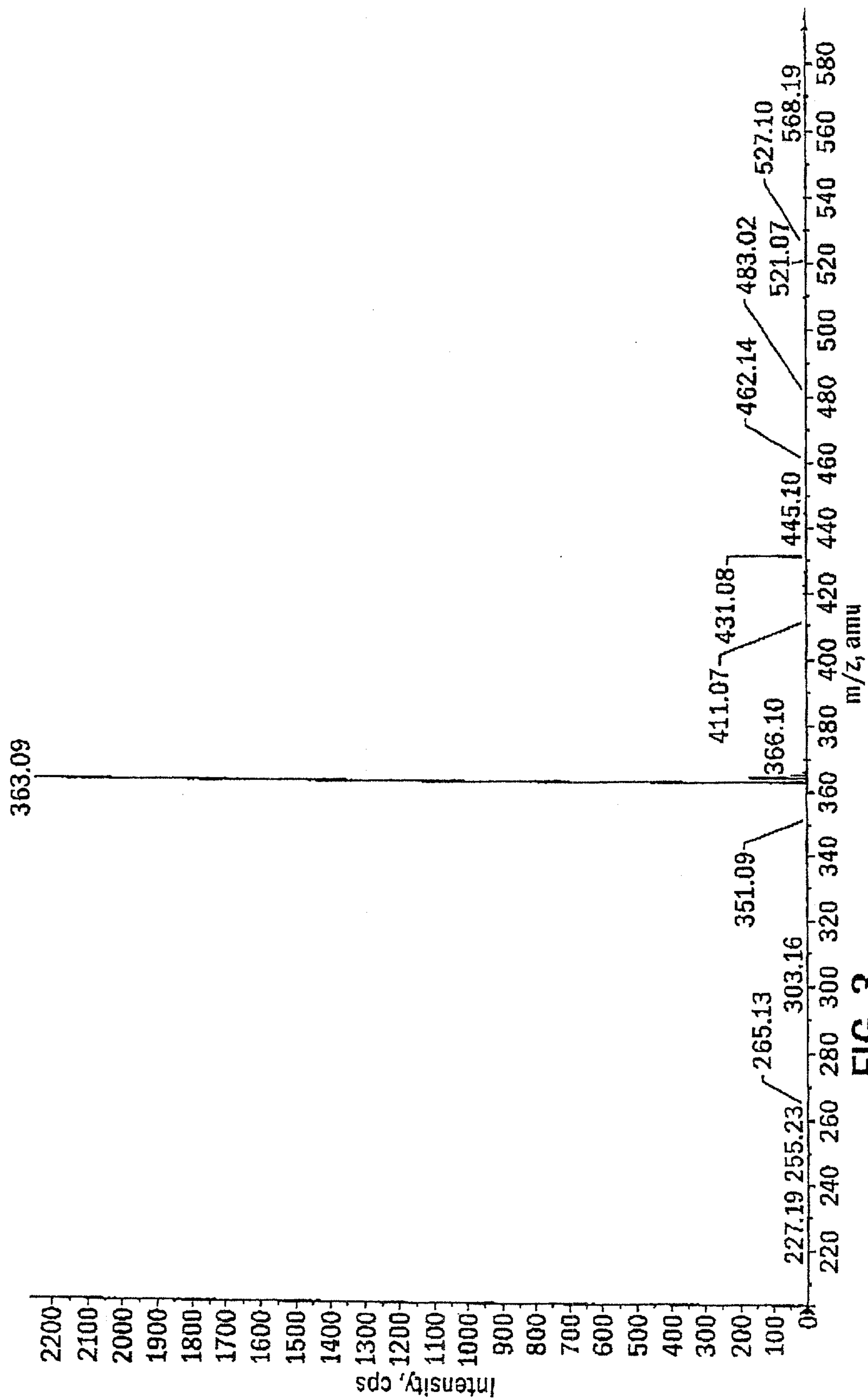
21. The method according to Claim 20, wherein the estrogen is
20 selected from the group consisting of estrone, 17 α -estradiol, 17 β -estradiol, equilin, 17 α -dihydroequilin, 17 β -dihydroequilin, equilenin, 17 α -dihydroequilenin, 17 β -dihydroequilenin, $\Delta^{8,9}$ -dehydroestrone, 17 α - $\Delta^{8,9}$ -dehydroestradiol, 17 β - $\Delta^{8,9}$ -dehydroestradiol, ethinyl estradiol, estradiol valerate, 6-OH equilenin, 6-OH 17 α -dihydroequilenin, 6-OH 17 β -dihydroequilenin, 17- β hydroxy derivatives thereof, salts thereof, ketones thereof, and mixtures thereof.

22. The method according to claim 16, wherein the estrogenic composition comprises $\Delta^{8,9}$ -dehydroestrone sulfate.

FIG. 1a



**FIG. 2**

**FIG. 3**

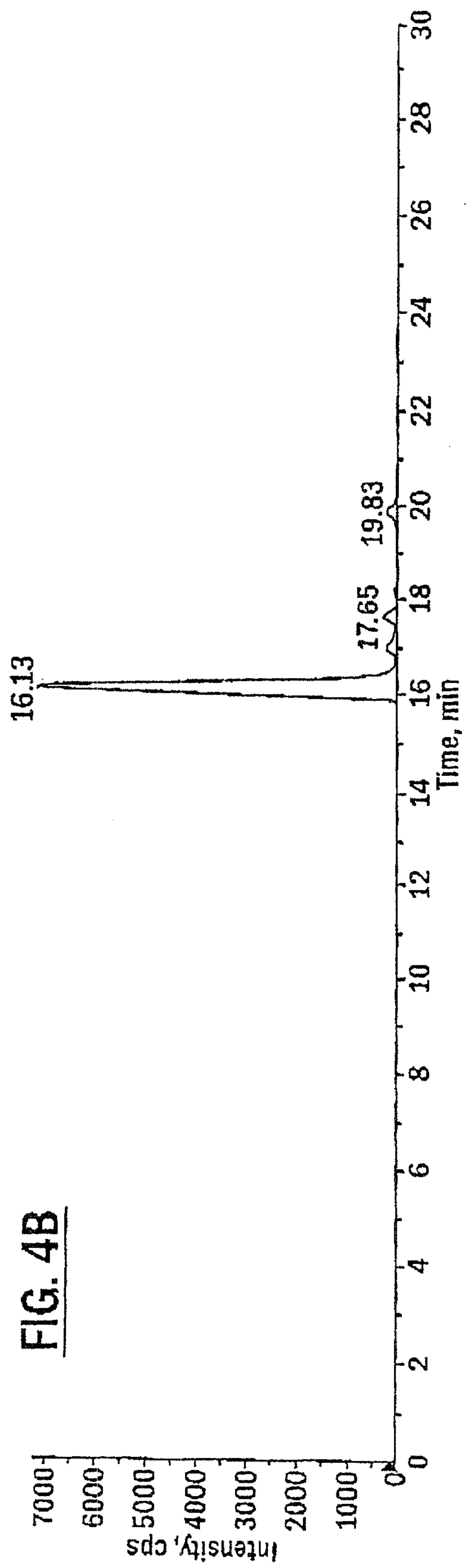
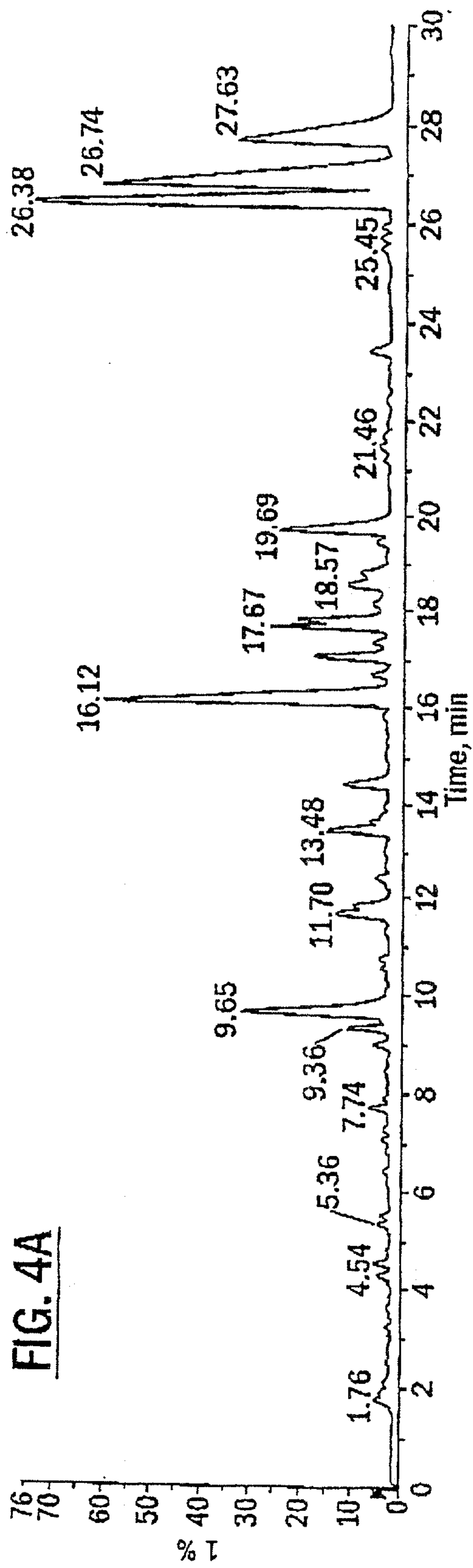
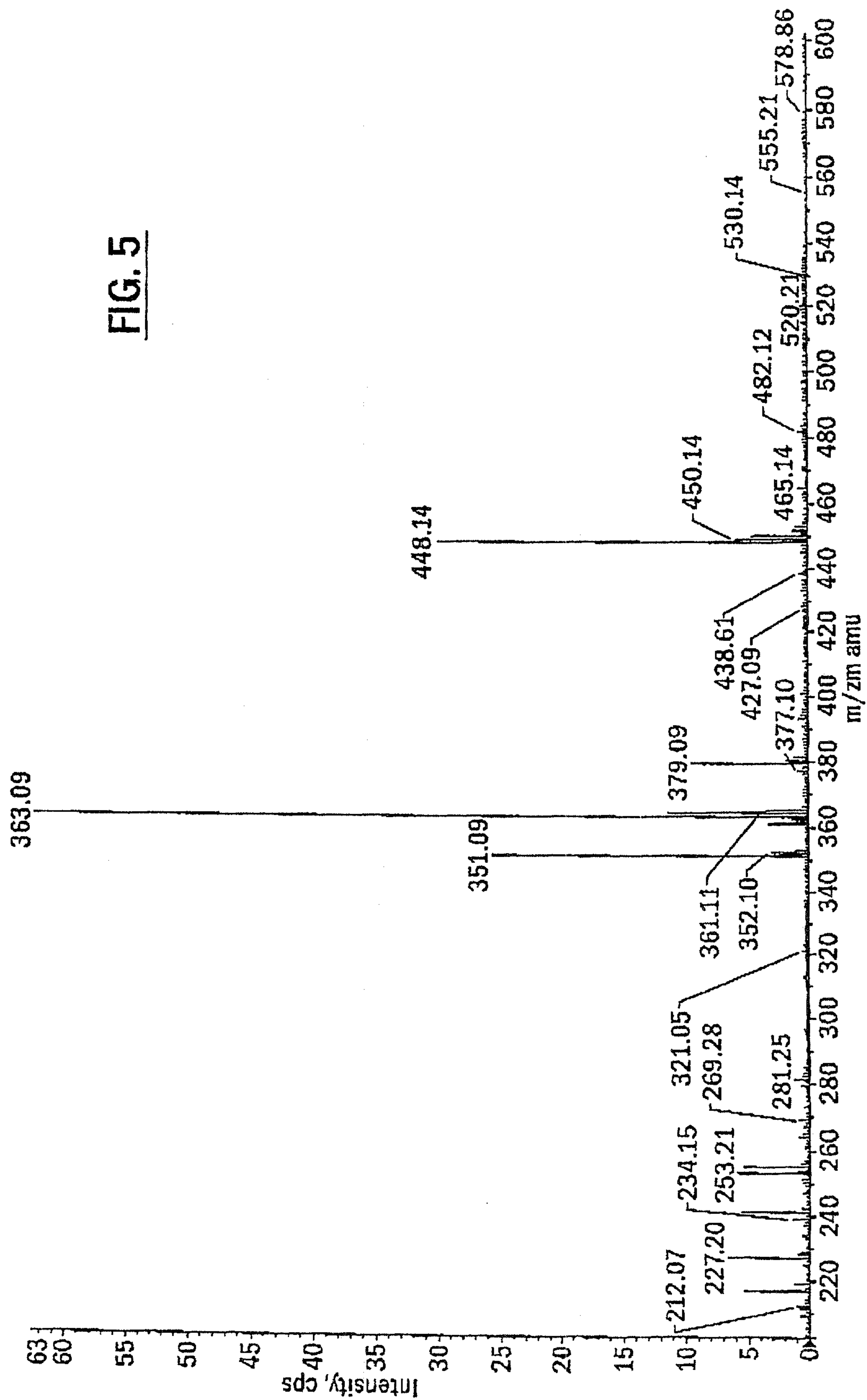


FIG. 5

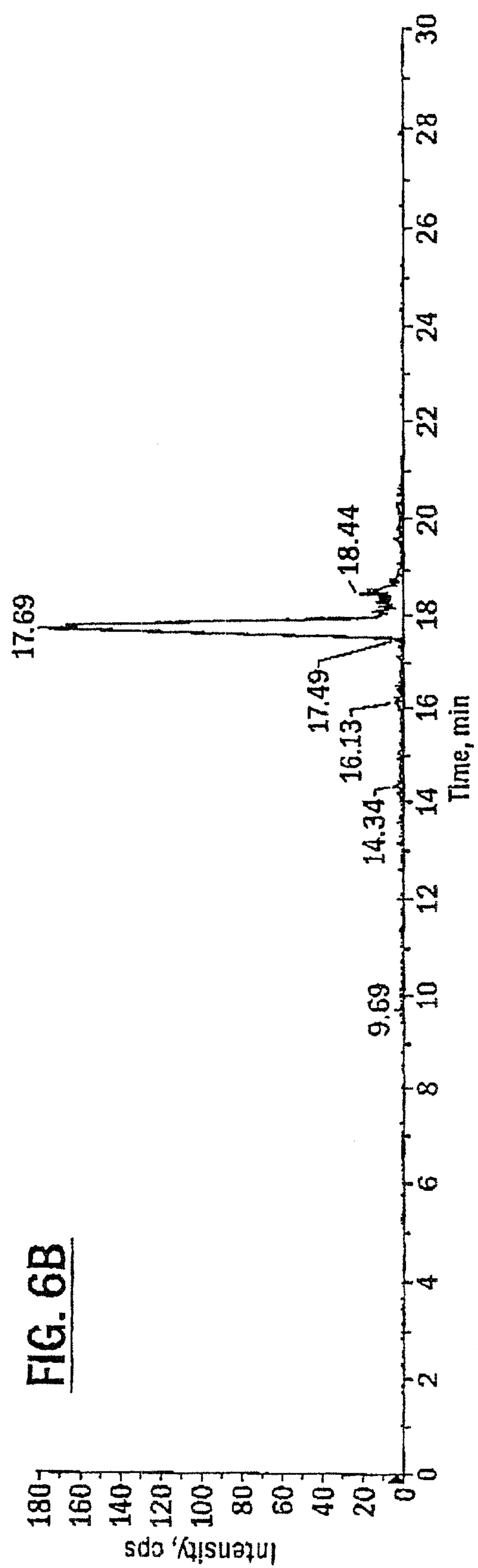
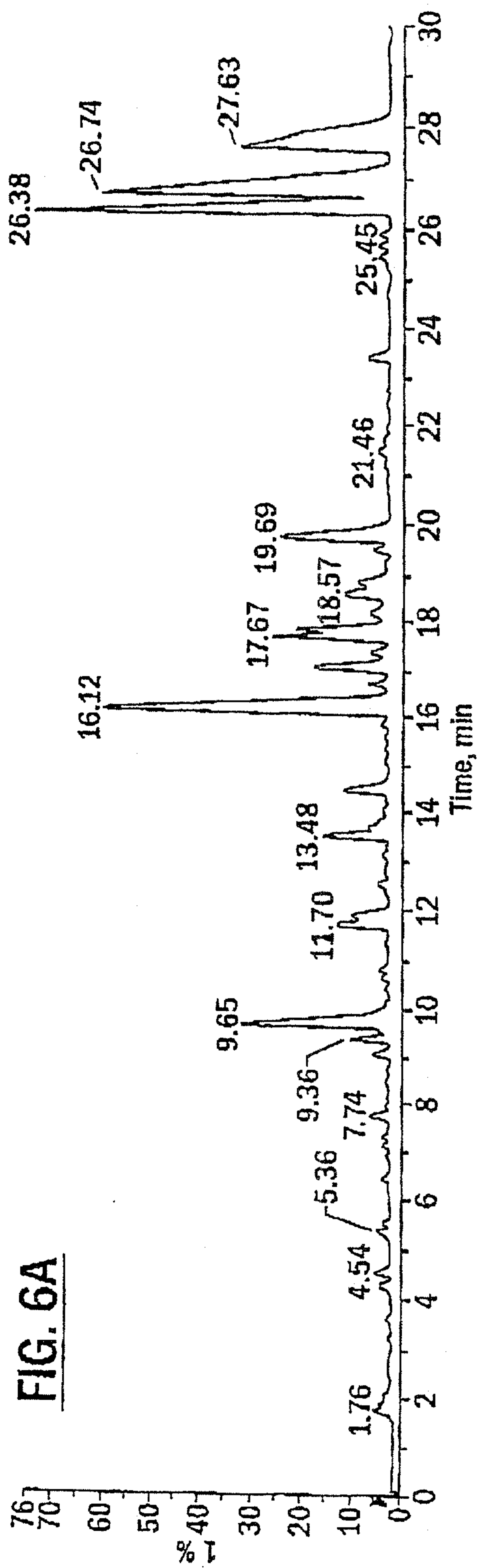


FIG. 7