

Description

FIELD OF INVENTION

5 The present invention relates to a novel method for the stereospecific synthesis of 24(R),25- and 24(S),25-dihydroxycholecalciferol, to novel intermediates used in that synthesis and to their preparation.

24,25-Dihydroxycholecalciferol (hereinafter "24,25(OH)₂D₃") is a metabolite of vitamin D₃ known to possess physiological activity related to that of vitamin D₃. Thus Edelstein, et al. (Nature 276, 517-519, (1978)) have shown that 24,25(OH)₂D₃ is essential for bone formation in chicks; and Norman et al. (Life Science, 27, 229-237, (1980)) have found it is indispensable for calcium and phosphorus homeostasis. Furthermore, Kanis et al. (Brit. Med. J., 1, 1382, (1978)) suggest that 24,25(OH)₂D₃ may be an important regulator of skeletal metabolism in humans. Recently it has been claimed in U.S. Patent No. 4,442,093 that this vitamin D₃ metabolite has anti-hypercalcemia, anti-ulcer and anti-tumor activities and is also active in controlling blood sugar levels in humans.

15 The naturally occurring metabolite 24,25(OH)₂D₃ is the 24(R) enantiomer and, as is well known, its physiological activity and, consequently, its therapeutic utility differ considerably from that of the 24(S)-isomer, which is not found in the natural metabolite, as shown by Stern et al. (Biochem. & Biophys. Res. Comm., 67, 965-971, (1975)).

DESCRIPTION OF PRIOR ART

Owing to the biological importance of 24,25(OH)₂D₃, many synthetic procedures for its preparation were proposed in the literature. However, these procedures are generally unsuitable for industrial-scale production of 24(R),25(OH)₂D₃. The majority of the aforesaid procedures are not stereospecific for the physiologically active 24(R) isomer. For example, M. Seki, et al. (Chem. Pharm. Bull. (Japan), 21, 2783, (1973)) reported a non-stereospecific synthesis of 24,25-dihydroxycholesterol starting from desmosterol, which is not commercially available. They introduced the C-24 and C-25 hydroxy groups either by epoxidation with m-chloroperbenzoic acid followed by hydrolysis or by hydroxylation with osmium tetroxide followed by reductive hydrolysis. In subsequent work Seki et al. (Tetrahedron Letters, 15, (1975)) described the resolution of these racemic epoxides by chromatographic means. Desmosterol was also the starting material used by R. Tchienehom et al. (European Patent No. 5,653) in their non-stereospecific synthesis via oxidative iodination followed by acetic acid solvolysis.

Lam et al. (Biochemistry, 12, 4851, (1973)) reported a non-stereospecific synthesis of 24,25-dihydroxycholesterol starting from 3 β -acetoxy-27-nor-5-cholestene-25-one (also not commercially available), via acetylation of the enol acetate. Likewise, there are several reported syntheses involving non-stereospecific reduction of the C-24 carbonyl group of 25-hydroxy-24-oxo-cholesterol derivatives. Eyley, et al. (J. Chem. Soc., 727, (1976)) described the preparation of such a derivative through aldol condensation between the C-22 aldehyde and 3-methyl-3-tetrahydropyran-2-butanone followed by reduction of the resulting enone. The preparation of such a ketol by C-25 oxidation of a 24-oxocholesterol derivative with subsequent non-stereospecific reduction was also reported (Japanese Patent Nos. 80,164,700 and 55,131,000). Thus, 24,25(OH)₂D₃ in the form of a mixture of the enantiomers is comparatively easy to produce, but so far no satisfactory procedure for the separation of the isomers on an industrial scale is available.

45 A stereoselective synthesis of 24,25(OH)₂D₃ was reported by J. Partridge, et al. (J. Amer. Chem. Soc., 98, 3739, (1976)) consisting of stereoselective epoxidation, with tert-butyl hydroperoxide in the presence of vanadyl acetoacetate, of the cis- Δ^{23} -25-hydroxycholesterol derivative available from the catalytic reduction of the corresponding alkyne. This synthesis requires stereoisomeric as well as regioisomeric separation of product mixtures.

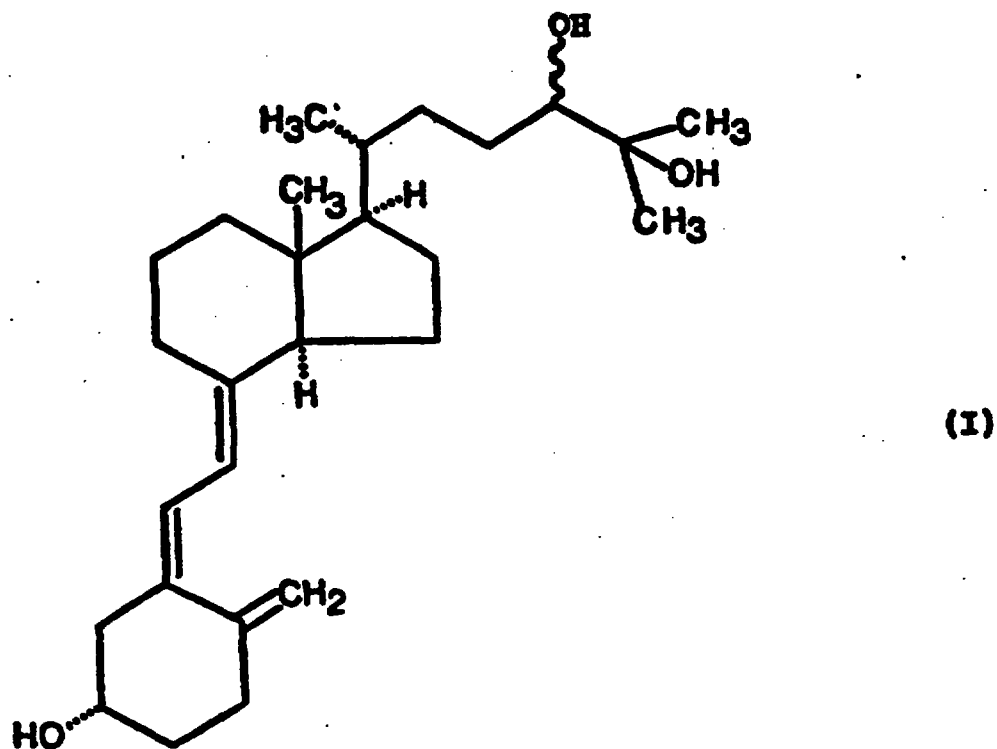
50 The most useful stereospecific syntheses of 24,25-dihydroxycholecalciferol known to date are based on the use of a 22-sulfonylcholesterol derivative. Takayama et al. (Tetrahedron Letters, 21, 5027, (1980)) condense such a compound with optically pure D-1,2-epoxy-3-methyl-3-butanol (prepared from D-glyceric acid). On the other hand, European Patent 063,678 teaches the condensation of a 22-sulfonylcholesterol derivative with 2,3-dihydroxypropanal-2,3-acetonide (also prepared from a D-glycerate derivative).

55 Even the last mentioned stereospecific syntheses have not proven to be practical for routine production, because, in common with all the other reported syntheses of 24,25(OH)₂D₃, the penultimate intermediate is a 24,25-dihydroxycholestan derivative which must be irradiated to complete the preparation of 24,25(OH)₂D₃. It is well-known that the irradiation of any such provitamin D derivative to provitamin D and the subsequent thermal isomerization of the latter to the desired vitamin D derivative are always low-yield steps affording a mixture of isomers from which the vitamin can be isolated only with great difficulty and in low yields. Efficient irradiation techniques are especially problematical for large-scale processes.

60 It is an object of the present invention to overcome the above drawbacks of the known procedures and to provide a novel method for the direct preparation of 24,25(OH)₂D₃ in a stereospecific manner

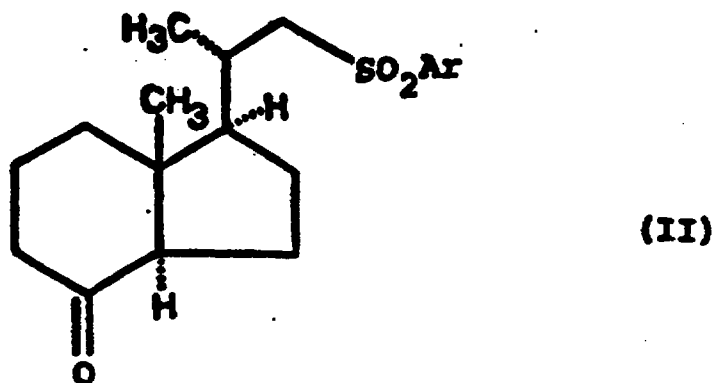
not requiring any photochemical transformation of a provitamin to a previtamin derivative, nor any isomerization to a vitamin derivative.

Thus, in accordance with one aspect of the present invention there is provided a stereospecific process for the preparation of 24(R),25- or 24(S),25-dihydroxycholecalciferol of the general formula (I)



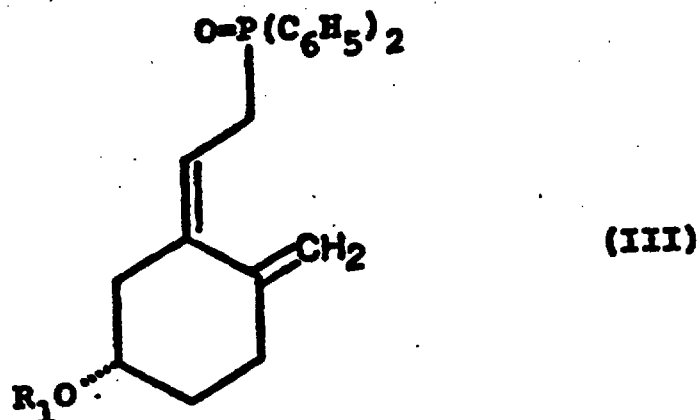
which comprises the steps of:

a) Condensing a compound of the general formula (II)



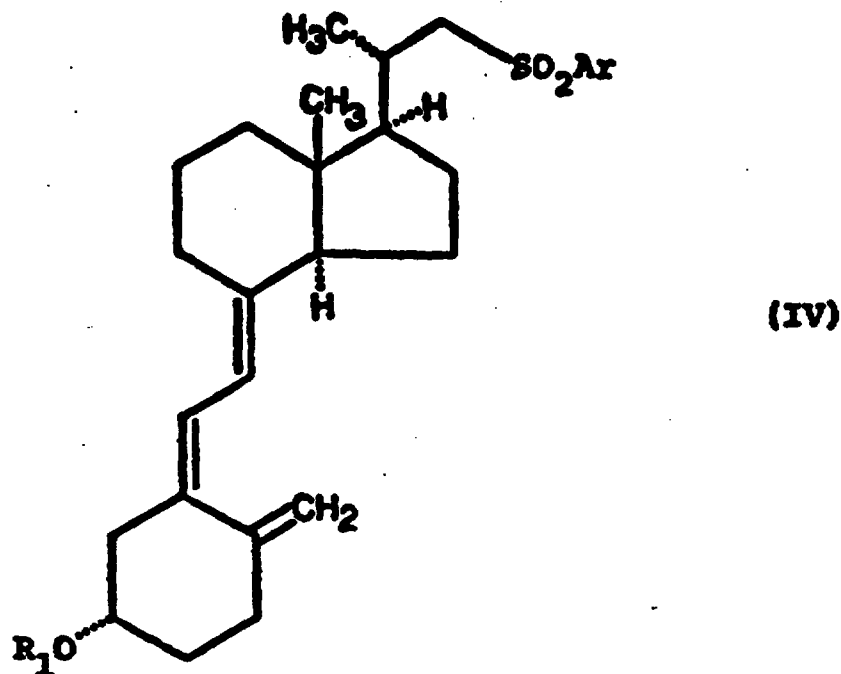
wherein

Ar is monocyclic aryl, having the (1R,6R,9R,2'S) configuration, with the base-generated carbanion derived from a compound of the formula (III)



wherein

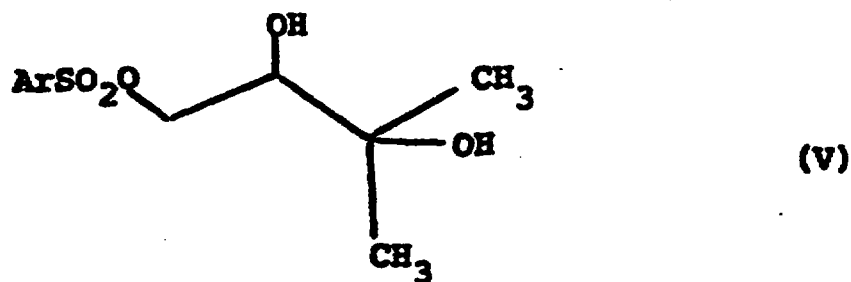
R_1 is a suitable base-stable hydroxy-protecting group, having the (S)-(Z) configuration, to give a compound of the formula (IV)



wherein

Ar and R_1 are as defined above;

b) Reacting the base-generated carbanion derived from the compound of formula (IV) above with the 2(R) or 2(S) isomer of 3-methylbutane-1,2,3-triol 1-arylsulfonate of the formula (V)



wherein,

Ar is as defined above, in the presence of a strong base, to give a compound of the formula (VI)



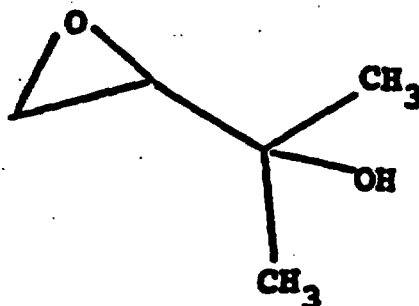
Ar and R₁ are as defined above:

d) Splitting off the hydroxy-protecting group R₁ from the compound thus obtained to yield the desired compound of formula (I) above.

As a base-stable hydroxy-protecting group R_1 there may be used any of such conventional groups well known in the art. As examples, there may be mentioned the methoxymethyl ether, tetrahydropyranyl ether, methylthiomethyl ether or tri-benzylsilyl ether groups, and most preferably the tert.-butyldimethylsilyl ether group.

The compound of formula (III) is dissolved in a suitable inert aprotic solvent, preferably tetrahydrofuran, and reacted with a strong base, preferably *n*-butyllithium at a temperature in the range of -80° to -40°C. To the resulting solution, containing the carbanion of the compound (III), there is then added a solution of the compound of formula (II) in the same solvent, and the reaction is allowed to proceed as in a Wittig reaction, at an appropriate temperature in the range of -60° to 20°C.

The reaction between compounds (IV) and (V) in step (b) of the process of the invention, is also performed in an inert aprotic solvent, preferably tetrahydrofuran, at a temperature in the range of -40° to -10°C under the influence of a strong base, preferably *n*-butyllithium. In a preferred embodiment of the invention, the base is used in excess and serves to generate the carbanion from the compound of formula (IV) and, possibly, also to convert the compound of formula (V) above, in situ, to the epoxide of the formula:

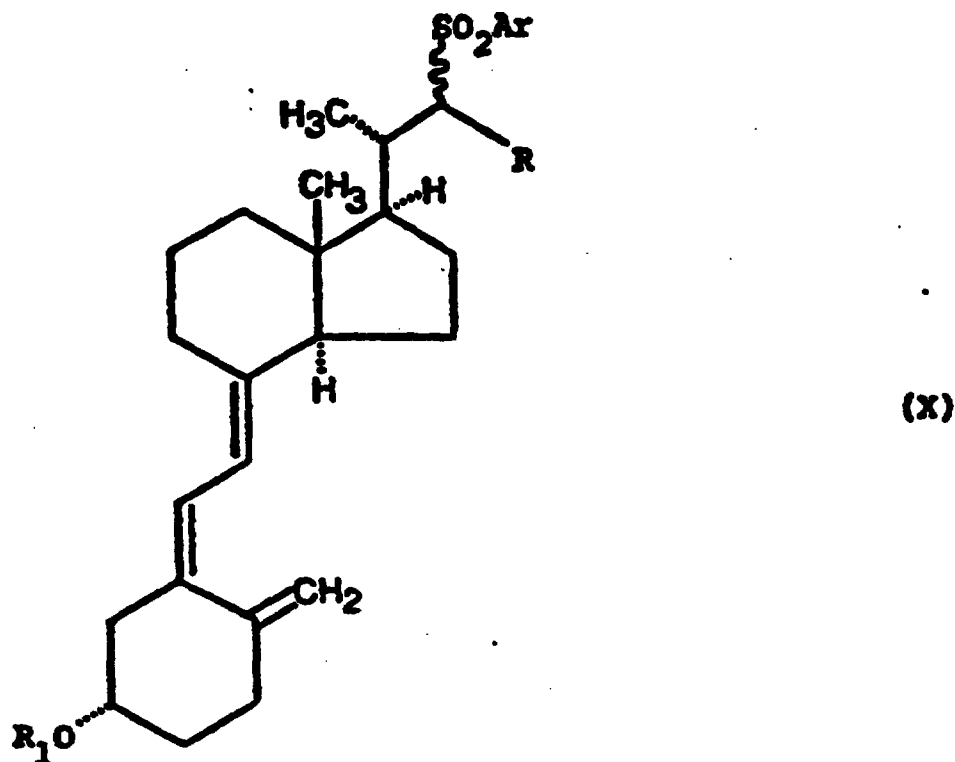


which is believed to be the species reacting with the carbanion of the compound of formula (IV).

In process step (c), the sulfone group may be split off from the complete vitamin D skeleton of the resulting compound of the formula (VI), by any of several methods described in the literature, e.g. by reaction with sodium amalgam, magnesium in methanol, lithium with ethylamine or Raney nickel.

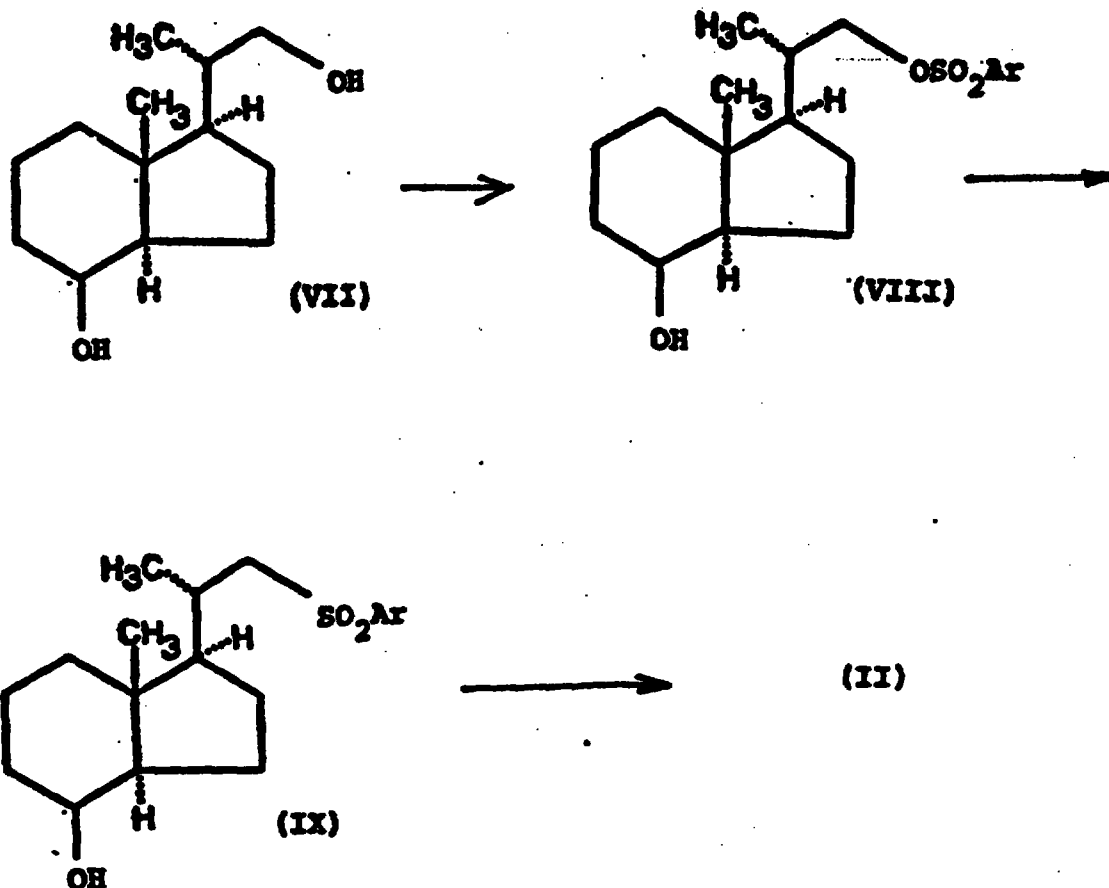
Similarly, in process step (d), the hydroxy-protecting group R in the product of step (c) above, may be removed by any suitable known method, according to the nature of the protecting group. Thus, if R is tert.-butyldimethylsilyl, it may be split off by reacting with tetra-butylammonium fluoride to give the desired 24,25(OH)₂D₃.

The compounds of formulae (IV) and (VI) are novel and form another aspect of the present invention. In accordance with that aspect there are thus provided compounds of the general formula (X)



in which Ar and R₁ are as defined above, and R is hydrogen or a radical of the formula -CH₂-CH(OH)-C(CH₃)₂-OH, having either the (R) or the (S) configuration at the asymmetric carbon atom.

The starting material of formula (II) above can be prepared according to the following reaction scheme:



The well known "Inhoffen-Lythgoe diol" (VII) (cf. Inhoffen et al. Ber. 91, 781, (1958)) is selectively aryl-sulfonated, e.g. with *p*-toluenesulfonic acid in pyridine, to form (VIII) which is then sulfonated, e.g. using sodium iodide and sodium arylsulfinate in a suitable inert solvent, preferably dimethyl formamide, under known conditions, to form the compound (IX). Compound (IX) is readily oxidized to the ketone (II) using a suitable oxidizing agent such as pyridinium dichromate or pyridinium chlorochromate in an inert solvent such as methylene chloride.

The other starting material of formula (III) is known and can be prepared according to Toh and Okamura, J. Org. Chem., 48, 1414, (1983).

The compounds of formula (V) above can be prepared, e.g. as described in Takayama et al, Tetrahedron Letters, 21, 5027-8, (1980).

The invention will now be further illustrated in more detail in the following non-limiting Examples.

EXAMPLE 1:

Preparation of (1R,6R,9R,2'S)-9-(1'-*p*-toluenesulfonylprop-2'-yl)-1-methyl-bicyclo(4.3.0)-nonan-5-ol (IX; Ar = *p*-CH₃-C₆H₄-).

To a solution of 14.5 g (40 mmole) of 1R,6R,9R,2'S)-9-(1'-*p*-toluenesulfonyloxyprop-2'-yl)-1-methylbicyclo(4.3.0)nonan-5-ol in 250 ml of dry dimethylformamide under an inert atmosphere were added 60.2 g (400 mmole) of sodium iodide and 10.7 g (60 mmole) of sodium *p*-toluenesulfinate. The resulting mixture was heated at 80°C for 2 hours, whereafter 1 liter of ethyl acetate was added. The resulting solution was washed twice with water, once with 5% aqueous sodium thiosulfate and once with brine. The organic layer was dried over anhydrous MgSO₄ and concentrated in vacuo. The title compound (7.1 g, 51%) was isolated by recrystallization from ethyl acetate, m.p. 125-126°C.

Anal.

Calcd. for C₂₀H₃₀O₃S: C, 68.53; H, 8.62; S, 9.14;

Found: 68.75 8.65 9.21;

IR (KBr) 3515, 1295 and 1135 cm⁻¹.

NMR (CDCl₃): 3.06 (m, 1H), 2.45 (s, 3H), 1.17 (d, 3H), 0.90 (s, 3H).

EXAMPLE 2:

Preparation of (1R,6R,9R,2'S)-9-(1'-p-toluenesulfonylprop-2'-yl)-1-methylbicyclo-(4.3.0)-nonan-5-one (II; Ar = p-CH₃-C₆H₄-).

To a stirred suspension of 12.4 g (33 mmole) of pyridinium dichromate in 40 ml of dry methylene chloride was added a solution of 7.6 g (22 mmole) of (1R,6R,9R,2'S)-9-(1'-p-toluenesulfonylprop-2'-yl)-1-methylbicyclo-(4.3.0)nonan-5-ol (from Example 1) in 40 ml of the same solvent. After 2 hours stirring at room temperature, 100 ml of diethyl ether were added and the dark suspension filtered with the aid of suction through a bed of silica gel, washing it through with a 9:1 solution of methylene chloride:diethyl ether. The solvent was removed in vacuo and the title compound (7 g, 92%) was isolated by recrystallization from ethyl acetate, m.p. 148-149°C.

Anal.

Calcd. for C₂₀H₂₈O₃S: C, 68.93; H, 8.10; S, 9.20;

Found: 68.61 8.20 9.34;

IR(KBr) 1703, 1355, 1190 cm⁻¹.

NMR (CDCl₃): δ 2.45 (s, 3H); 1.24 (d, 3H), 0.61 (s, 3H).

EXAMPLE 3:

Preparation of 3β-tert.-butyldimethylsilyl-22-p-toluenesulfonyl-23,24,25,26,27-pentanocholecalciferol (IV; R₁ = TBDMS, Ar = p-CH₃-C₆H₄-).

To a solution of 6.8 g (15.0 mmole) of (S)-(Z)-[2-(5'-tert.-butyldimethylsilyloxy-2'-methylenecyclohexylidene)ethyl]diphenylphosphine oxide in 75 ml of dry tetrahydrofuran at -45°C were added dropwise 9.3 ml (14.4 mmole) of 1.55 M n-butyllithium. After 45 mins. there were added dropwise to the resulting red solution 4.2 g (12.1 mmole) of (1R,6R,9R,2'S)-9-(1'-p-toluenesulfonylprop-2'-yl)-1-methylbicyclo(4.3.0)nonan-5-one (from Example 2) in 60 ml of dry tetrahydrofuran. After an additional 90 mins. at -45°C the reaction mixture was allowed to warm to room temperature and treated with 30 ml of saturated aqueous sodium bicarbonate and 70 ml of diethyl ether. The mixture was extracted twice with diethyl ether and the combined organic layers washed with brine, dried over anhydrous MgSO₄ and the solvent removed in vacuo. The title compound (6.2 g, 88%) was isolated by flash column chromatography, using 12% ethyl acetate in hexane as eluant.

Anal.

Calcd. for C₃₅H₅₄O₃SSi: C, 72.11; H, 9.35; S, 5.50;

Found: 72.06 9.06 5.79;

IR (CHCl₃): 1600, 1300, 1135, 1080 cm⁻¹.

NMR (CDCl₃): δ 6.03 (d of d, 2H); 4.86 (d, 2H); 3.2 (m, 1H), 2.45 (s, 3H); 1.23 (d, 3H); 0.88 (s, 9H); 0.52 (s, 3H).

EXAMPLE 4:

Preparation of 3β-tert.-butyldimethylsilyl-24(R),25-dihydroxy-22-p-toluenesulfonyl-cholecalciferol (VI; R₁ = TBDMS; Ar = p-CH₃-C₆H₄-).

To a solution of 4.6 g (16.6 mmole) of 3-methylbutane-1,2(R),3-triol 1-p-toluenesulfonate (V; Ar = p-CH₃-C₆H₄-) and 4.8 g (8.3 mmole) of 3-tert.-butyldimethylsilyl-22-p-toluenesulfonyl-23,24,25,26,27-pentanocholecalciferol (from Example 3) in 25 ml of dry tetrahydrofuran at -20°C under an inert atmosphere, were added dropwise 32 ml (49.7 mmole) of 1.55 M n-butyllithium. After 1 hour at -20°C, 30 ml of a saturated aqueous ammonium chloride solution were added and the mixture extracted twice with diethyl ether. The combined organic phases were washed successively with saturated aqueous ammonium chloride and brine, dried over anhydrous MgSO₄ and concentrated in vacuo to an oil. The title compound (5.2 g, 92%) was isolated by flash column chromatography, using a 1:1 solution of ethyl acetate:hexane as eluant.

Anal.

Calcd. for C₄₀H₆₄O₅SSi: C, 70.13; H, 9.42; S, 4.68

Found: 69.88 9.14 5.08;

IR (CHCl₃): 1600, 1135, 1080 cm⁻¹.

NMR (CDCl₃): δ 6.02 (d of d, 2H); 4.86 (d, 2H); 2.45 (s, 3H); 1.34 (s, 3H); 1.27 (s, 3H); 0.99 (d, 3H); 0.88 (s, 9H); 0.83 (s, 3H).

EXAMPLE 5:

Preparation of 3 β -tert-butyldimethylsilyl-24(R),25-dihydroxycholecalciferol.

To a solution of 4.09 g (6 mmole) of 3 β -tert-butyldimethylsilyl-24(R),25-dihydroxy-22-p-toluenesulfonylcholecalciferol (from Example 4) in 80 ml of methanol, were added 17 g (120 mmole) of anhydrous disodium hydrogen phosphate and 55 g (120 mmole) of 5% sodium amalgam and the resulting mixture stirred at 35°C under an inert atmosphere. After 4 hours the precipitate which formed was removed by filtration and the solvent was removed from the filtrate in vacuo. The residue was extracted with ethyl acetate, the resulting solution was washed with brine, dried over anhydrous MgSO₄ and the solvent removed in vacuo. The title compound (2.3 g, 73%) was isolated by flash chromatography eluting with hexane:ethyl acetate (7:3). UV: λ_{max} = 265 nm.

EXAMPLE 6:

Preparation of 24(R),25-dihydroxycholecalciferol (I).

To a solution of 2.13 g (4 mmole) of 3 β -tertbutyldimethylsilyl-24(R),25-dihydroxycholecalciferol (from Example 5) in 40 ml of dry tetrahydrofuran were added 28 ml (28 mmole) of 1 M tetrabutylammonium fluoride in tetrahydrofuran, with stirring under an inert atmosphere. After 2 hours at room temperature, the volatiles were removed in vacuo and the residue extracted with ethyl acetate, which was subsequently washed 5 times with water and once with brine, dried over anhydrous MgSO₄ and the solvent removed in vacuo. The residue was purified by elution through silica gel with ethyl acetate, with the aid of suction to give the title compound (1.6 g, 95%); m.p. 137-140°C (methyl formate). UV: λ_{max} = 265 nm.

EXAMPLE 7:

Preparation of 24(S),25-dihydroxycholecalciferol (I).

The procedure of Example 4 was followed, except that 3-methylbutane-1,2(S),3-triol 1-p-toluenesulfonate is employed instead of the 2(R) isomer. The 3 β -tert-butyldimethylsilyl-24(S),25-dihydroxy-22-p-toluenesulfonyl-cholecalciferol thus obtained, was submitted to the procedures described in Examples 5 and 6, to yield the title compound.

The features disclosed in the foregoing description and in the following claims may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

Claims

1. A process for the stereospecific preparation of a 24(R),25- or 24(S),25-dihydroxycholecalciferol of the general formula (I)

**EXAMPLE 5:**

Preparation of 3 β -tert-butyldimethylsilyl-24(R),25-dihydroxycholecalciferol.

To a solution of 4.09 g (6 mmole) of 3 β -tert-butyldimethylsilyl-24(R),25-dihydroxy-22-p-toluenesulfonylcholecalciferol (from Example 4) in 80 ml of methanol, were added 17 g (120 mmole) of anhydrous disodium hydrogen phosphate and 55 g (120 mmole) of 5% sodium amalgam and the resulting mixture stirred at 35°C under an inert atmosphere. After 4 hours the precipitate which formed was removed by filtration and the solvent was removed from the filtrate in vacuo. The residue was extracted with ethyl acetate, the resulting solution was washed with brine, dried over anhydrous MgSO₄ and the solvent removed in vacuo. The title compound (2.3 g, 73%) was isolated by flash chromatography eluting with hexane:ethyl acetate (7:3). UV: λ_{max} = 265 nm.

EXAMPLE 6:

Preparation of 24(R),25-dihydroxycholecalciferol (I).

To a solution of 2.13 g (4 mmole) of 3 β -tertbutyldimethylsilyl-24(R),25-dihydroxycholecalciferol (from Example 5) in 40 ml of dry tetrahydrofuran were added 28 ml (28 mmole) of 1 M tetrabutylammonium fluoride in tetrahydrofuran, with stirring under an inert atmosphere. After 2 hours at room temperature, the volatiles were removed in vacuo and the residue extracted with ethyl acetate, which was subsequently washed 5 times with water and once with brine, dried over anhydrous MgSO₄ and the solvent removed in vacuo. The residue was purified by elution through silica gel with ethyl acetate, with the aid of suction to give the title compound (1.6 g, 95%); m.p. 137-140°C (methyl formate). UV: λ_{max} = 265 nm.

EXAMPLE 7:

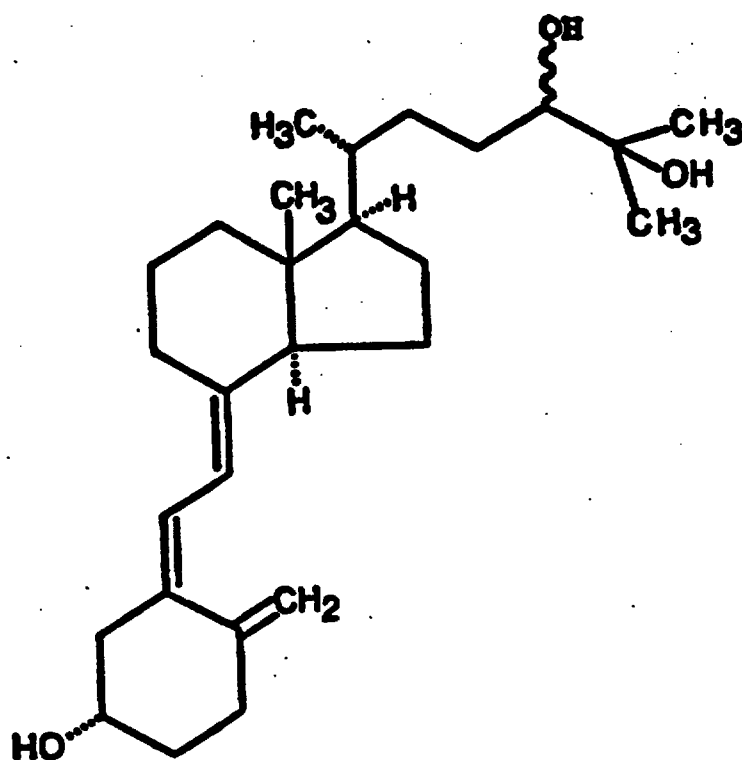
Preparation of 24(S),25-dihydroxycholecalciferol (I).

The procedure of Example 4 was followed, except that 3-methylbutane-1,2(S),3-triol 1-p-toluenesulfonate is employed instead of the 2(R) isomer. The 3 β -tert-butyldimethylsilyl-24(S),25-dihydroxy-22-p-toluenesulfonyl-cholecalciferol thus obtained, was submitted to the procedures described in Examples 5 and 6, to yield the title compound.

The features disclosed in the foregoing description and in the following claims may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

Claims

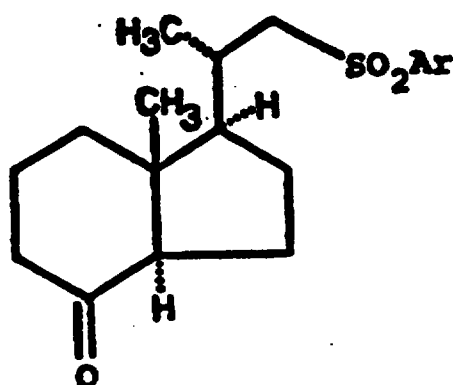
1. A process for the stereospecific preparation of a 24(R),25- or 24(S),25-dihydroxycholecalciferol of the general formula (I)



(I)

which comprises the steps of:

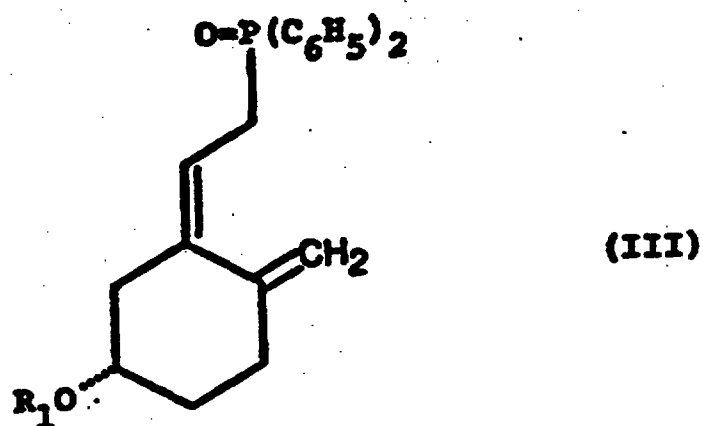
a) Condensing a compound of the general formula (II)



(II)

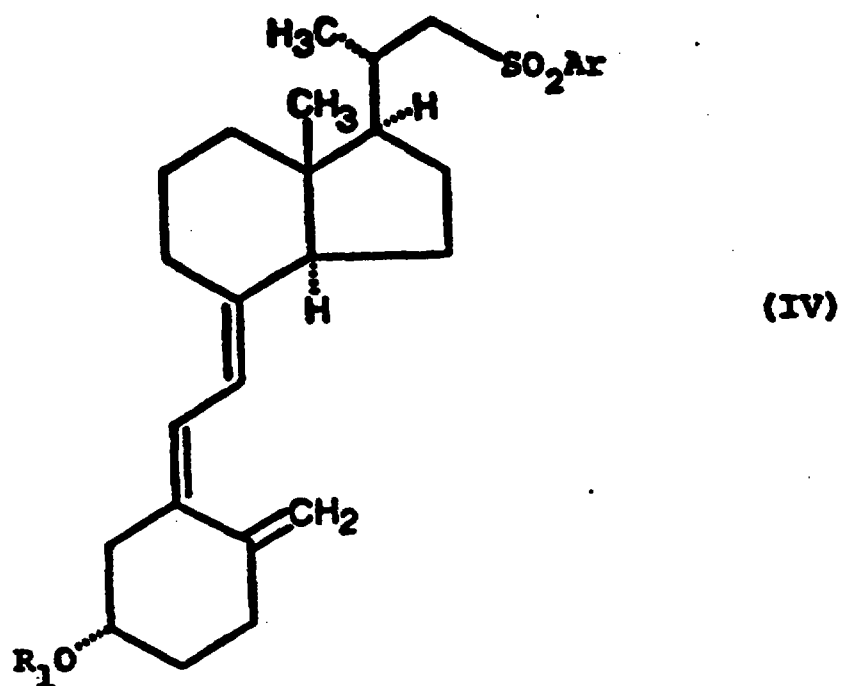
wherein

Ar is monocyclic aryl, having the (1R,6R,9R,2'S) configuration, with the base-generated carbanion derived from a compound of the formula (III)



wherein

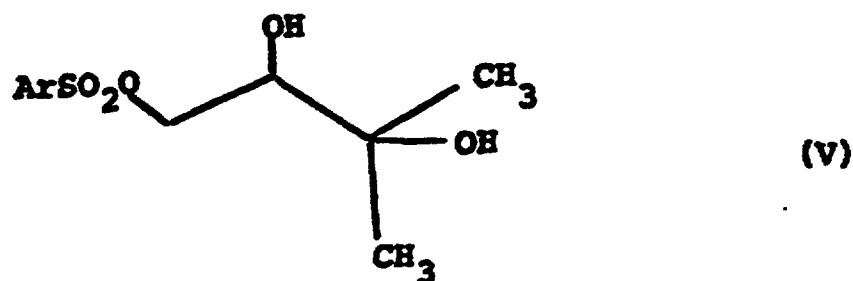
R₁ is a suitable base-stable hydroxy-protecting group, having the (S)-(Z) configuration, to give a compound of the formula (IV)



wherein

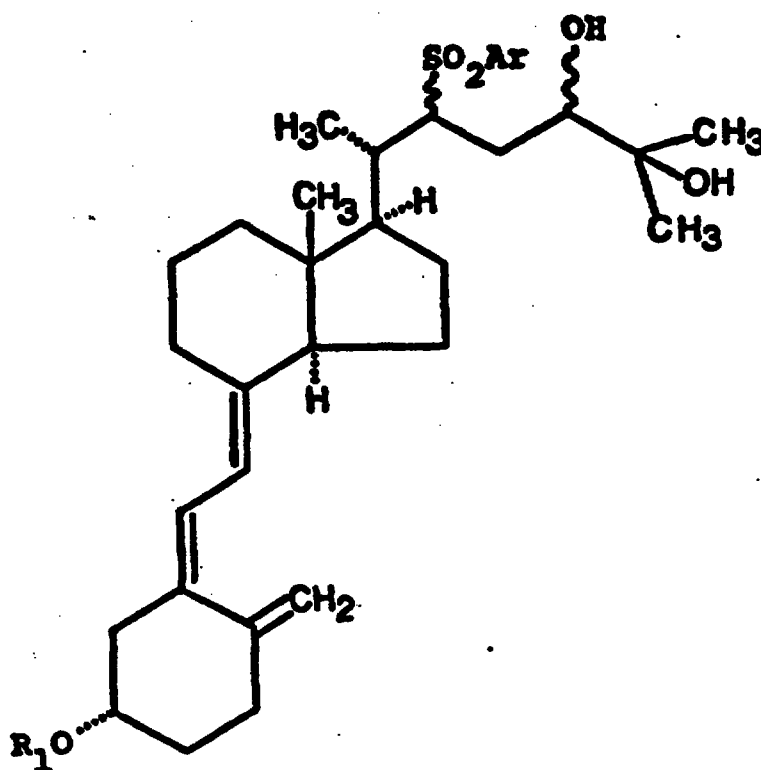
Ar and R₁ are as defined above;

b) Reacting the base-generated carbanion derived from the compound of formula (IV) above with the 2(R) or 2(S) isomer of 3-methylbutane-1,2,3-triol 1-arylsulfonate of the formula (V)



wherein

Ar is as defined above, in the presence of a strong base, to give a compound of the formula (VI)



(VI)

wherein

Ar and R₁ are as defined above;

c) Splitting off the 22-sulfonyl group from the compound of the formula (VI) above by known methods; and

d) Splitting off the hydroxy-protecting group R₁ from the compound thus obtained to yield the desired compound of formula (I) above.

2. A process according to claim 1 wherein the compound of formula (I) prepared is 24(R),25-dihydroxy-cholecalciferol.

3. A process according to claims 1 to 2, wherein R₁ in compounds (III), (IV) and (VI) is tert.-butyldimethylsilyl.

4. A process according to any one of the preceding claims wherein Ar in compounds (II), (IV) and (VI) is p-tolyl.

5. A process according to any one of the preceding claims wherein the condensation reaction in step (a) is conducted in an inert aprotic solvent in the presence of n-butyllithium.

6. A process according to any one of the preceding claims wherein the reaction in process step (b) is conducted in an inert aprotic solvent in the presence of excess n-butyllithium.

7. Compounds of the general formula (X)



8. Compounds of the formula (X) in claim 7 in which R is hydrogen.

10. Compounds according to claim 7 in which R is the radical $-\text{CH}_2-\dot{\text{C}}\text{H}(\text{OH})-\text{C}(\text{CH}_3)_2\text{OH}$, having either the (R) or the (S) configuration at the asymmetric carbon atom.

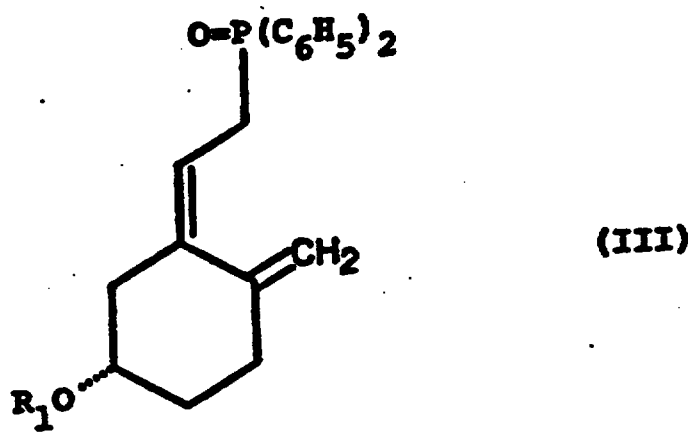
11. A compound according to claim 10 having the 24(R) configuration.

12. 3 β -tert.-Butyldimethylsilyl-24(R),25-dihydroxy-22-p-toluenesulfonylcholecalciferol.

13. A process for the preparation of a compound according to claim 8, which comprises condensing a compound of the general formula (II)



Ar is monocyclic aryl, having the (1R,6R,9R,2'S) configuration, with the base-generated carbanion derived from a compound of the formula (III)

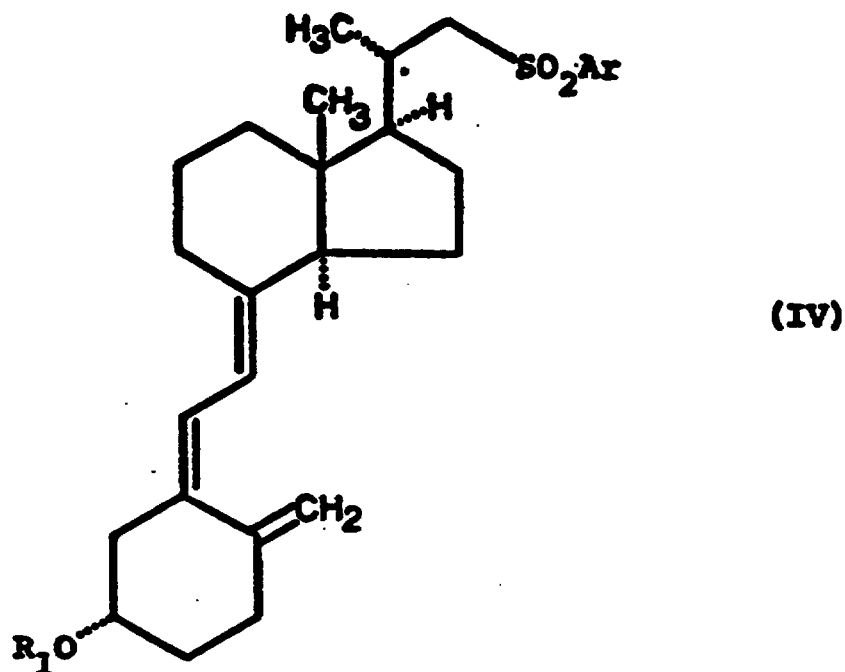


wherein

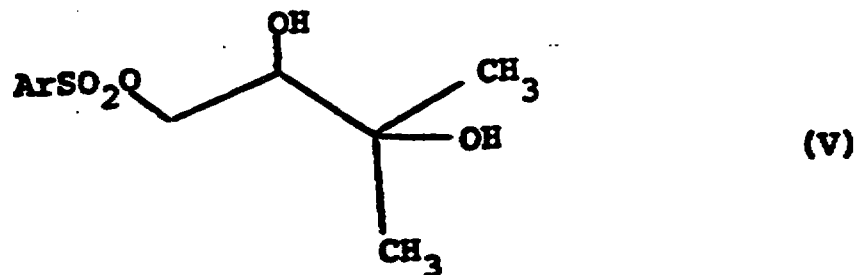
R_1 is a suitable base-stable hydroxy-protecting group, having the (S)-(Z) configuration.

14. A process according to claim 13 wherein the condensation is conducted in an inert aprotic solvent in the presence of *n*-butyllithium.

15. A process for the preparation of a compound according to claim 10, which comprises reacting the base-generated carbanion derived from the compound of formula (IV)



50 in which Ar and R_1 are as defined in claim 1, with the 2(R) or 2(S) isomer of 3-methylbutane-1,2,3-triol 1-arylsulfonate of the formula (V)



wherein

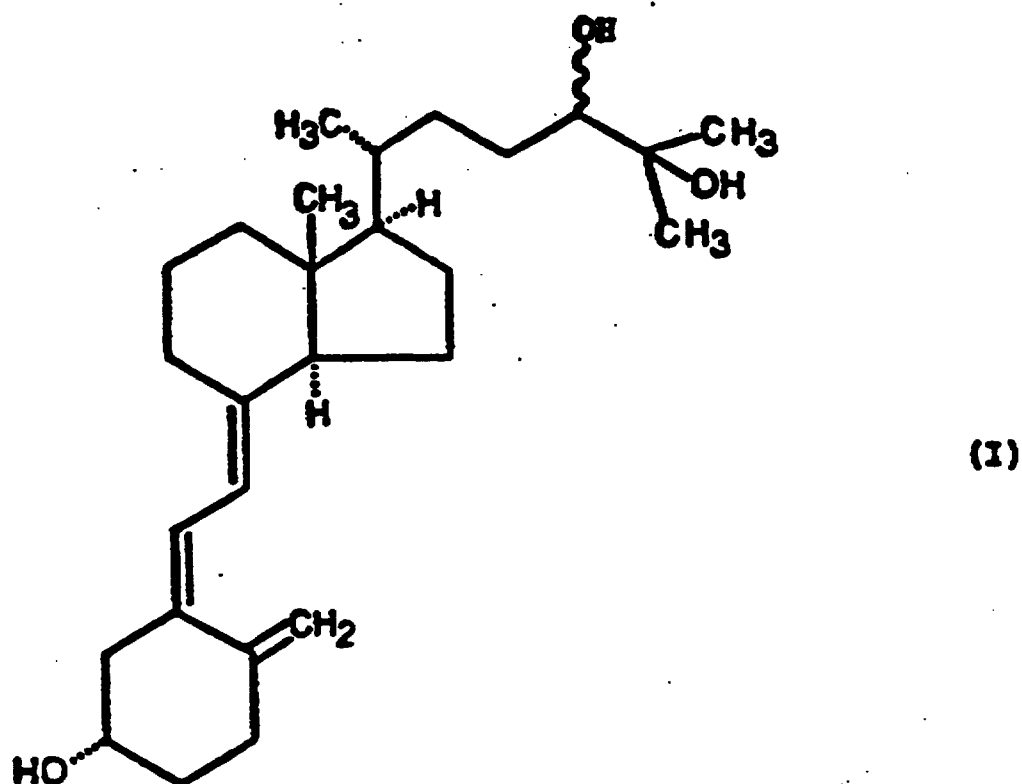
Ar is as defined above, in the presence of a strong base.



16. A process according to claim 15 wherein the reaction is conducted in an inert aprotic solvent in the presence of excess n-butyllithium.

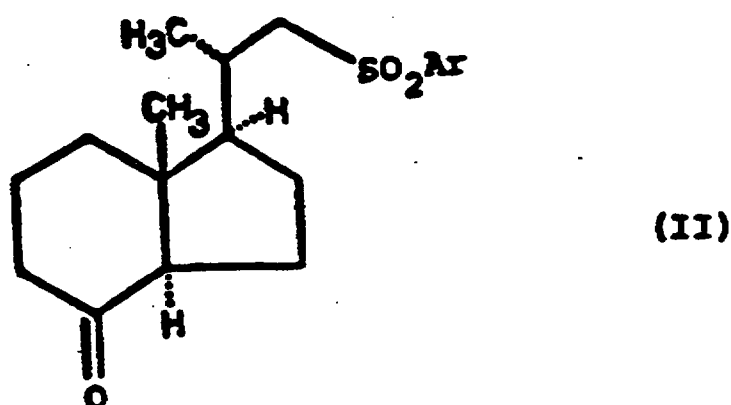
Patentansprüche

1. Verfahren für die stereospezifische Darstellung eines 24(R),25- oder 24(S),25-Dihydroxycholecalciferol der allgemeinen Formel (I)

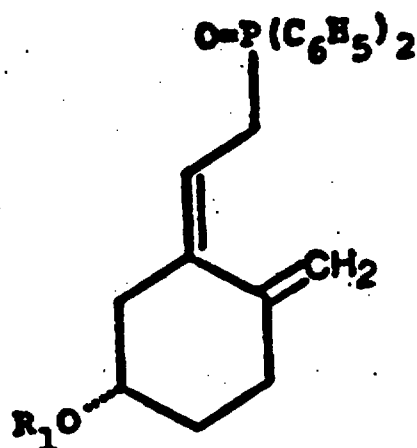


das die folgenden Schritte umfaßt:

a) Kondensieren einer Verbindung der allgemeinen Formel (II)

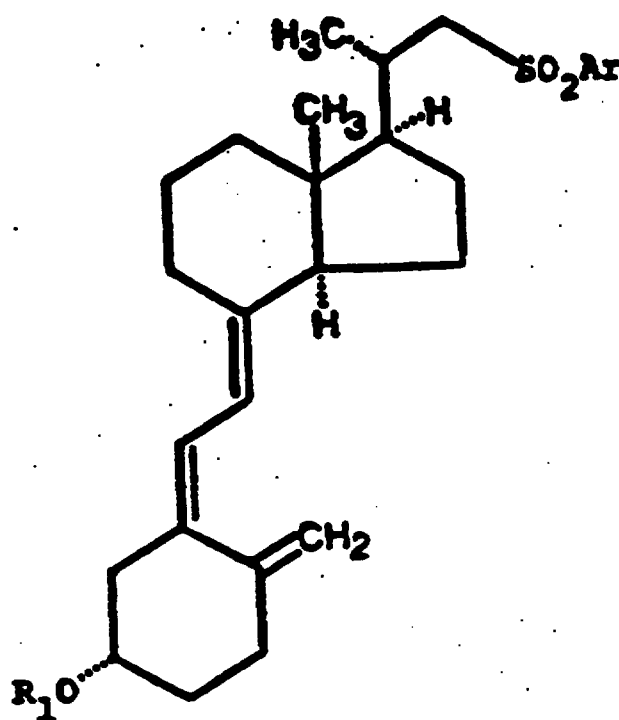


in der Ar monozyklisches Aryl ist, mit der (1R, 6R, 9R, 2'S)-Konfiguration, mit dem basenerzeugten Carbanion, das aus einer Verbindung der Formel (III) abgeleitet ist



(III)

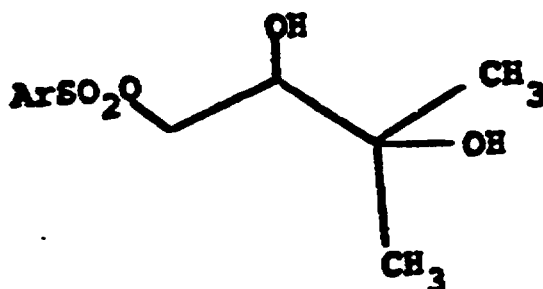
in der R_1 eine geeignete basenstabile Hydroxy-Schutzgruppe ist, mit der (S)-(Z)-Konfiguration, um eine Verbindung der Formel (IV) zu ergeben



(IV)

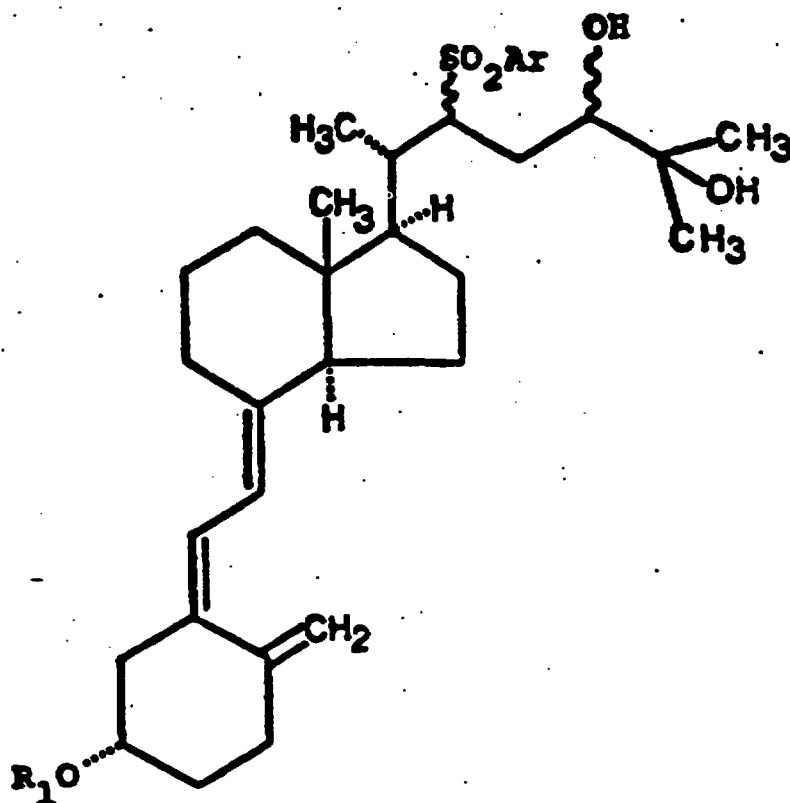
in der Ar und R_1 wie oben definiert sind;

b) Umsetzen des basenerzeugten Carbanions, das aus der Verbindung der Formel (IV) oben abgeleitet ist, mit dem 2(R)- oder 2(S)-Isomeren von 3-Methylbutan-1, 2, 3-triol-1-arylsulfonat der Formel (V)



(V)

in der Ar wie oben definiert ist, in Gegenwart einer starken Base, um eine Verbindung der Formel (VI) zu ergeben



(VI)

In der Ar und R_1 wie oben definiert sind;

c) Abspalten der 22-Sulfonylgruppe von der Verbindung der Formel (VI) oben mit bekannten Verfahren; und

d) Abspalten der Hydroxy-Schutzgruppe R_1 von der so erhaltenen Verbindung, um die gewünschte Verbindung der Formel (I) oben zu liefern.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die dargestellte Verbindung der Formel (I) 24(R), 25-Dihydroxycholecalciferol ist.

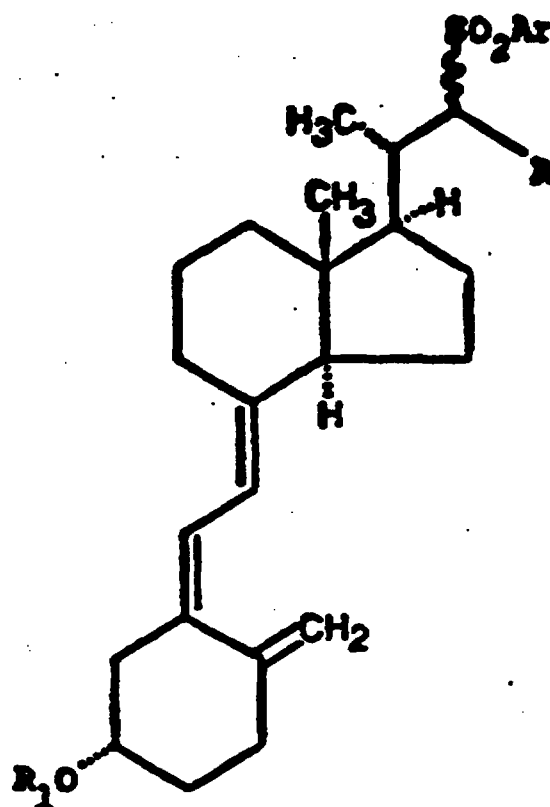
3. Verfahren nach den Ansprüchen 1 oder 2, dadurch gekennzeichnet, daß R_1 in den Verbindungen (III), (IV) und (VI) tert.-Butyldimethylsilyl ist.

4. Verfahren nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß Ar in den Verbindungen (II), (IV) und (VI) p-Tolyl ist.

5. Verfahren nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß die Kondensationsreaktion in Schritt (a) in einem inerten aprotischen Lösungsmittel in Gegenwart von n-Butyllithium durchgeführt wird.

6. Verfahren nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß die Reaktion im Verfahrensschritt (b) in einem inerten aprotischen Lösungsmittel in Gegenwart von überschüssigem n-Butyllithium durchgeführt wird.

7. Verbindungen der allgemeinen Formel (X).



(X)

in der Ar und R₁ wie in Anspruch 1 definiert sind und R Wasserstoff oder ein Rest der Formel $-\text{CH}_2-\dot{\text{C}}\text{H}(\text{OH})-\text{C}(\text{CH}_3)_2\text{OH}$ ist, mit entweder der (R)- oder der (S)-Konfiguration am asymmetrischen Kohlenstoffatom.

8. Verbindungen der Formel (X) in Anspruch 7, dadurch gekennzeichnet, daß R Wasserstoff ist.

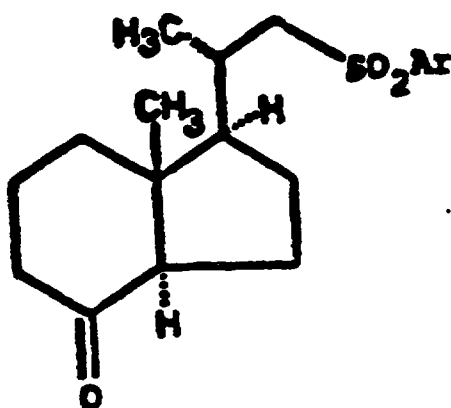
9. 3 β -tert.-Butyldimethylsilyl-22-p-toluolsulfonyl-23, 24, 25, 26, 27-pentanorcholecalciferol.

10. Verbindungen nach Anspruch 7, dadurch gekennzeichnet, daß R der Rest $-\text{CH}_2-\dot{\text{C}}\text{H}(\text{OH})-\text{C}(\text{CH}_3)_2\text{OH}$ ist, mit entweder der (R)- oder der (S)-Konfiguration am asymmetrischen Kohlenstoffatom.

11. Verbindung nach Anspruch 10, gekennzeichnet durch die 24(R)-Konfiguration.

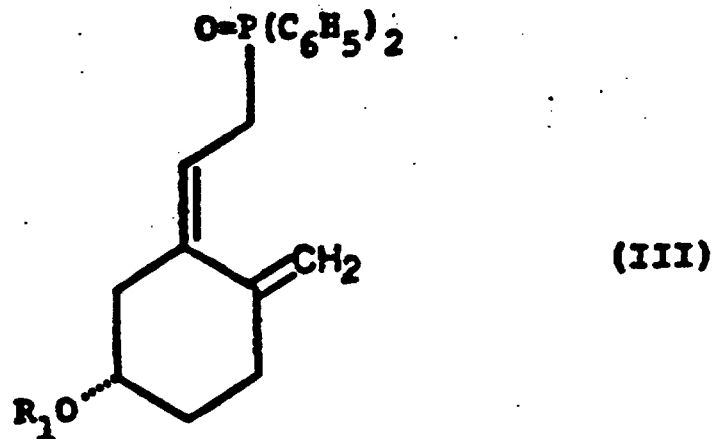
12. 3 β -tert.-Butyldimethylsilyl-24(R), 25-dihydroxy-22-p-toluolsulfonylcholecalciferol.

13. Verfahren zur Darstellung einer Verbindung gemäß Anspruch 8, gekennzeichnet durch das Kondensieren einer Verbindung der allgemeinen Formel (II)



(II)

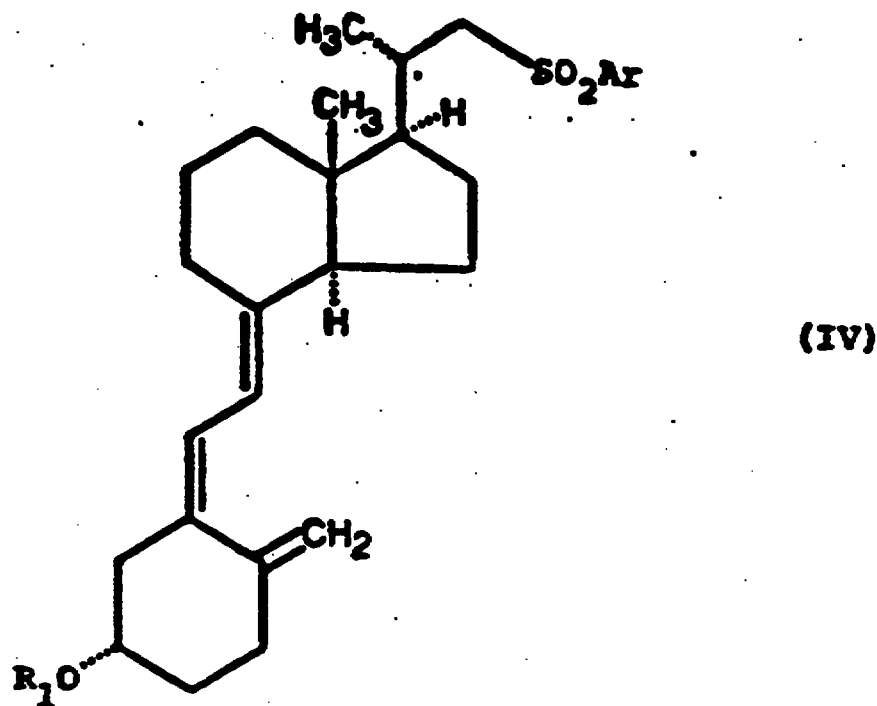
in der Ar monozyklisches Aryl ist, mit der (1R, 6R, 9R, 2'S)-Konfiguration, mit dem basenerzeugten Carbanion, das von einer Verbindung der Formel (III) abgeleitet ist



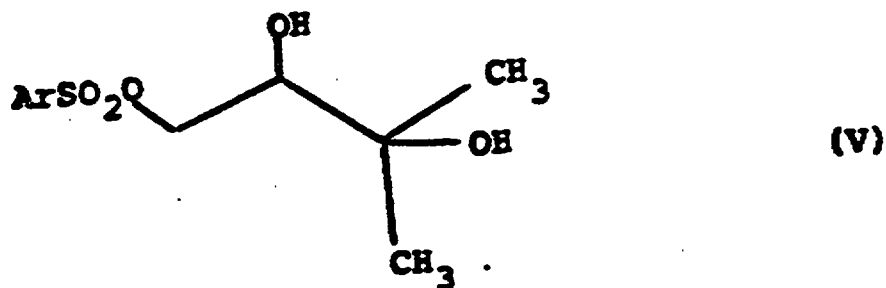
in der R_1 eine geeignete basenstabile Hydroxy-Schutzgruppe ist, mit der (S)-(Z)-Konfiguration.

14. Verfahren nach Anspruch 13, dadurch gekennzeichnet, daß die Kondensation in einem inerten aprotischen Lösungsmittel in Gegenwart von n-Butyllithium durchgeführt wird.

15. Verfahren für die Darstellung einer Verbindung nach Anspruch 10, gekennzeichnet durch das Umsetzen des basenerzeugten Carbanions, das aus der Verbindung der Formel (IV) abgeleitet ist



50 in der Ar und R_1 wie in Anspruch 1 definiert sind, mit dem 2(R)- oder 2(S)-Isomeren von 3-Methylbutan-1,2,3-triol-1arylsulfonat der Formel (V)



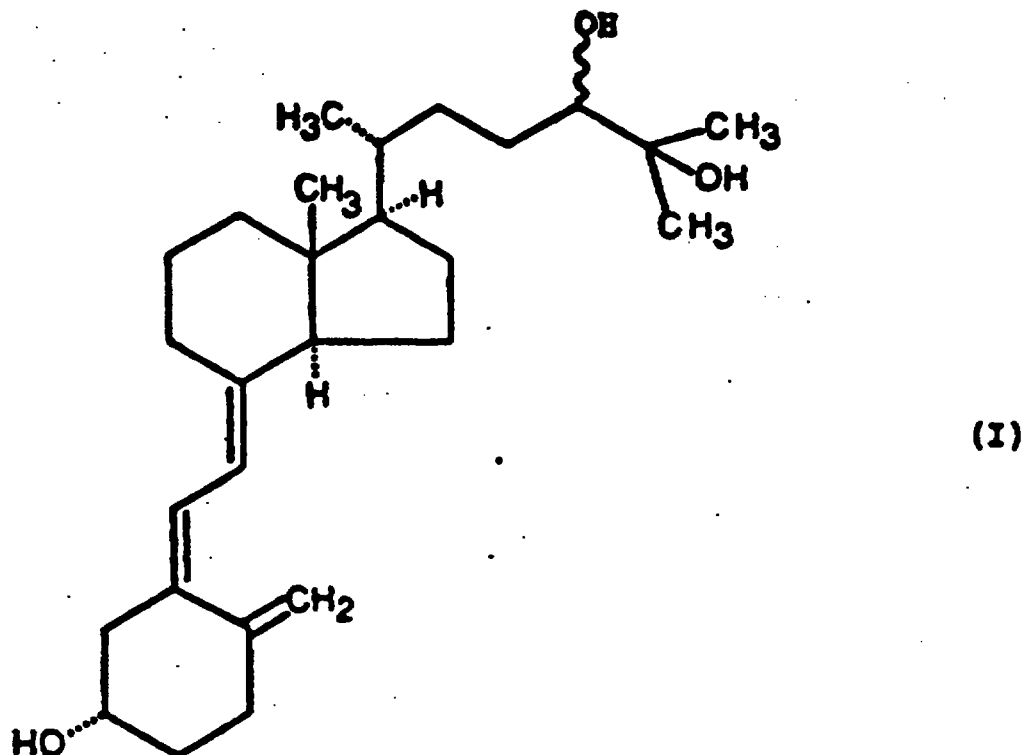
65 in der Ar wie oben definiert ist, in Gegenwart einer starken Base.



16. Verfahren gemäß Anspruch 15, dadurch gekennzeichnet, daß die Reaktion in einem inerten aprotischen Lösungsmittel in Gegenwart von überschüssigem η -Butyllithium durchgeführt wird.

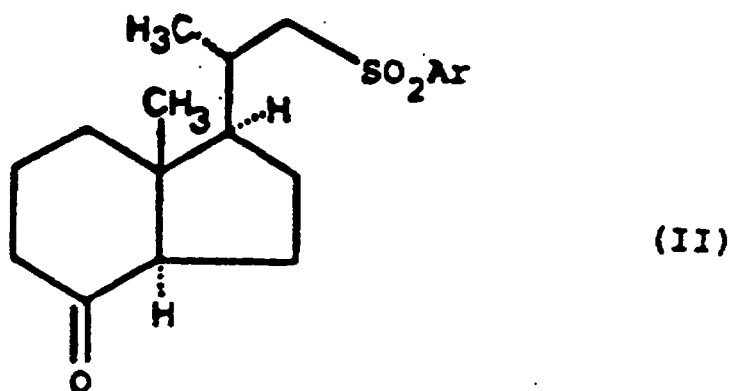
Revendications

1. Procédé de préparation stéréospécifique d'un 24(R),25- ou 24(S),25-dihydroxycholécalférol de formule générale (I)



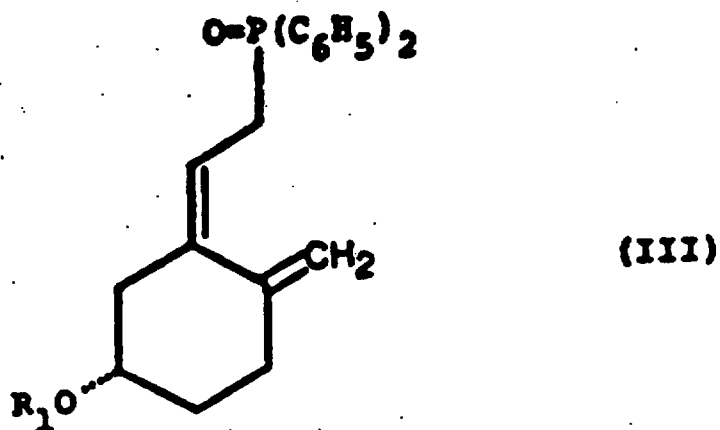
comprenant les étapes de:

a) condensation d'un composé de formule générale (II)

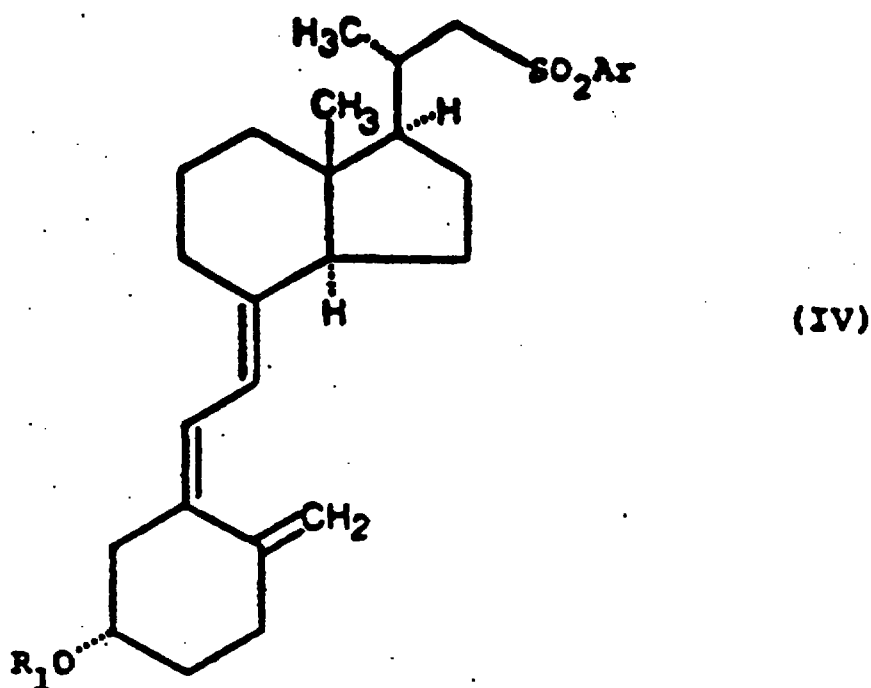


où

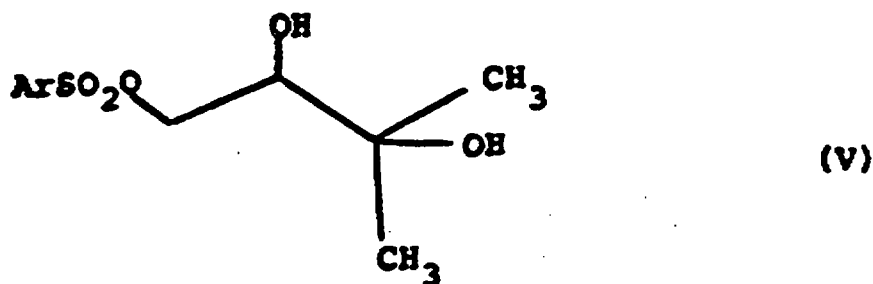
Ar est un aryle monocyclique, ayant la configuration (1R,6R,9R,2'S), avec le carbanion généré par une base dérivé d'un composé de formule (III)



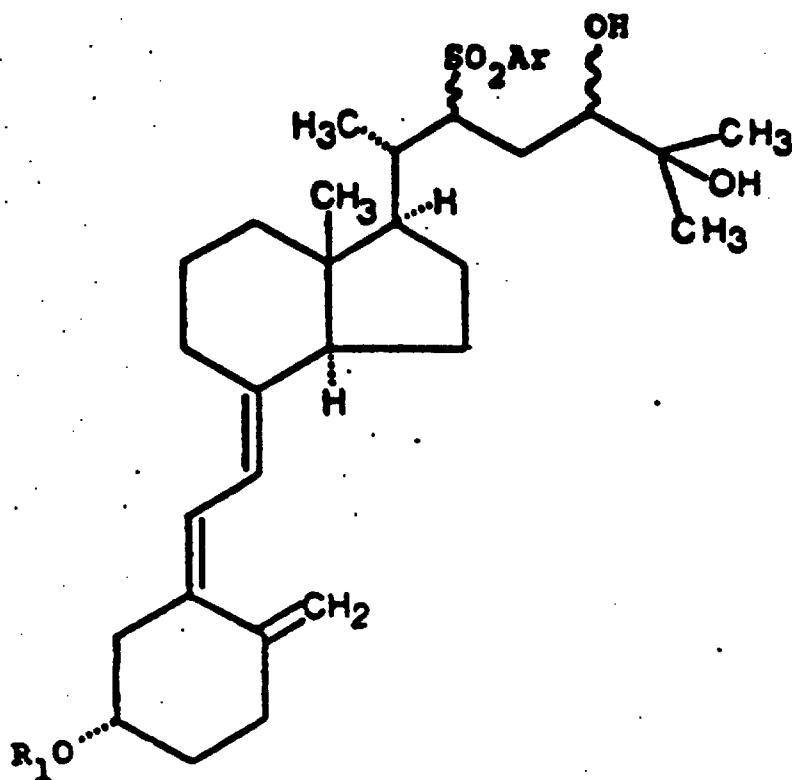
où
 R_1 est un groupe protecteur d'hydroxy stable vis à vis des bases approprié, ayant la configuration (S)-(Z), pour obtenir un composé de formule (IV)



où
 Ar et R_1 sont tels que définis ci-dessus;
 b) réaction du carbanion généré par une base dérivé du composé de formule (IV) ci-dessus avec l'isomère 2(R) ou 2(S) du 3-méthylbutane-1, 2, 3-triol-1-arylsulfonate de formule (V)



où
 Ar est tel que défini ci-dessus, en présence d'une base forte, pour obtenir un composé de formule (VI)



(VI)

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Ar et R_1 sont tels que définis ci-dessus:

c) séparation du groupe 22-sulfonyle du composé de formule (VI) ci-dessus par des procédés connus; et

d) séparation du groupe protecteur d'hydroxy R_1 du composé ainsi obtenu pour obtenir le composé de formule (I) désiré ci-dessus.

2. Procédé selon la revendication 1, où le composé de formule (I) préparé est le 24(R),25-dihydroxy-cholécalciférol.

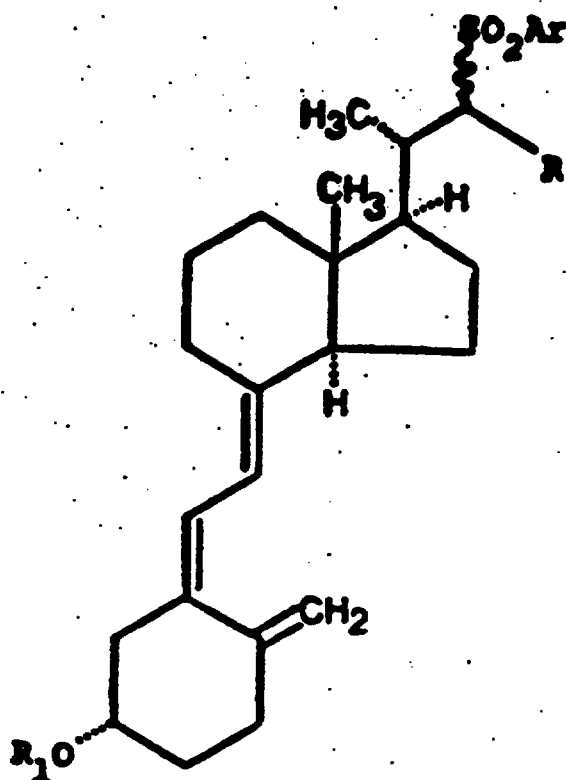
3. Procédé selon les revendications 1 ou 2, où R_1 dans les composés (III), (IV) et (Vi) est le tert.-butyldiméthylsilyle.

4. Procédé selon l'une quelconque des revendications précédentes dans lequel Ar dans les composés (II), (IV) et (VI) est le p-tolyle.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la réaction de condensation dans l'étape (a) est conduite dans un solvant aprotique inerte en présence de *n*-butyllithium.

6. Procédé selon l'une quelconque des revendications précédentes dans lequel la réaction dans l'étape (b) du procédé est conduite dans un solvant aprotique inerte en présence d'un excès de *n*-butyllithium.

7. Composés de formule générale (X)



(X)

dans lequel Ar et R₁ sont tels que définis dans la revendication 1 et R est un hydrogène ou un radical de formule $-\text{CH}_2-\dot{\text{C}}\text{H}(\text{OH})-\text{C}(\text{CH}_3)_2\text{OH}$, ayant la configuration (R) ou (S) à l'atome de carbone asymétrique.

8. Composés de formule (X) dans la revendication 7, où R est un hydrogène.

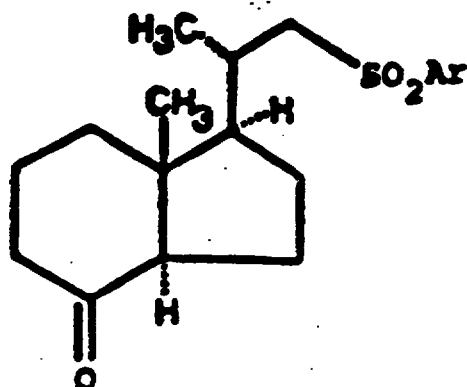
9. 3β-tert.-butyldiméthylsilyl-22-p-toluènesulfonyl-23,24,25,26,27-pentanorcholécalférol.

10. Composés selon la revendication 7 où R est le radical $-\text{CH}_2-\dot{\text{C}}\text{H}(\text{OH})-\text{C}(\text{CH}_3)_2\text{OH}$, ayant la configuration (R) ou (S) à l'atome de carbone asymétrique.

11. Composé selon la revendication 10, ayant la configuration 24(R).

12. 3β-tert.-butyldiméthylsilyl-24(R),25-dihydroxy-22-p-toluènesulfonylcholécalférol.

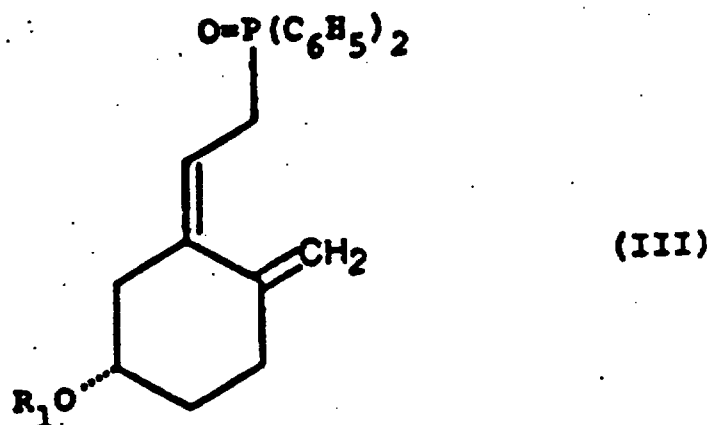
13. Procédé de préparation d'un composé selon la revendication 8, dans lequel on condense un composé de formule générale (II)



(II)

où

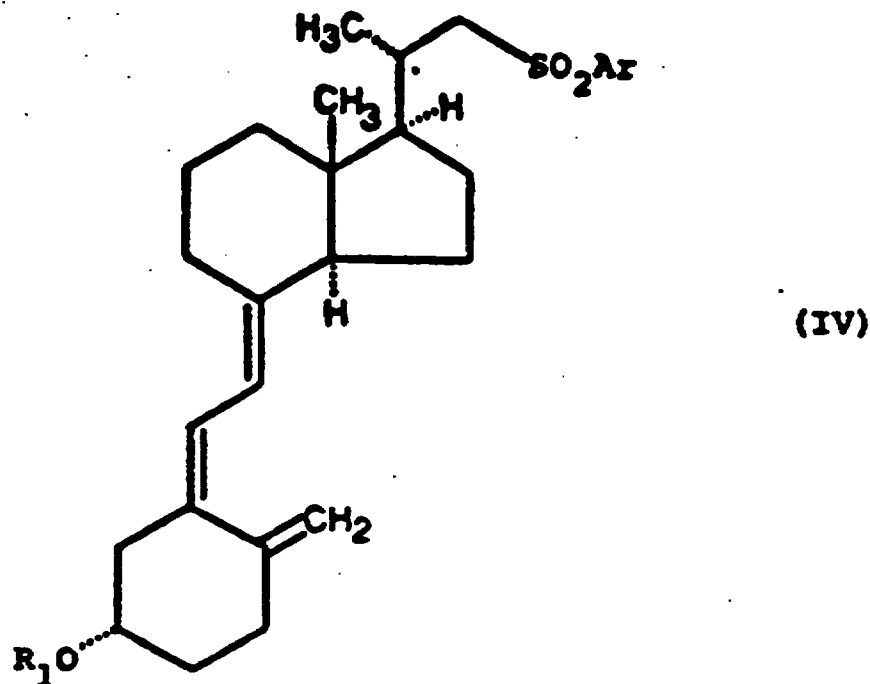
Ar est un aryle monocyclique, ayant la configuration (1R,6R,9R,2'S), avec le carbanion généré par une base dérivé d'un composé de formule (III)



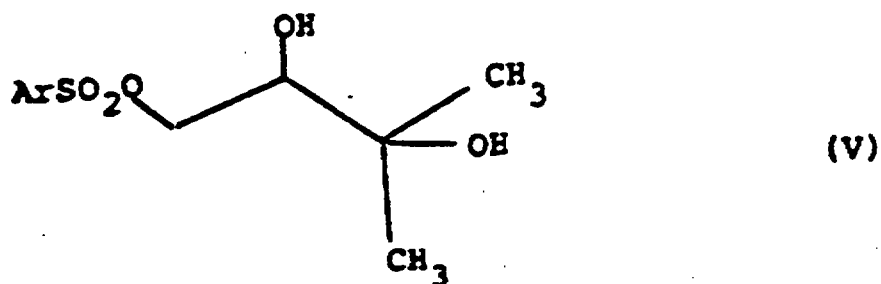
où R_1 est un groupe protecteur d'hydroxy stable vis à vis des bases approprié, ayant la configuration (S)-(Z).

14. Procédé selon la revendication 13, dans lequel la condensation est conduite dans un solvant aprotique inerte en présence de n-butyllithium.

15. Procédé de préparation d'un composé selon la revendication 10, dans lequel on fait réagir le carbanion généré par une base dérivé du composé de formule (IV)



dans lequel Ar et R_1 sont tels que définis dans la revendication 1, avec l'isomère 2(R) ou 2(S) du 3-méthylbutane-1, 2, 3-triol 1-arylsulfonate de formule (V)





où

Ar est tel que défini ci-dessus, en présence d'une base forte.

16. Procédé selon la revendication 15, dans lequel la réaction est conduite dans un solvant aprotique inerte en présence d'un excès de n-butyllithium.

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