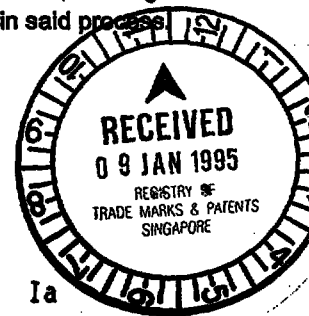
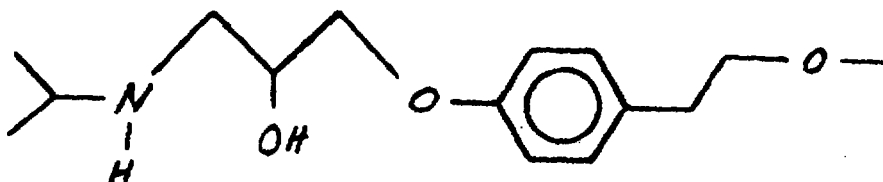


**Description**

The present invention is related to a novel process for preparing S-metoprolol, or a salt thereof, with high enantiomeric purity. The invention is also related to preparation of an intermediate employed in said process.

**Background art**

Metoprolol, having the formula



is a wellknown pharmaceutical compound having a strongly selective blocking effect on the cardiac  $\beta_1$ -receptors in animals and man, and being used *inter alia* in the treatment of hypertension, cardiac arrhythmias, angina pectoris and migraine. It is a well established fact that in metoprolol, like in other  $\beta$ -blockers the  $\beta$ -blocking effect resides only in the S-enantiomer, while possibly occurring side effects may reside in either or both enantiomers.

To our knowledge two earlier publications regarding the preparation of (S)-metoprolol exist. One of them, EP-A-179 031, relates to a chemical process for preparing (S)-metoprolol starting from D-mannitol which process differs from the process according to the present invention.

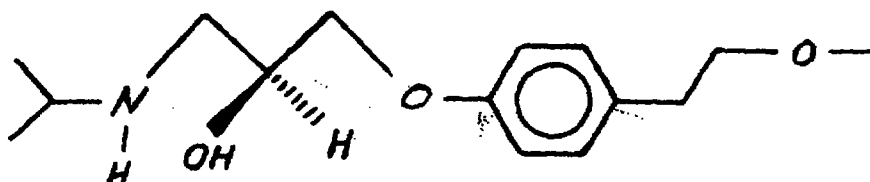
The other one DE-A-2 810 732 uses (4R)-2,2-dimethyl-1,3-dioxolan-4-carbaldehyde as the chiral starting material, originated from D-mannitol in two steps. The process is carried out through compound VII (shown below) via a reductive amination, ethoxycarbonylation, hydrolysis of the 1,3-dioxolan group and subsequent cyclisation of the carbaldehyde mentioned above. After reacting compound VII to the sulfonic acid ester II (shown below) several  $\beta$ -blockers are made in two further reaction steps through reaction with a suitable phenolic compound, followed by hydrolysis of the oxazolidinone to give (S)-metoprolol.

It is also known from Chemical Abstracts 97 (1982), p.676, 162 573n, that racemic alprenolol can be made from the racemic compound VII in a similar way as above. Racemic VII was prepared from 3-isopropylamino-1,2-propanediol in refluxing diethyl carbonate for 18 h. When carrying out said process, diethyl carbonate caused us some problems, either concerning the yield, purity and/or enantiomeric purity depending on the conditions used.

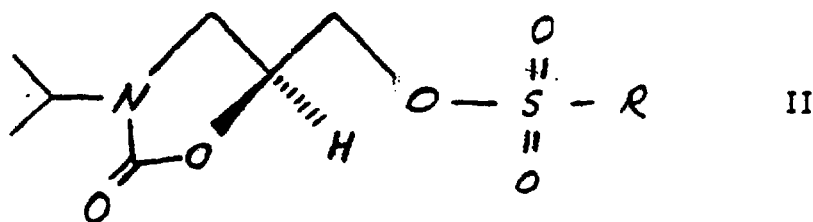
**Description of the invention**

The object of the present invention is to obtain a process for preparing S-metoprolol with very high enantiomeric purity. A further object is to obtain such a process enabling an economical and convenient preparation of S-metoprolol.

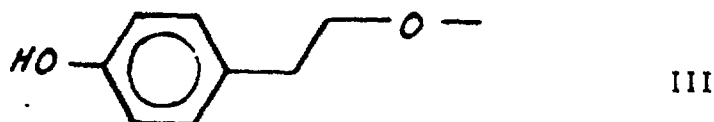
The invention is related to a process for preparing S-metoprolol of the formula



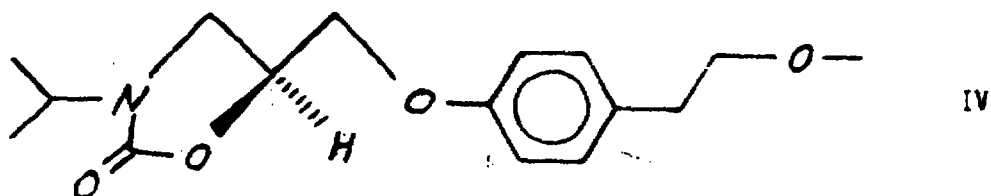
or a salt thereof, with high enantiomeric purity, whereby a (S)-5-hydroxymethyl-3-isopropylloxazolidin-2-one sulfonic acid ester of the formula



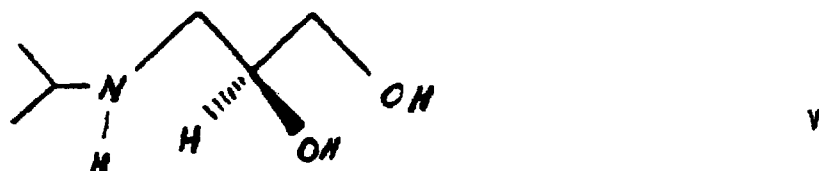
10 wherein R is tolyl, is prepared, and further reacted with 4-[2-methoxyethyl]phenol of the formula



20 and the resulting intermediate of the formula



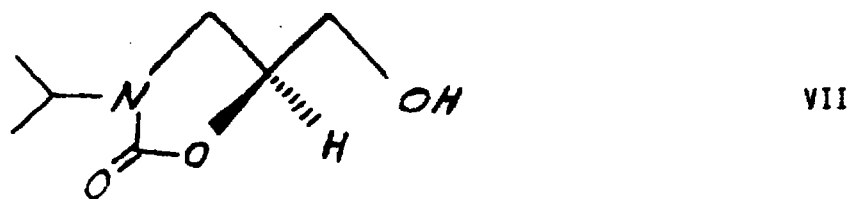
30 is hydrolysed to S-metoprolol. The novel process is characterized in that the (S)-5-hydroxymethyl-3-isopropoxyloxazolidin-2-one sulfonic acid ester of formula II is prepared by reacting (S)-3-isopropylamino-1,2-propandiol of the formula



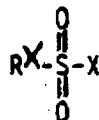
40 with a chloroformic acid ester of the formula



wherein R' is an alkyl group having 1-3 carbon atoms or a phenyl group, to the formation of (S)-5-hydroxymethyl-3-isopropoxyloxazolidin-2-one of the formula



55 which is reacted in a manner known per se with an activated sulfonic acid of the formula



wherein  $\text{R}^x$  is an aryl group such as tolyl and X is a halogen such as Cl, to formation of the ester of formula II, which when required is enriched with the (S)-enantiomer by crystallization.

By the present invention a S/R enantiomeric ratio of metoprolol greater than 99.0/1.0 may be obtained. The ratio 99.0/1.0 is expected to become a standard ratio for S-metoprolol as a pharmaceutical. The desired ratio is achieved by preparing the intermediate of formula II with high enantiomeric purity. It is an important finding by the inventors that said intermediate will be enriched with the S-enantiomer on crystallization. Thus, according to preferred embodiments of the invention, S-metoprolol with at least the desired enantiomeric ratio is obtained either by using the starting compound of formula V with a S/R enantiomer ratio of at least 95/5, and making several recrystallizations of the subsequently obtained intermediate II, or by using said starting compound with a S/R enantiomer ratio of at least 98/2, whereby normally a single crystallization of the intermediate II will suffice.

Furthermore, the inventors have found that the step of synthesis of the compound of formula VII proceeds without substantial racemization.

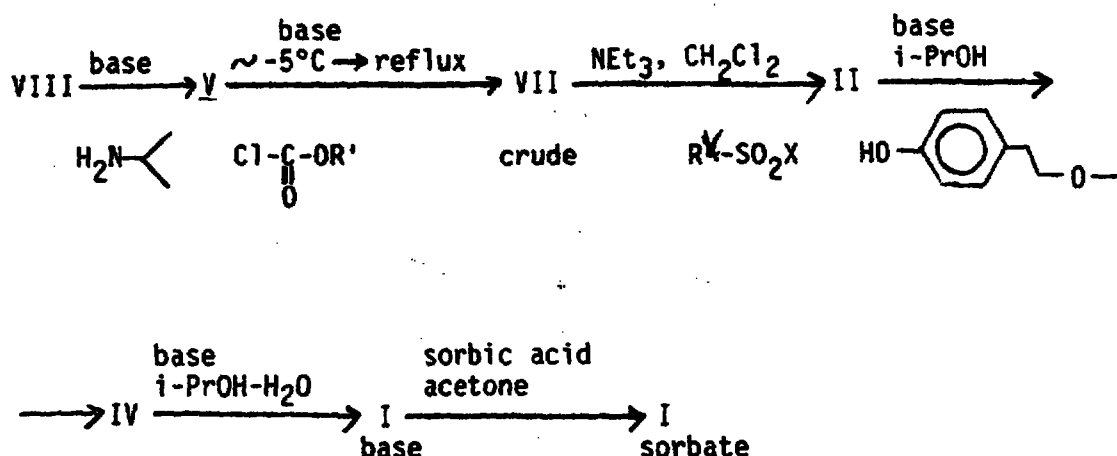
The starting material of formula V may be obtained by several routes such as reacting (R)-3-chloro-1,2-propanediol of the formula



VIII

which compound is described in Agric. Biol. Chem. 46 (1982) 1153, with isopropylamine in the presence of potassium carbonate in isopropyl alcohol. (It will of course be realized that compound VIII in R-form and compound V in S-form have the same configuration around the asymmetric carbon atoms, although the terminology is different.) This synthesis proceeds without substantially changing the enantiomeric ratio. Thus, the process of the invention may suitably be started with the compound of formula VIII with the same enantiomeric ratio as required for the compound of formula V. There will then usually not be any need to isolate the compound of formula V.

The process of the invention may suitably be carried out under the following conditions



A further aspect of the invention is a process for preparing the intermediate of formula II, said process comprising the reaction steps V to VII to II as described above.

Pharmaceutical preparations of S-metoprolol and salts thereof, and of the sorbate in particular may be obtained as known for racemic metoprolol, and in particular as known from EP-A1-0 220 143. It will of course

be realized that only half the amount of active compound will be required for a dosage unit, as compared with racemic metoprolol.

Pharmaceutically acceptable acid addition salts of S-metoprolol will be evident for one of ordinary skill in the art and include, but are not limited to those known for racemic metoprolol, and in particular the sorbate, succinate and tartrate.

The invention is further illustrated by the following examples:

#### Example 1

##### Step 1. (S)-3-isopropylamino-1,2-propandiol (compound 1)

A mixture of potassium carbonate (5.60 kg, 40.5 mol), water (1.10 kg, 61.1 mol) and isopropanol (23 l) was stirred at room temperature for two and a half hours. The formation of potassium carbonate sesquihydrate was checked using TGA.

(R)-3-chloro-1,2-propandiol (4.50 kg, 40.7 mol) was subsequently added and the mixture cooled to 10°C. Isopropyl amine (16.8 kg, 284 mol) was added during 30 minutes. After completed addition the mixture was heated to 40°C and stirred for 14 hours, after which the temperature was increased to 45°C and stirred for another six hours to complete the reaction.

The mixture was filtered, the solids were washed with isopropanol (25 l) and the filtrate was evaporated in vacuo.

Isopropanol (30 l) was added to the resulting oil, and the solution was evaporated in vacuo to yield (S)-3-isopropylamino-1,2-propandiol as an oil. The product was used directly in the following step without further purification.

Purity GC: 94 %

Water content: 1.3 % (w/w) (Karl Fischer)

##### Step 2. (S)-5-hydroxymethyl-3-isopropyl-oxazolidin-2-one (compound 2)

Potassium carbonate (6.10 kg, 44.1 mol), water (1.03 kg, 57.2 mol) and isopropanol (15 l) were added to the oily (S)-3-isopropylamino-1,2-propandiol. The mixture was stirred at room temperature for three hours. The formation of potassium carbonate sesquihydrate was checked using TGA.

Ethyl chloroformate (3.94 kg, 36.3 mol) was added during one hour to the cooled mixture, keeping the temperature at -5°C. After completed addition, the mixture was stirred for another two hours at -5°C. The mixture was then heated to reflux (83°C), stirred for 18 hours and filtered. The solids were washed with isopropanol (15 l) and the filtrate was evaporated in vacuo to yield a yellow oil. Toluene (20 l) was added and the resulting solution was evaporated in vacuo. This was repeated once, yielding (S)-5-hydroxy-methyl-3-isopropyl-oxazolidin-2-one as a semicrystalline oil containing <1 % of isopropanol. The product was used directly in the following step without further purification.

Purity GC: 94 %

##### Step 3. (S)-3-isopropyl-5-p-toluenesulfonyloxymethyl-oxazolidin-2-one (compound 3)

To a stirred solution of (2) and triethylamine (4.70 kg, 46.4 mol) in methylene chloride (25 l) at 0°C, p-toluenesulfonylchloride (7.65 kg, 40.1 mol) was added during 30 minutes. The mixture was stirred for 20 hours at room temperature and then quenched by adding water (8 l). The aqueous layer was separated off and the organic phase was washed with aqueous sodium bicarbonate (4 l, 5 %), followed by water (4 l) adjusted to pH = 4 with hydrochloric acid (6 M, 0.9 l). The organic phase was dried with sodium sulfate (0.65 kg), filtered and evaporated to give an oil. Isopropanol (10 l) was added to give a slurry, which was evaporated in vacuo once more.

Isopropanol (36 l) was added and the slurry was heated to 40°C. The resulting solution was allowed to cool slowly to -5°C. The crystals were filtered off and washed with cold isopropanol (10 l), yielding 13.84 kg (wet weight) of (S)-3-isopropyl-5-p-toluene-sulfonyloxymethyl-oxazolidin-2-one. This corresponds to 7.90 kg of dry weight (62 % from (1)).

Melting point: 75°C

Purity GC: 93-96 %

Purity TLC: one minor impurity

Optical rotation:  $[\alpha]_D^{20.3} = +53.7^\circ$  (C = 0.90 CHCl<sub>3</sub>)

Step 4. (S)-metoprolol base or (S)-1-isopropylamino-3-[p-(2-methoxy-ethyl)phenoxy]-2-propanol (compound 4)

Potassium carbonate (4.70 kg, 34.0 mol), water (0.90 kg, 50.0 mol) and isopropanol (66 l) were stirred at room temperature for two hours. 2-Methoxyethylphenol (5.17 kg, 34.0 mol) in isopropanol (3.5 l), followed by (3) (13.84 kg (wet), 25.2 mol) were added. The mixture was heated to reflux (83°C) and stirred for 18 hours. GC and TLC indicated a complete conversion giving (S)-3-isopropyl-5-[4-(2-methoxyethyl)-phenoxy-methyl]-oxazolidin-2-one. To the refluxing mixture, potassium hydroxide (7.30 kg, 130 mol) in water (9.1 kg) was added. The mixture was stirred, still at reflux, for another 20 hours, filtered and the filtrate was evaporated in vacuo. Toluene (15 l) was added and the solution was evaporated in vacuo, to yield an oil. Toluene (30 l) and water (8 l) were added to the oil and the two-phase system was stirred for one hour. The aqueous phase was separated off. To the organic phase, water (30 l) and sulfuric acid (6 M, 1.75 l) were added to give pH 5. The organic phase was separated off and toluene (30 l) was added to the aqueous phase. Sodium hydroxide (45 %, 1.40 l) was added to give pH > 12 and the aqueous phase was separated off. The organic phase was washed with water (5 l) and evaporated in vacuo to yield an oil. Acetone (20 l) was added and the solution was evaporated in vacuo. This was repeated twice and finally the oil was diluted with 20 litres of acetone, yielding 36.35 kg of a solution containing 0.53 mol of metoprolol base per kg of solution (76 % from (3)). Purity GC: 90 %.

Step 5. (S)-metoprolol sorbate or (S)-1-isopropylamino-3-[p-(2-methoxyethyl)-phenoxy]-2-propanol sorbate (compound 5)

To the stirred acetone solution of metoprolol base (19.3 mol), acetone (30 l) and sorbic acid (2.12 kg, 18.9 mol) were added at room temperature. The mixture was heated to reflux and the hot solution was filtered. The filtrate was allowed to cool slowly to 0°C. The crystals were centrifugated off, washed with cold acetone (10 l) and dried for three days in vacuo at room temperature to yield 5.95 kg of crystalline (S)-metoprolol. (81 % from (4)).

Melting point: 113°C

Purity GC: 100.0 %

Purity HPLC: 100.0 %

R/S (HPLC): 0.1/99.9

By concentrating the mother liquor, an additional 560 g of (S)-metoprolol sorbate was obtained. (7 % from (4)). Purity HPLC: 99.9 %

R/S (HPLC): 0.0/100.0

Giving a total yield of 88 % from (4)

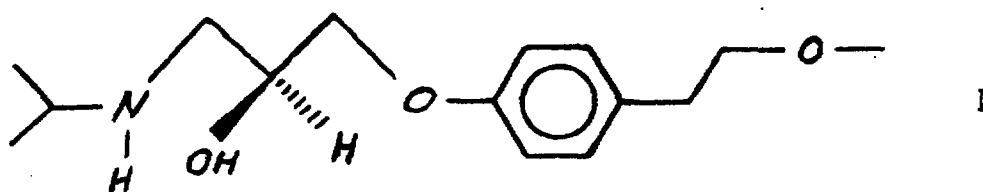
Example 2

Example 1 was repeated in laboratory scale with different R/S enantiomeric ratios of compound 1.

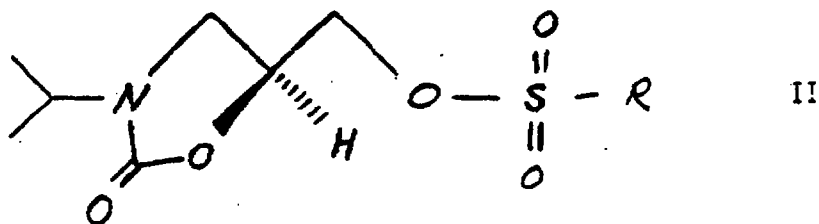
|                                         |                     |          |          |          |
|-----------------------------------------|---------------------|----------|----------|----------|
| Compound 1                              | R/S:                | 10/90    | 5.0/95.0 | 2.4/97.6 |
| Compound 2                              | Yield:              | 75%      | 74%      | 71%      |
| Compound 3                              | Yield:              | 55%      | 64%      | 62%      |
|                                         | $[\alpha]_D^{20}$ : | +42.2°   | +47.6°   | +52.7°   |
| Compound 3<br>recrystallized            | Yield:              |          | 83%      |          |
|                                         | $[\alpha]_D^{20}$ : |          | +48.9°   |          |
| Compound 5<br>(S-metoprolol<br>sorbate) | R/S:                | 9.5/90.5 | 3.5/96.5 | 3.0/97.0 |
|                                         |                     |          |          | 0.1/99.9 |

## Claims

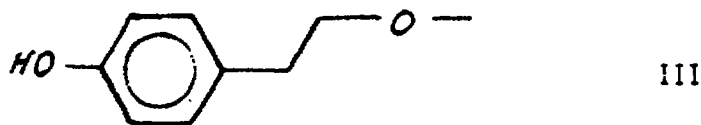
1. A process for preparing S-metoprolol of the formula



or a salt thereof, with high enantiomeric purity, whereby a (S)-5-hydroxymethyl-3-isopropoxyoxazolidin-2-one sul-  
fonic acid ester of the formula



wherein R is tolyl, is prepared, and further reacted with 4-[2-methoxyethyl]phenol of the formula



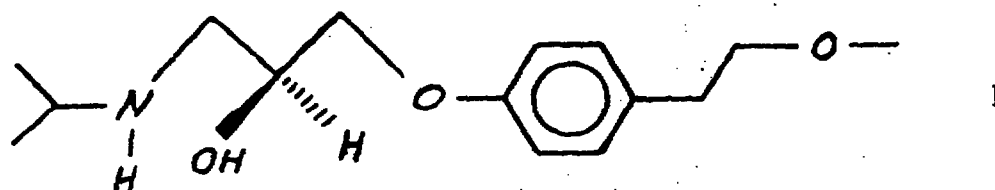
and the resulting intermediate of the formula



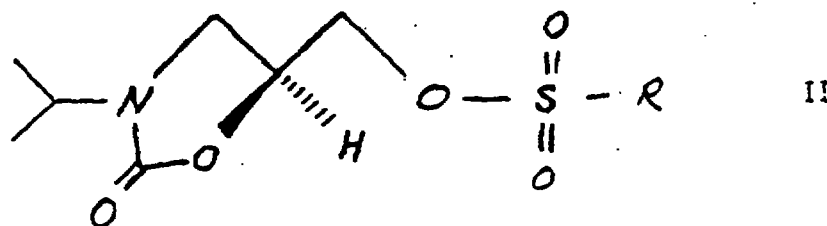
|                                         |                     |          |          |          |
|-----------------------------------------|---------------------|----------|----------|----------|
| Compound 1                              | R/S:                | 10/90    | 5.0/95.0 | 2.4/97.6 |
| Compound 2                              | Yield:              | 75%      | 74%      | 71%      |
| Compound 3                              | Yield:              | 55%      | 64%      | 62%      |
|                                         | $[\alpha]_D^{20}$ : | +42.2°   | +47.6°   | +52.7°   |
| Compound 3<br>recrystallized            | Yield:              |          | 83%      |          |
|                                         | $[\alpha]_D^{20}$ : |          | +48.9°   |          |
| Compound 5<br>(S-metoprolol<br>sorbate) | R/S:                | 9.5/90.5 | 3.5/96.5 | 3.0/97.0 |
|                                         |                     |          |          | 0.1/99.9 |

## Claims

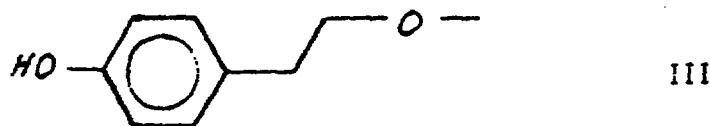
1. A process for preparing S-metoprolol of the formula



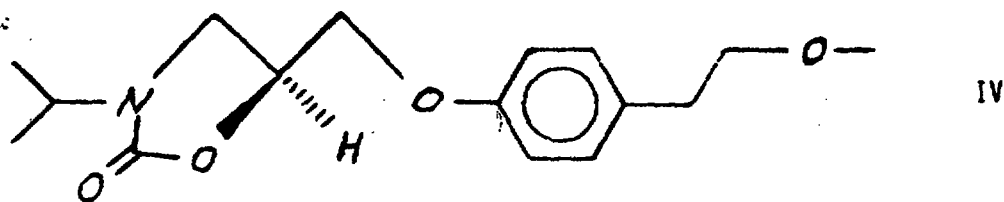
or a salt thereof, with high enantiomeric purity, whereby a (S)-5-hydroxymethyl-3-isopropyl-oxazolidin-2-one sulfonic acid ester of the formula



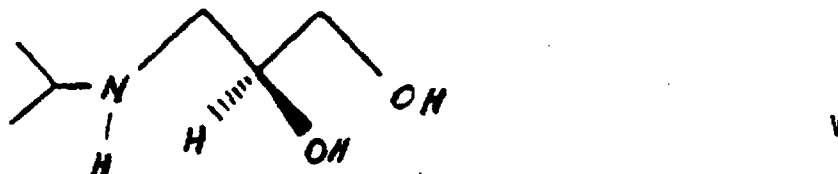
wherein R is tolyl, is prepared, and further reacted with 4-[2-methoxyethyl]phenol of the formula



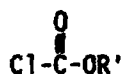
and the resulting intermediate of the formula



10 is hydrolysed to S-metoprolol, characterized in that the (S)-5-hydroxymethyl-3-isopropyl-2-oxazolidinone sulfonic acid ester of formula II is prepared by reacting (S)-3-isopropylamino-1,2-propanediol of the formula

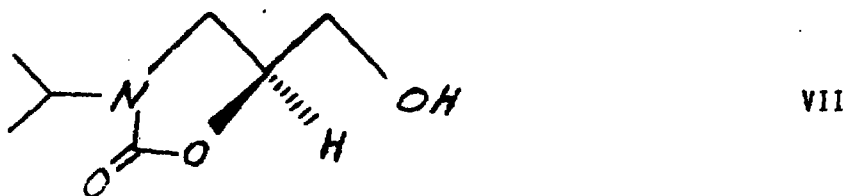


20 with a chloroformic acid ester of the formula

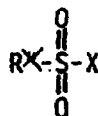


VI

wherein R' is an alkyl group having 1-3 carbon atoms or a phenyl group, to the formation of (S)-5-hydroxymethyl-3-isopropyl-2-oxazolidinone of the formula



35 which is reacted in a manner known per se with an activated sulfonic acid of the formula



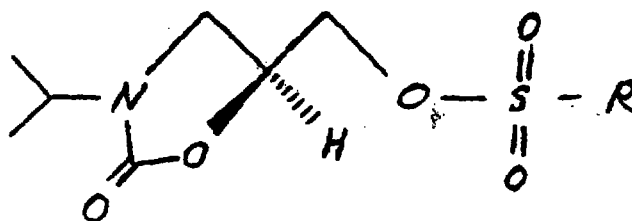
45 wherein R<sup>x</sup> is tolyl and X is Cl, to formation of the ester of formula II, which when required is enriched with the (S)-enantiomer by crystallization.

2. A process according to claim 1, characterized in using the compound of formula V with a S/R enantiomer ratio of at least 95/5, and making several recrystallizations of the compound of formula II to obtain S-metoprolol or a salt thereof with a S/R enantiomer ratio of at least 99.0/1.0.

3. A process according to claim 1, characterized in using the compound of formula V with a S/R enantiomer ratio of at least 98/2 to obtain S-metoprolol or a salt thereof with a S/R enantiomer ratio of at least 99.0/1.0.

4. A process according to one or more of the preceding claims, characterized in isolating the compound of formula I as the sorbate.

5. A process for preparing a (S)-5-hydroxymethyl-3-isopropyl-2-oxazolidinone sulfonic acid ester of the formula



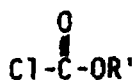
II

or a salt thereof, with high enantiomeric purity, characterized in reacting (S)-3-isopropylamino-1,2-propanediol of the formula



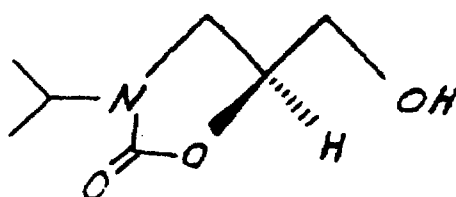
V

with a chloroformic acid ester of the formula



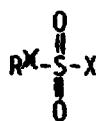
VI

wherein R' is an alkyl group having 1-3 carbon atoms or a phenyl group, to the formation of (S)-5-hydroxymethyl-3-isopropylloxazolidin-2-one of the formula



VII

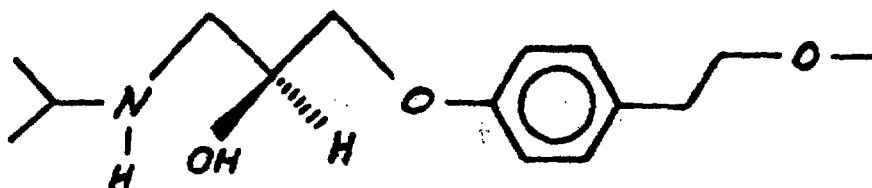
which is reacted in a manner known per se with an activated sulfonic acid of the formula



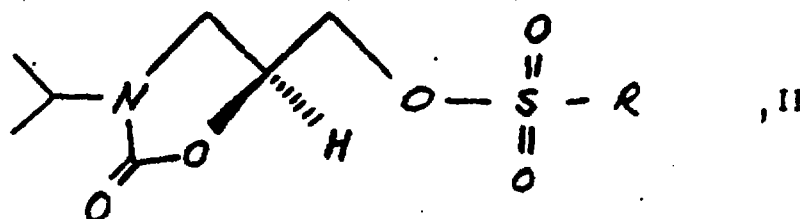
wherein R<sup>x</sup> is tolyl and X is Cl, to formation of the ester of formula II, which when required is enriched with the (S)-enantiomer by crystallization.

### Patentansprüche

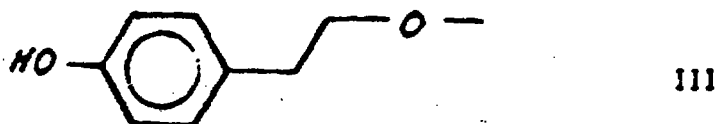
1. Verfahren zur Herstellung von S-Metoprolol der Formel



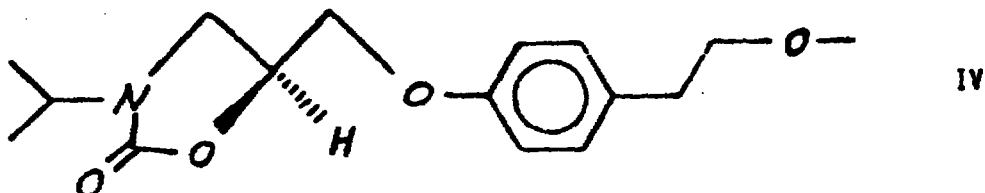
oder eines Salzes davon, mit hoher enantiomerer Reinheit, wobei ein (S)-5-Hydroxymethyl-3-isopropylloxazolidin-2-on-sulfonsäureester der Formel



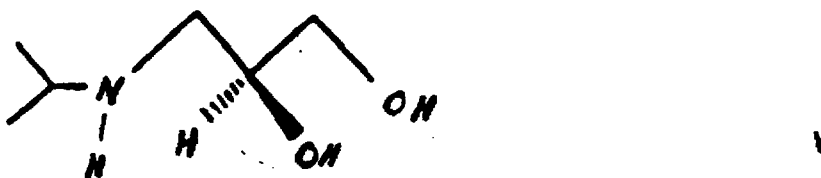
worin R TolyI bedeutet, hergestellt wird und weiter umgesetzt wird mit 4-[2-Methoxyäthyl]-phenol der Formel



und das resultierende Zwischenprodukt der Formel



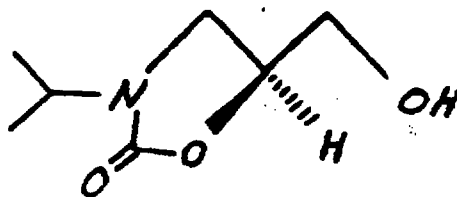
zu S-Metoprolol hydrolysiert wird, dadurch gekennzeichnet, daß der (S)-5-Hydroxymethyl-3-isopropylloxazolidin-2-on-sulfonsäureester der Formel II hergestellt wird durch Umsetzung von (S)-3-Isopropylamino-1,2-propandiol der Formel



mit einem Chlorameisensäureester der Formel

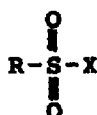


worin R' eine Alkylgruppe mit 1-3 Kohlenstoffatomen oder eine Phenylgruppe bedeutet, zur Bildung von (S)-5-Hydroxymethyl-3-isopropylloxazolidin-2-on der Formel



, VII

welches in an sich bekannter Weise umgesetzt wird mit einer aktivierten Sulfonsäure der Formel



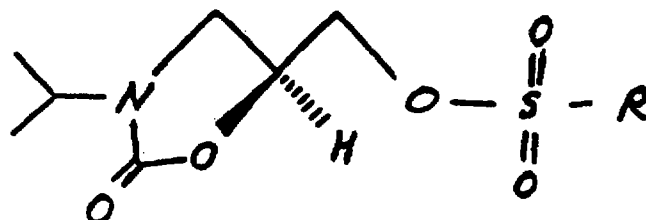
worin R TolyI bedeutet und X für Cl steht, zur Bildung des Esters der Formel II, welcher, wenn erforderlich, mit dem (S)-Enantiomeren durch Kristallisation angereichert wird.

2. Verfahren nach Anspruch 1, gekennzeichnet durch die Verwendung der Verbindung der Formel V mit einem S/R-Enantiomerenverhältnis von mindestens 95/5, und die Durchführung mehrerer Umkristallisierungen der Verbindung der Formel II zum Erhalt von S-Metoprolol oder einem Salz davon mit einem S/R-Enantiomerenverhältnis von mindestens 99,0/1,0.

3. Verfahren nach Anspruch 1, gekennzeichnet durch die Verwendung der Verbindung der Formel V mit einem S/R-Enantiomerenverhältnis von mindestens 98/2 zum Erhalt von S-Metoprolol oder einem Salz davon mit einem S/R-Enantiomerenverhältnis von mindestens 99,0/1,0.

4. Verfahren nach einem oder mehreren der vorhergehenden Ansprüche, gekennzeichnet durch die Isolierung der Verbindung der Formel I als Sorbat.

5. Verfahren zur Herstellung eines (S)-5-hydroxymethyl-3-isopropylloxazolidin-2-on-sulfonsäureesters der Formel



II

oder eines Salzes davon, mit hoher enantiomerer Reinheit, gekennzeichnet durch die Umsetzung von (S)-3-Isopropylamino-1,2-propandiol der Formel



V

mit einem Chlorameisensäureester der Formel

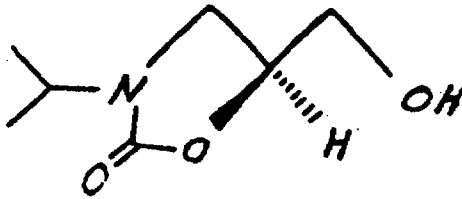


, VI

worin R' eine Alkylgruppe mit 1-3 Kohlenstoffatomen oder eine Phenylgruppe ist, zur Bildung von (S)-5-Hydroxymethyl-3-isopropylloxazolidin-2-on der Formel



VII



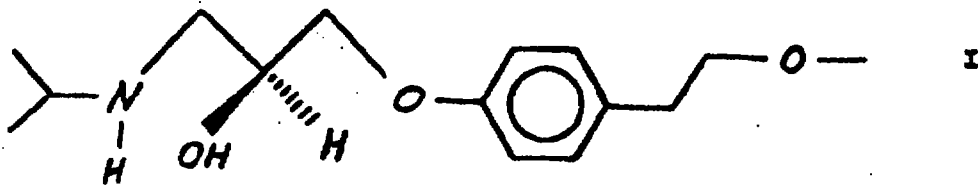
welches auf an sich bekannte Weise umgesetzt wird mit einer aktivierten Sulfonsäure der Formel



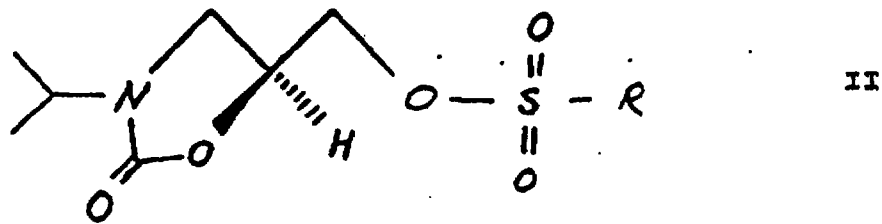
worin R Tolyl bedeutet und X für Cl steht, zur Bildung des Esters der Formel II, der, wenn erforderlich, mit dem (S)-Enantiomeren durch Kristallisation angereichert wird.

### Revendications

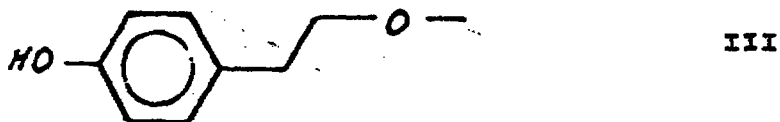
1. Un procédé pour la préparation du S-métoprolol de formule



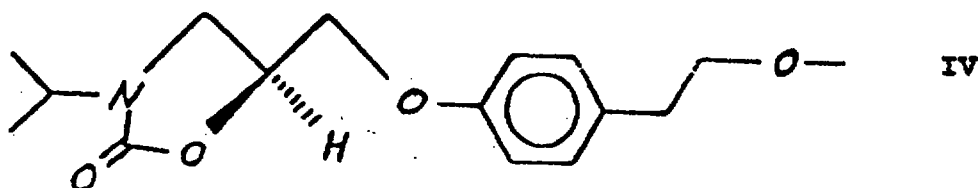
ou d'un sel de ce dernier, à un haut degré de pureté énantiomère, par lequel on prépare un ester de l'acide (S)-5-hydroxyméthyl-3-isopropyl-2-oxazolidine-2-one sulfonique de formule



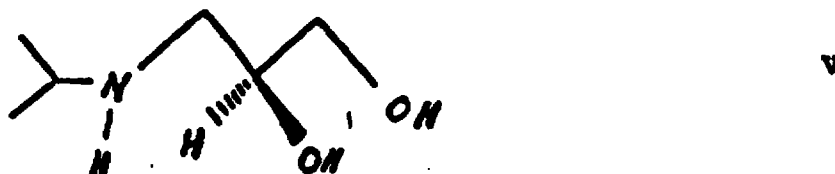
dans laquelle R représente le groupement tolyle, que l'on fait ensuite réagir avec du 4-[2-méthoxyéthyl]phénol de formule



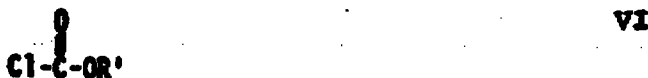
et l'on hydrolyse le produit intermédiaire de formule



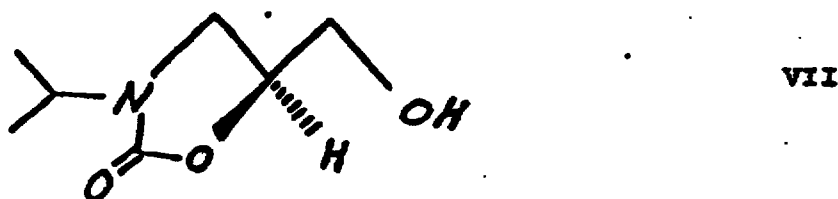
qui résulte de la réaction, en S-métoprolol, caractérisé par le fait que l'ester de l'acide (S)-5-hydroxyméthyl-3-isopropyl-oxazolidine-2-one sulfonique de formule II se prépare par réaction avec le (S)-3-isopropylamino-1,2-propanediol de formule



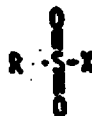
avec un ester de l'acide chloroformique de formule



dans laquelle R' représente un groupement alkyle possédant 1-3 atomes de carbone ou un groupement phényle, jusqu'à formation de la (S)-5-hydroxyméthyl-3-isopropyl-oxazolidine-2-one de formule



que l'on fait réagir de façon intrinsèquement connue avec un acide sulfonique activé de formule



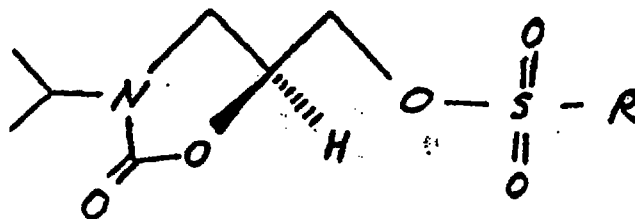
dans laquelle R représente le groupement tolyle et X représente Cl, jusqu'à formation de l'ester de la formule II, que l'on enrichit, quand cela est nécessaire, de l'énantiomère S par cristallisation.

2. Un procédé selon la revendication 1, caractérisé par l'emploi du composé de la formule V dans un rapport d'énantiométrie S/R d'au moins 95/5, et par la réalisation de plusieurs recristallisations du composé de la formule II afin d'obtenir du S-métoprolol ou un sel de ce dernier dans un rapport d'énantiométrie S/R d'au moins 99.0/1.0.

3. Un procédé selon la revendication 1, caractérisé par l'emploi du composé de la formule V dans un rapport d'énantiométrie S/R d'au moins 98/2 afin d'obtenir du S-métoprolol ou un sel de ce dernier dans un rapport d'énantiométrie S/R d'au moins 99.0/1.0.

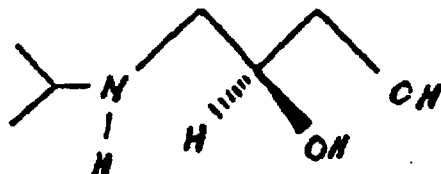
4. Un procédé selon une ou plusieurs des revendications précédentes, caractérisé par l'isolation du composé de la formule I en tant que produit d'absorption.

5. Un procédé pour la préparation d'un ester de l'acide (S)-5-hydroxyméthyl-3-isopropyl-oxazolidine-2-one sulfonique de formule



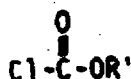
II

ou d'un sel de ce dernier, à un haut degré de pureté énantiomère, caractérisé par la réaction du (S)-3-isopropylamino-1,2-propanediol de formule



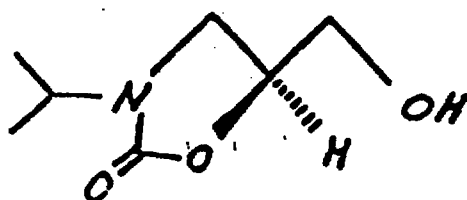
V

avec un ester de l'acide chloroformique de formule



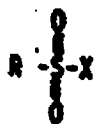
VI

dans laquelle R' représente un groupement alkyle possédant 1-3 atomes de carbone ou un groupement phényle, jusqu'à formation de la (S)-5-hydroxyméthyl-3-isopropyl-oxazolidine-2-one de formule



VII

que l'on fait réagir de façon intrinsèquement connue avec un acide sulfonique activé de formule



dans laquelle R représente le groupement toyle et X représente Cl, jusqu'à formation de l'ester de la formule II, que l'on enrichit, quand cela est nécessaire, de l'énantiomère S par cristallisation.