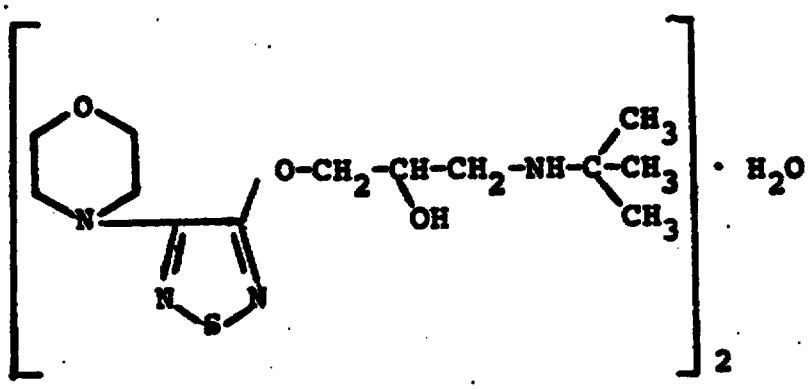
Description

The object of the present invention is a novel crystalline S-timolol derivative, in particular a novel hydrate form of S-timolol. The object of the invention is also a process for the preparation of this novel S-timolol derivative.

S-timolol, i.e. S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxypropoxy)-1,2,5-thiadiazole and its acid addition salts, are known pharmacologically valuable β-blocking agents. In pharmaceutical preparations S-timolol is, as a rule, used as maleate salt, which, being a well crystallizing salt, has clear advantages compared to the free S-timolol base. The free S-timolol base is namely an oily sticky substance and thus difficult to process further, for example to purify and to dose. The use of the free S-timolol base in certain pharmaceutical preparations, especially in so called transdermal medicated patches or bandages, involves, however, advantages as compared to the acid addition salts as regards their penetration through the skin. Thus the EP publication EP-A-0197504 discloses a transdermal delivery system, wherein use is made of i.a. timolol maleate, which is transformed to the nonionic, more easily absorbed timolol base form with a buffer. In the delivery system a solvent is used in which both the salt form and the free base form are soluble. The concentration of the timolol base form in the system is regulated with the pH of the buffer. From the viewpoint of easy manufacture of e.g. the transdermal system, it would be of advantage to prepare a S-timolol compound in the base form which crystallizes well in a non-sticky manner, which may be isolated in a pure form and which may be exactly dosed, and which at the same time exhibits a good penetration capacity when used in medicated bandages.

Now it has surprisingly been discovered that S-timolol may easily be crystallized as the hemihydrate compound. Thus the object of the invention is, as a novel compound, S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxypropoxy)-1,2,5-thiadiazol hemihydrate of the formula



This compound, as obtained in a stable crystalline form, and the preparation thereof, are not known from the prior art. The well-crystallized and stable compound according to the invention may thus find use in applications, e.g. medicated bandages, where the exact dosing of the active ingredient in base form is of importance.

The structure of the compound has been elucidated using X-ray diffraction. The results indicate for the compound a crystal structure wherein four S-timolol base molecules and two water molecules are situated in the same unit cell, the hydrophilic parts (-NH, -OH) of each pair of two S-timolol molecules being arranged around one water molecule. The hydrogen bridges formed by the water molecule and the two polar groups, along with the favourable lipophilic intermolecular forces, existing in the crystal lattice provide for optimal packing of the molecules. Because of the above mentioned molecular arrangement, S-timolol hemihydrate may be crystallized in an optical purity of 100% e.e., which means that S-timolol hemihydrate and the crystallization procedure may also be used for purification purposes, e.g. small amounts of the corresponding R-timolol enantiomer generally encountered in the starting material prepared by any current method, may be removed completely. The molecular arrangement in the crystal lattice along with easily controlled crystal growth is the reason for this surprisingly simple removal of impurities in one single crystallization step.

The appended Fig. 1 discloses the arrangement of S-timolol hemihydrate in the unit cell, omitting the hydrogen atoms.

The crystal structure for S-timolol hemihydrate (single crystals from water-methylene chloride) was measured with a Enraf-Nonius CAD-4 diffractometer using graphite-monochromatized MoK_α (0.71073 Å) and ω-2θ method at 21 °C. The cell parameters and orientation matrix were determined from 18 reflections ($6 < \theta < 10°$). The measuring rate (° min^{-1}) was 0.87 - 16.5, width (θ) 0.5 + 0.344tan θ and area (θ) 2 - 25. The following crystal data were obtained: space group monoclinic, C2 (No 5); a = 23.435(3) Å, b = 6.384(8) Å, c = 11.591(1) Å, α = 90.00 °, β = 103.081(1) °, γ = 90.00 °, V = 1687(3) Å , Z = 2, d = 1.281 gcm^{-3}.

The results obtained with a NMR spectrometer support the above obtained X-ray diffraction results (Instrument Bruker AC 250/Aspect 3000). ^{1}H-NMR (solvent $CDCl_3$) δ (ppm): 1.09 (s, 9H), 2.0 (b, appr. 2.5H), 2.57 (d+d, 1H; 12.0 and 8.0 Hz), 2.80 (d+d, 1H; 12.0 and 4.0 Hz), 3.52 (m, 4H), 3.79 (m, 4H), 3.91 (m, 1H), 4.36 (d+d, 1H; 11.1 and 5.8 Hz), 4.47 (d+d, 1H; 11.1 and 4.1 Hz). ^{13}C-NMR (solvent $CDCl_3$) δ (ppm): 28.91 (q), 50.24 (s), 44.33 (t), 66.10 (d), 72.76 (t), 153.66 (s), 149.78 (s), 47.78 (t), 66.33 (t).

S-timolol hemihydrate has also been analyzed thermogravimetrically (Perkin Elmer, TGS-2 thermogravimetric analyzer and attached differential scanning DSC 4 calorimeter). The TG graph indicates splitting off of the hydrate water at about 50 °C, the DSC gives a melting point of 53.3 °C.

According to the invention the novel crystalline S-timolol hemihydrate may be prepared in a very simple manner by crystallizing the same from a solution prepared with an aqueous organic solvent or solvent mixture of the S-timolol base. As a starting material, also a salt of the S-timolol base, for example the maleate salt, may be used, whereby the free S-timolol base is first liberated with an alkaline agent, especially with sodium hydroxide, and the hemihydrate is thereafter crystallized as described above. As already mentioned earlier, the starting material may contain small amounts of impurities, e.g. in form of the corresponding R-timolol base or the corresponding salt, respectively, which R-enantiomer may be removed completely in a single crystallization step, to give the desired S-timolol hemihydrate in optically pure form. When the process is used for purification purposes, the pure hemihydrate thus obtained may then be converted back to the free S-timolol base or its salt.

In the process, any organic solvent or solvent mixture may be used in which the S-timolol base dissolves but in which, in the presence of water, the formed hemihydrate is sparingly soluble. The process is generally carried out by forming a solution of the S-timolol base with an organic solvent. Water is added in an amount sufficient for the formation of the hemihydrate, and the S-timolol hemihydrate is allowed to crystallize. As the organic solvent which dissolves the timolol base, for example, an aromatic hydrocarbon, such as toluene or xylene, especially toluene, an ether-type solvent, such as di-isopropyl ether, an alcohol, such as ethanol, or a chlorinated hydrocarbon, such as methylene chloride, may be used. The solubilities of the timolol base and the hemihydrate may be regulated by means of an additional organic solvent, or in some cases by the amount or ratio of water used. Thus, for example, an aliphatic hydrocarbon, such as hexane, may be used as a solvent component which reduces the solubility of the hemihydrate. In the system, the amount of water may vary from the stochiometric amount to an amount greatly exceeding the stochiometric amount, e.g. up to 20 - 30 times the stochiometric amount. Rather than crystallizing the hemihydrate from the aqueous solvent mixture, proper crystallization is also achieved by evaporating the organic solvent component, preferably a low-boiling one, while retaining a sufficient amount or ratio of water. The solvent may if needed, be heated to facilitate dissolution of the timolol base, and after the addition of water and possibly auxiliary solvent, the mixture is preferably stirred to facilitate the formation and crystallization of the hemihydrate. As regards the volume ratio between water and organic solvent, generally organic solvent is used in an excess. From a process technical viewpoint, a suitable ratio could be, e.g., from about 1:5 to 1:30.

The identity of crystals obtained from the different above mentioned procedures was confirmed by comparing their powder X-ray diffraction patterns.

From the above it is clear that R-timolol inevitably forms the corresponding hemihydrate in an analogous manner.

Pharmaceutical dosage forms may be prepared from the S-timolol hemihydrate for enteral or parenteral and especially for topical administration, e.g. tablets, capsules, solutions, suspensions and emulsions, and especially transdermal administration forms for transdermal administration. Conventional organic or inorganic adjuvants may be used in the pharmaceutical preparations in a manner known to the man skilled in the art.

The following examples illustrate the invention without limiting its scope.

Example 1

S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadiazole hemihydrate (S-timolol hemihydrate)

366 g of S-timolol base are dissolved in 1.5 litres of toluene. The solution is cooled to 0 °C. 175 ml of water and thereafter 875 ml of hexane are added while vigorously stirring. Crystallization sets in after approximately 30 to 60 minutes.

Thereafter stirring is continued for about 30 minutes. 25 ml of water and 1750 ml of hexane are added, whereafter mixing is continued for about 2 hours at 0 °C. the precipitate is filtered and washed with appr. 300 ml of hexane. Drying is carried out at room temperature.

335 g (89 %) of the title product are obtained, m.p. 48 to 50 °C (capillary tube). Optical purity 100% e.e.,

$$[\alpha]_{405}^{25°} = -16.0°.$$

Example 2

S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadiazole hemihydrate (S-timolol hemihydrate)

500 g of S-timolol maleate are weighed into a flask and 2 litres of water are added. Stirring is continued for about 10 minutes, 1 litre of toluene is added and the mixture is cooled to about 15 °C, at which temperature a 47 % NaOH solution is added dropwise until the pH is about 12.5. The phases are separated. The toluene phase is recovered and the water phase is re-extracted with 0.5 litres of toluene. The toluene phases are combined and washed with water. The toluene solution is cooled to 0 °C. 175 ml of water are added and thereafter 875 ml of hexane while vigorously stirring. Crystallization sets in after about 30 to 60 minutes. Thereafter stirring is continued for about 30 minutes. 25 ml of water and 1750 ml of hexane are added, whereafter stirring is continued for about 2 hours at 0 °C. The precipitate is filtered and washed with about 300 ml of hexane. Drying is effected at room temperature.

335 g of the title compound are obtained (89 % calculated on the S-timolol maleate), m.p. 48 to 50 °C (capillary tube). Optical purity 100% e.e.,

$$[\alpha]_{405}^{25°} = -16.0°.$$

Example 3

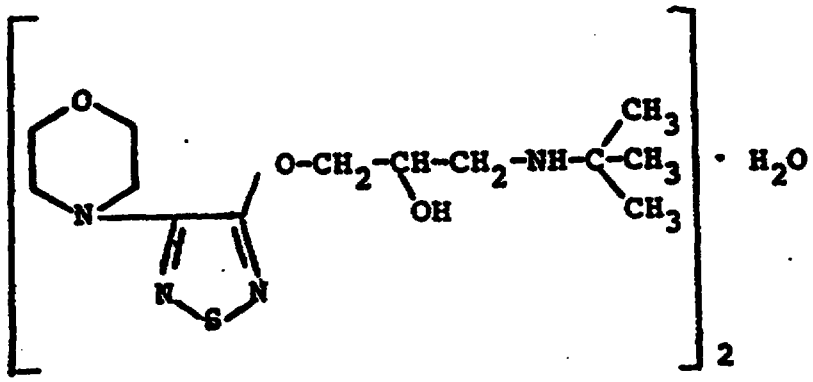
S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadiazole hemihydrate (S-timolol hemihydrate)

100 g of S-timolol base are dissolved in 500 ml of di-isopropyl ether while boiling. 50 ml of water are added and the mixture is cooled to +10 to +20 °C. 0.1 g of S-timolol hemihydrate is added as a seed while vigorously stirring. After the crystallization has set in the mixture is cooled to 0 °C, at which temperature stirring is continued for 1 hour. The crystals are filtered, washed with di-isopropyl ether and dried below 4 °C. The yield is 81 g (79%) of S-timolol hemihydrate, m.p. 48 to 50 °C (capillary tube). Optical purity 100% e.e.,

$$[\alpha]_{405}^{25°} = -16.0°.$$

Claims

1. S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadiazole hemihydrate, i.e. S-timolol hemihydrate, **characterized** in that its formula is



2. Process for the preparation of S (-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadiazole hemihydrate according to the claim 1, **characterized** in that S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadiazole, i.e. S-timolol, is crystallized as the hemihydrate from a mixture containing organic solvent(s) and water.

3. Process according to the claim 2, **characterized** in that the organic solvent or solvent mixture is such in which S-timolol is soluble but in which, in the presence of water, the formed S-timolol hemihydrate is sparingly soluble.

4. Process according to the claim 2, **characterized** in that S-timolol is dissolved in an organic solvent, at least a stochiometric amount of water is added for the formation of S-timolol hemihydrate, and S-timolol hemihydrate is crystallized, optionally after the addition of an auxiliary solvent.

5. Process according to the claim 3 or 4, **characterized** in that as the solvent mixture an aqueous toluene-hexane mixture is used, hexane being used as the auxiliary solvent.

6. Process according to the claim 2, **characterized** in that as the solvent mixture aqueous di-isopropyl ether is used.

7. Process according to the claim 2, **characterized** in that as the solvent mixture aqueous methylene chloride is used.

8. Process according to claim 2, **characterized** in that the S-timolol base is obtained from a salt of the base, especially the maleate salt, by liberating the base with an alkaline agent, preferably sodium hydroxide.

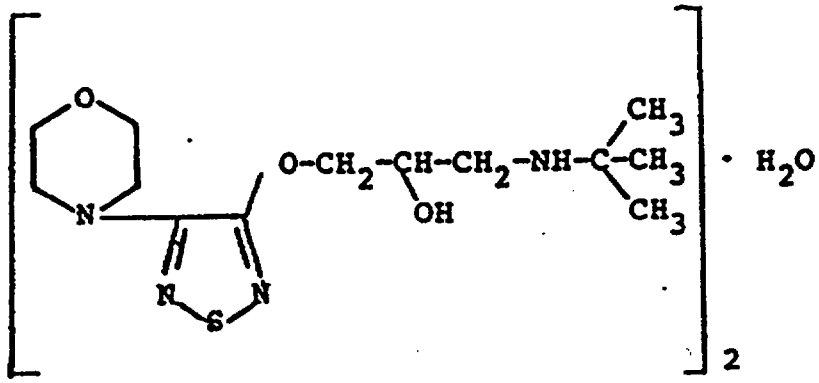
9. Process for the purification of S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadiazole or its salt, especially for the removal therefrom of the corresponding R-enantiomer, **characterized** in that S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadiazole, or its salt, is crystallized as the hemihydrate in accordance with any one of the preceeding claims 2 to 8, and optionally converted back to the free S-timolol base or its salt.

10. Pharmaceutical composition, **characterized** in that it as the active agent contains a compound according to claim 1 together with pharmaceutically acceptable per se known adjuvants.

* C L M S *

Patentansprüche

1. S-(-)-3-Morpholino-4-(3-tert.-butylamino-2-hydroxypropoxy)-1,2,5-thiadiazolhemihydrat, d.h. S-Timololhemihydrat, dadurch gekennzeichnet, daß seine Formel



ist.

2. Verfahren zur Herstellung von S-(-)-3-Morpholino-4-(3-tert.-butylamino-2-hydroxypropoxy)-1,2,5-thiadiazolhemihydrat nach Anspruch 1, dadurch gekennzeichnet, daß S-(-)-3-Morpholino-4-(3-tert.-butylamino-2-hydroxypropoxy)-1,2,5-thiadiazol, d.h. S-Timolol, aus einem Gemisch, das organische(s) Lösungsmittel und Wasser enthält, als Hemihydrat kristallisiert wird.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß das organische Lösungsmittel oder Lösungsmittelgemisch ein solches ist, in dem S-Timolol löslich ist, aber in dem, in Gegenwart von Wasser, das gebildete S-Timololhemihydrat wenig löslich ist.

4. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß S-Timolol in einem organischen Lösungsmittel gelöst wird, mindestens eine stöchiometrische Menge Wasser für die Bildung von S-Timololhemihydrat zugesetzt wird und S-Timololhemihydrat, gegebenenfalls nach Zusatz eines Hilfslösungsmittels, kristallisiert wird.

5. Verfahren nach Anspruch 3 oder 4, dadurch gekennzeichnet, daß als Lösungsmittelgemisch ein wäßriges Toluol-Hexan-Gemisch verwendet wird, wobei Hexan als Hilfslösungsmittel verwendet wird.

6. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daS als Lösungsmittelgemisch wäßriger Diisopropylether verwendet wird.

7. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß als Lösungsmittelgemisch wäßriges Methylenchlorid verwendet wird.

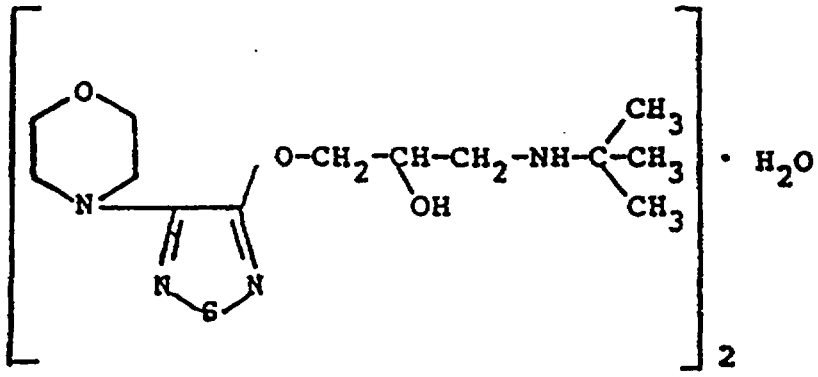
8. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die S-Timololbase aus einem Salz der Base, insbesondere dem Maleatsalz, durch Freisetzen der Base mit einem alkalischen Reagens, bevorzugt Natriumhydroxid, erhalten wird.

9. Verfahren zur Reinigung von S-(-)-3-Morpholino-4-(3-tert.-butylamino-2-hydroxypropoxy)-1,2,5-thiadiazol oder seinem Salz, besonders zur Abtrennung des entsprechenden R-Enantiomers, dadurch gekennzeichnet, daß S-(-)-3-Morpholino-4-(3-tert.-butylamino-2-hydroxypropoxy)-1,2,5-thiadiazol oder sein Salz gemäß einem der vorstehenden Ansprüche 2 bis 8 als Hemihydrat kristallisiert wird und gegebenenfalls wieder in die freie S-Timololbase oder ihr Salz umgewandelt wird.

10. Arzneimittel, dadurch gekennzeichnet, daß es als Wirkstoff eine Verbindung nach Anspruch 1 zusammen mit an sich bekannten pharmazeutisch verträglichen Adjuvantien enthält.

Revendications

1. S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadioazole semi-hydraté, c'est-à-dire le S-timolol semi-hydraté, caractérisé en ce que sa formule est :



2. Procédé pour la préparation de S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadioazole semi-hydraté selon la revendication 1, caractérisé en ce qu'on fait cristalliser le S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadioazole, c'est-à-dire le S-timolol, sous la forme semi-hydratée dans un mélange contenant un ou plusieurs solvants organiques et de l'eau.

3. Procédé selon la revendication 2, caractérisé en ce que le solvant organique ou le mélange de solvants est tel que le S-timolol est soluble dans celui-ci, mais, en présence d'eau, le S-timolol semi-hydraté formé est modérément soluble.

4. Procédé selon la revendication 2, caractérisé en ce qu'on dissout le S-timolol dans un solvant organique, on ajoute au moins une quantité stoechiométrique d'eau pour la formation du S-timolol semi-hydraté et on fait cristalliser le S-timolol semi-hydraté, éventuellement après l'addition d'un solvant auxiliaire.

5. Procédé selon la revendication 3 ou 4, caractérisé en ce qu'on utilise, comme mélange de solvants, un mélange aqueux de toluène et d'hexane, l'hexane étant utilisé comme le solvant auxiliaire.

6. Procédé selon la revendication 2, caractérisé en ce qu'on utilise, comme mélange de solvants, une solution aqueuse d'éther diisopropylique.

7. Procédé selon la revendication 2, caractérisé en ce qu'on utilise, comme mélange de solvants, une solution aqueuse de chlorure de méthylène.

8. Procédé selon la revendication 2, caractérisé en ce qu'on obtient la base de S-timolol à partir d'un sel de la base, en particulier le sel maléate, en libérant la base avec un agent alcalin, de préférence l'hydroxyde de sodium.

9. Procédé pour la purification du S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadioazole ou de son sel, en particulier pour éliminer de celui-ci l'énantiomère R correspondant, caractérisé en ce qu'on fait cristalliser le S-(-)-3-morpholino-4-(3-tert-butylamino-2-hydroxy-propoxy)-1,2,5-thiadioazole, ou son sel, sous la forme semi-hydratée, selon l'une quelconque des revendications 2 à 8 précédentes, et, éventuellement, on le transforme de nouveau en la base libre de S-timolol ou son sel.

10. Composition pharmaceutique caractérisée en ce qu'elle contient, comme agent actif, un composé selon la revendication 1, conjointement avec des adjuvants pharmaceutiquement acceptables connus en soi.