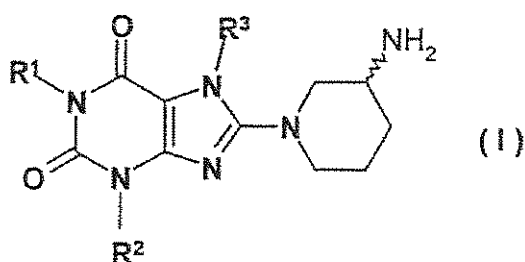


Method for producing chiral 8-(3-amino-piperidin-1-yl)-xanthines

Disclosed herein is an improved process for preparing chiral 8-(3-aminopiperidin-1-yl)-xanthines, their enantiomers and their physiologically tolerated salts.

In a first aspect, there is provided a process for preparing a compound of the formula (I)



or an enantiomer or salt thereof

in which R^1 is a phenylcarbonylmethyl, benzyl, naphthylmethyl, pyridinylmethyl, pyrimidinylmethyl, quinolinylmethyl, isoquinolinylmethyl, quinazolinylmethyl, quinoxalinylmethyl, naphthyridinylmethyl or phenanthridinylmethyl group in which the aromatic or heteroaromatic moiety is in each case mono- or disubstituted by R_a , where the substituents may be the same or different and

R_a is a hydrogen, cyano, methyl, trifluoromethyl, ethyl, phenyl, methoxy, difluoromethoxy, trifluoromethoxy or ethoxy group, or two R_a radicals, that are bonded to adjacent carbon atoms, may also be an $-O-CH_2-O-$ or $-O-CH_2-CH_2-O-$ group,

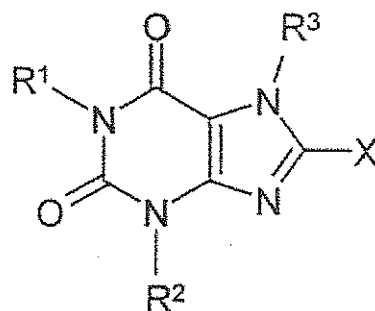
R^2 is a methyl, ethyl, propyl, isopropyl, cyclopropyl or phenyl group and

R^3 is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, 2-buten-1-yl, 2-fluorobenzyl, 2-chlorobenzyl, 2-bromobenzyl, 2-iodobenzyl, 2-methylbenzyl, 2-(trifluoromethyl)benzyl or 2-cyanobenzyl group,

1a

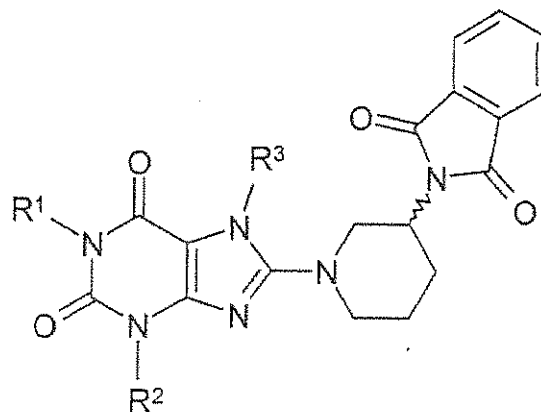
the process comprising:

reacting a compound of the formula (III) with
3-(phthalimido)piperidine or an enantiomer thereof



(III)

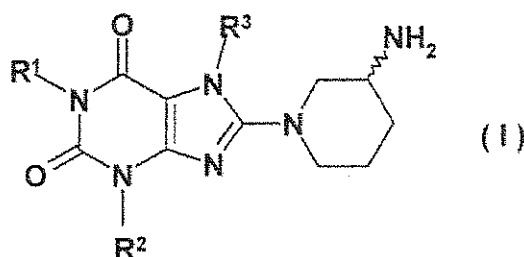
in which X is a leaving group selected from the group consisting of
halogens, phenylsulphonyloxy, p-toluenesulphonyloxy,
methylsulphonyloxy and trifluoromethylsulphonyloxy, and
R¹ to R³ are each defined as mentioned above to obtain a compound of
the formula (II)



(II)

in which R¹ to R³ are each defined as mentioned above; and deprotecting
the obtained compound of the formula (II) to obtain the compound of
formula (I).

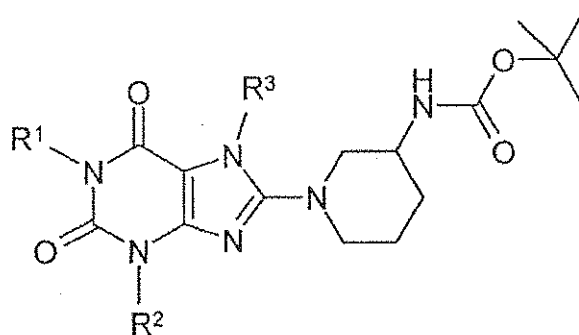
8-(3-aminopiperidin-1-yl)-xanthines of the following general structure



(I)

in which R¹ is, for example, an optionally substituted arylmethyl group or an optionally substituted heteroarylmethyl group, R² is, for example, an alkyl group and R³ is, for example, an optionally substituted benzyl group or a straight-chain or branched alkenyl or alkynyl group are already known from the international applications WO 02/068420, WO 04/018468, WO 04/018467, WO 2004/041820 and WO 2004/046148, in which compounds having valuable pharmacological properties are described, which include in particular an inhibiting action on the activity of the enzyme dipeptidylpeptidase IV (DPP-IV). Therefore, compounds of this type are suitable for preventing or treating disorders or states which are connected with an increased DPP-IV activity or which can be prevented or alleviated by reduction in the DPP-IV activity, especially of diabetes mellitus type I or type II, prediabetes, or reduction of glucose tolerance.

WO 04/018468 discloses a preparation process in which 8-(3-aminopiperidin-1-yl)-xanthines are prepared by deprotecting a corresponding tert.-butoxycarbonyl-protected derivative of the general formula (II).



(II)

In this process, impurities which were difficult to remove, especially on the industrial scale, occurred, and are attributable to the protecting group used.

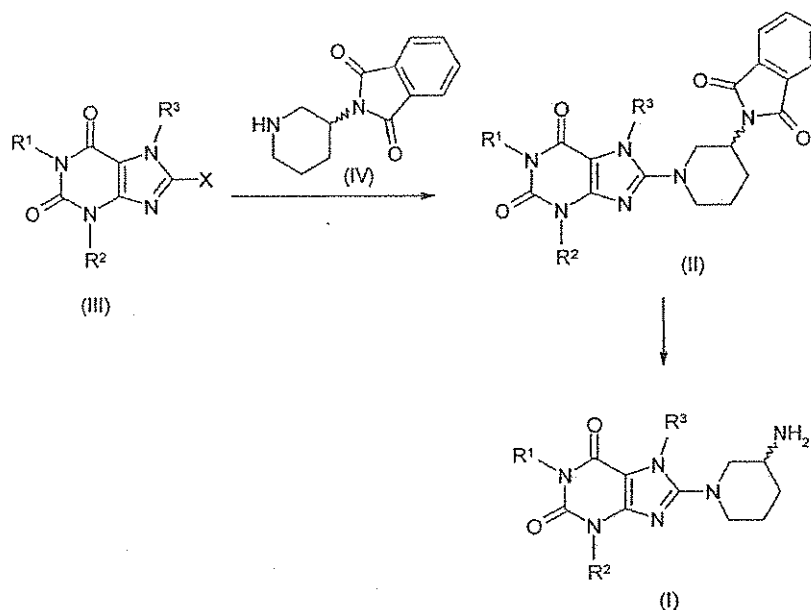
5 The process was therefore unsuitable for the industrial preparation of 8-(3-aminopiperidin-1-yl)-xanthines, especially for medicament production with its strict demands on purity. Furthermore, the method had the disadvantage that the preparation of the enantiomerically pure precursor 3-(tert.-butyloxycarbonylamino)piperidine is complicated and expensive. However,
10 enantiomerically pure active ingredients are to be preferred for the pharmaceutical application owing to the risk of side effects and for the reduction of the dose to a minimum. These circumstances count against the suitability of the known process for the industrial preparation of enantiomerically pure 8-(3-aminopiperidin-1-yl)-xanthines.

15 In the light of the above-described disadvantages of the known preparation process, it is an object of the present invention to provide a process which allows the preparation of enantiomerically pure 8-(3-aminopiperidin-1-yl)-xanthines using readily obtainable starting materials in high chemical and
20 optical purity and without great technical cost and inconvenience. This novel process should also be suitable for synthesis on the industrial scale and thus for commercial application.

25 This object is achieved by the process according to the invention for preparing chiral 8-(3-aminopiperidin-1-yl)-xanthines. In addition to high yield industrial performance, very good chemical and optical purities are further advantages of the inventive synthetic route.

30 According to the process of the present invention, the appropriate xanthine precursor (III) is reacted according to scheme 1 with enantiomerically pure or racemic 3-(phthalimido)piperidine in suitable solvents at temperatures of

20 to 160°C; preferably of 8 to 140°C. The solvents used may, for example, be tetrahydrofuran (THF), dioxane, N,N-dimethylformamide (DMF), dimethylacetamide (DMA), N-methyl-2-pyrrolidone (NMP) or dimethyl sulphoxide (DMSO). Preference is given to using NMP. Subsequently, the phthalyl protecting group is detached by processes known per se. Possible detachment methods are described, for example, by T.W. Greene in "Protective Groups in Organic Synthesis", Wiley 1981 on page 265 (for example hydrazine in ethanol).



10 In the abovementioned formulae,

X is a leaving group selected from the group of the halogens, for example a fluorine, chlorine or bromine atom, or of the sulphonic esters, for example a phenylsulphonyloxy, p-toluenesulphonyloxy, methylsulphonyloxy or trifluoromethylsulphonyloxy group,

R¹ is a phenylcarbonylmethyl, benzyl, naphthylmethyl, pyridinylmethyl, pyrimidinylmethyl, quinolinylmethyl, isoquinolinylmethyl, quinazolinylmethyl, quinoxalinylmethyl, naphthyridinylmethyl or phenanthridinylmethyl group in which the aromatic or heteroaromatic moiety is in each case mono- or disubstituted by R_a, where the substituents may be identical or different and

R_a is a hydrogen, fluorine, chlorine or bromine atom or a cyano, methyl, trifluoromethyl, ethyl, phenyl, methoxy, difluoromethoxy, trifluoromethoxy or ethoxy group,

or two R_a radicals, when they are bonded to adjacent carbon atoms, may also be an $-O-CH_2-O-$ or $-O-CH_2-CH_2-O-$ group,

R^2 is a methyl, ethyl, propyl, isopropyl, cyclopropyl or phenyl group and

R^3 is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, 2-butyne-1-yl, 2-fluorobenzyl, 2-chlorobenzyl, 2-bromobenzyl, 2-iodobenzyl, 2-methylbenzyl, 2-(trifluoromethyl)benzyl or 2-cyanobenzyl group.

The process is preferable for those compounds in which

X is a chlorine or bromine atom,

R^1 is a phenylcarbonylmethyl, benzyl, naphthylmethyl, pyridinylmethyl, pyrimidinylmethyl, quinolinylmethyl, isoquinolinylmethyl, quinazolinylmethyl, quinoxalinyl-methyl or naphthyridinylmethyl group in which the aromatic or heteroaromatic moiety is in each case mono- or disubstituted by R_a , where the substituents may be identical or different and

R_a is a hydrogen, fluorine or chlorine atom or a cyano, methyl, ethyl, methoxy or ethoxy group,

R^2 is a methyl, ethyl, propyl, isopropyl, cyclopropyl or phenyl group and

R^3 is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, 2-butyne-1-yl, 2-fluorobenzyl, 2-chlorobenzyl, 2-bromobenzyl, 2-iodobenzyl, 2-methylbenzyl, 2-(trifluoromethyl)benzyl or 2-cyanobenzyl group.

The process is more preferable for those compounds in which

X is a chlorine or bromine atom,

R^1 is a cyanobenzyl, (cyanopyridinyl)methyl, quinolinylmethyl, (methylquinolinyl)methyl, isoquinolinylmethyl, (methylisoquinolinyl)methyl, quinazolinylmethyl, (methylquinazolinyl)methyl, quinoxazinylmethyl, (methylquinoxalinyl)methyl, (dimethylquinoxalinyl)methyl or naphthyridinylmethyl group,

R² is a methyl, cyclopropyl or phenyl group and

R³ is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, 2-butyn-1-yl, 2-chlorobenzyl, 2-bromobenzyl or 2-cyanobenzyl group,

5

but in particular for the compounds 1-[(4-methylquinazolin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(R)-aminopiperidin-1-yl)-xanthine,

1-[(3-methylisoquinolin-1-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-((R)-3-aminopiperidin-1-yl)-xanthine and 1-[(3-cyanopiperidin-2-yl)methyl]-

10 3-methyl-7-(2-butyn-1-yl)-8-(3-(R)-aminopiperidin-1-yl)-xanthine, where X is bromine.

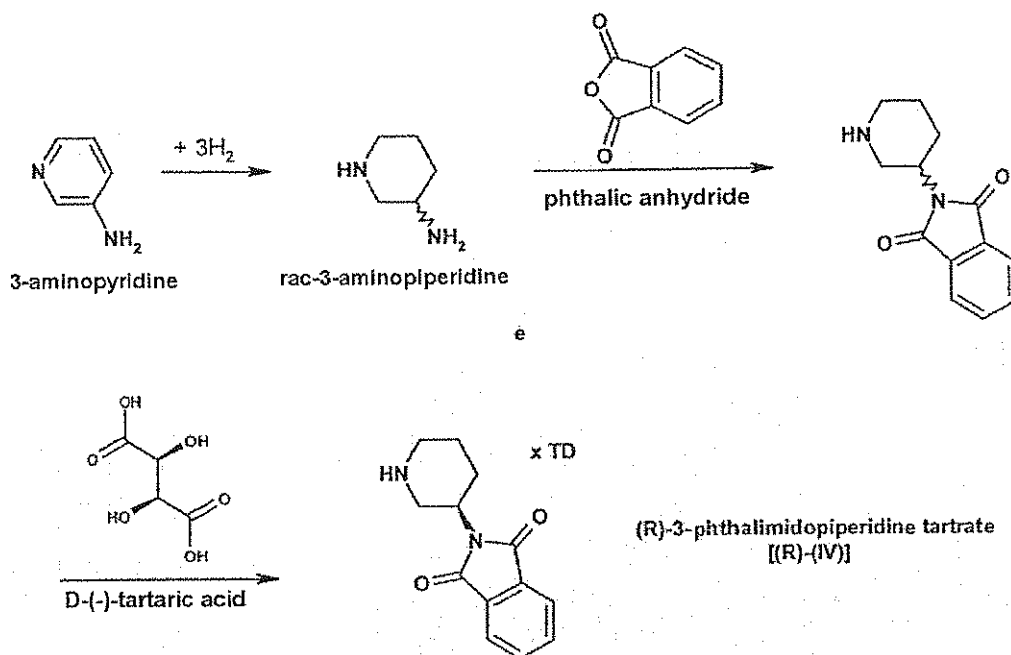
Preference is given in each case to using (R)-3-(phthalimido)piperidine as a reagent. The preparation of the compounds of the formula (III) has been
15 described in the literature which has already been cited above and is effected by processes known per se.

The invention further provides a process for preparing optically active 3-(phthalimido)piperidine. In this process, 3-aminopyridine is initially
20 hydrogenated by means of processes known per se. The thus obtained racemic 3-aminopiperidine is then converted to the corresponding phthalimide by means of phthalic anhydride. The (R) enantiomer can be precipitated selectively out of the solution of the racemic, crude phthalimide (IV) by means of D-tartaric acid. It is also possible to obtain the (S)
25 enantiomer of (IV) in a simple manner from the mother liquor of this salt precipitation by adding L-tartaric acid, without preceding removal of the excess of D-tartaric acid still present in the mother liquor.

This extremely simple enantiomeric separation of the compound of the formula (IV) is surprising to those skilled in the art. The racemic base from
30 the hydrogenation reaction does not have to be purified beforehand for this purpose. The process works without any problem even on the industrial scale.

35 In addition, the unexpectedly clean reaction of 3-aminopiperidine with phthalic anhydride is surprising per se, since, according to the literature (for example US patent US 4,005,208, especially Example 27), mixtures would be expected which, in addition to the desired product, comprise derivatives

in which the ring nitrogen atom is acylated.



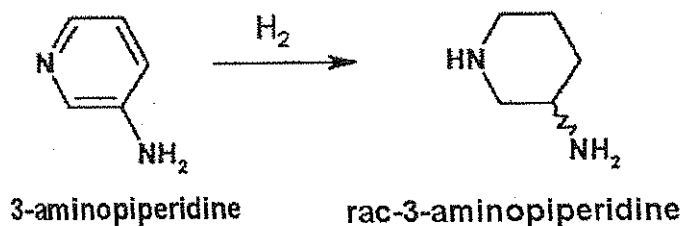
- 5 The examples which follow will illustrate the invention in greater detail:

Example 1

D-Tartaric acid salt of the R enantiomer of 3-(phthalimido)piperidine

10

a. Hydrogenation:



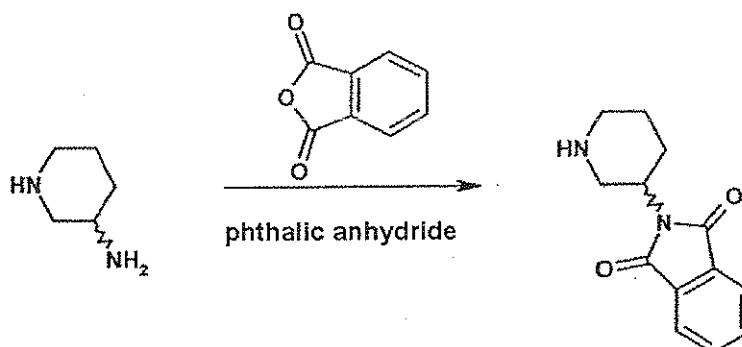
15

10.00 kg (106.25 mol) of 3-aminopyridine, 500 g of technical-grade activated carbon and 65 litres of acetic acid are initially charged in a hydrogenation reactor. 50 g of Nishimura catalyst (a commercially available rhodium/platinum mixed catalyst) are added slurried in 2.5 litres of acetic acid and flushed in with 2.5 litres of acetic acid. Hydrogenation is effected at 50°C and 100 bar of hydrogen pressure until hydrogen uptake stops and

post-hydrogenation is subsequently effected at 50°C for 30 minutes. The catalyst and the activated carbon are filtered off and washed with 10 litres of acetic acid. The product solution is reacted further without purification.

- 5 The reaction also proceeds under less severe pressures.

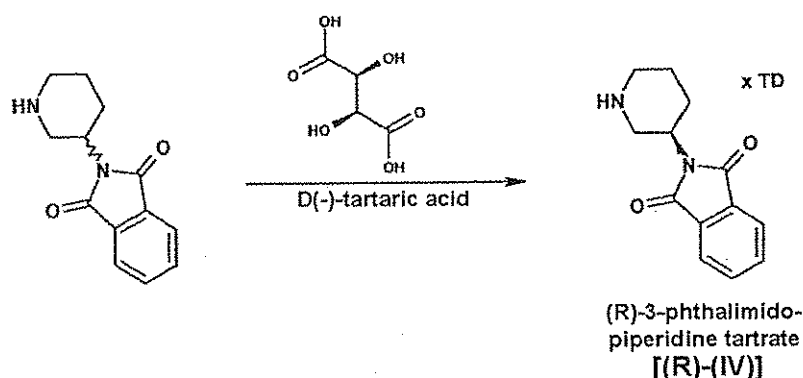
b. Acylation



- 10 15.74 kg (106.25 mol) of phthalic anhydride are initially charged in the reactor and admixed with the filtrate from the hydrogenation. It is flushed in with 7.5 litres of acetic acid and the reaction mixture is subsequently heated to reflux, in the course of which approx. 30% of the acetic acid used is distilled off within one hour. The reaction solution is cooled to 90°C. The product solution is reacted further without purification.

15

c. Optical resolution



- 20 A solution, heated to 50°C, of 11.16 kg of D-(-)-tartaric acid (74.38 mol) in 50 litres of absolute ethanol is metered into the acylation reaction solution at 90°C. It is flushed in with 10 litres of absolute ethanol and stirred at 90°C for 30 minutes, in the course of which the product crystallizes. After cooling to 5°C, the product was centrifuged off and washed with absolute ethanol.

The product solution is reacted further without purification.

d. Recrystallisation

- 5 The moist crude product is heated to reflux in a mixture of 50 litres of acetone and 90 litres of water until a solution has formed. Subsequently, the solution is cooled to 5°C, in the course of which the product crystallizes out. The suspension is stirred at 5°C for 30 minutes, and the product is centrifuged off and finally washed with a mixture of 20 litres of acetone and
10 10 litres of water. The mixture is dried at 45°C in a drying cabinet under inertization.

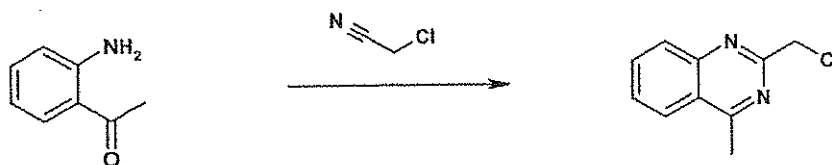
Yields: 11.7-12.5 kg (29-31% of theory)

Example 2

15

Synthesis of 1-[(4-methylquinazolin-2-yl)methyl]-3-methyl-7-(2-butyln-1-yl)-8-(3-(*R*)-aminopiperidin-1-yl)-xanthine

a. 2-Chloromethyl-4-methylquinazoline

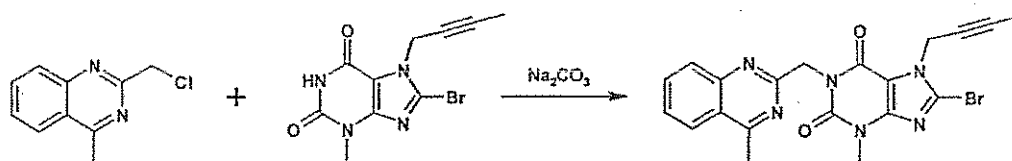


- 10.00 kg (73.98 mol) of 2-aminoacetophenone are initially charged and
20 24.5 litres of 1,4-dioxane are added. The solution, cooled to 10°C, is admixed with 16.72 kg (458.68 mol) of hydrogen chloride by blanketing. The reaction mixture warms up to 22-25°C. At this temperature, further hydrogen chloride is blanketed in. From about half of the total blanketing amount, the mixture is cooled to -10°C and blanketing is continued.
- 25 Subsequently, the suspension formed is left to stand at -10°C overnight. A solution of 6.70 kg (88.78 mol) of chloroacetonitrile in 2.5 litres of 1,4-dioxane is added at -10°C within one hour. The feed vessel is flushed with 2 litres of 1,4-dioxane. Afterwards, the reactor contents are warmed to 6°C and stirred for a further approx. 2 hours.
- 30 A further reactor is initially charged with a mixture of 122 litres of water and 62.04 kg (775.31 mol) of sodium hydroxide solution (50%) and cooled to 6°C. The reaction mixture from the first reactor is added in portions. The internal temperature is not more than 11°C. Subsequently, the first reactor

is flushed first with 6 litres of 1,4-dioxane and then with 6 litres of water. The resulting suspension is stirred at 5°C for a further 30 minutes. The product is centrifuged off, washed with 41 litres of water and dried at 35°C in a drying cabinet under inertization.

5 Yield: 10.5-12.1 kg (74-85% of theory)

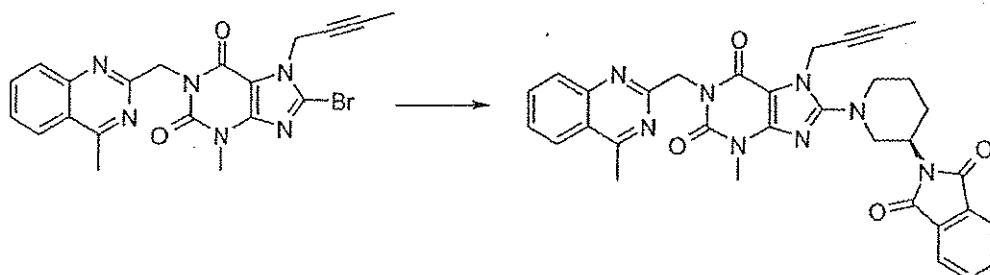
b. 1-[(4-Methylquinazolin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-bromoxanthine



10 10.00 kg (33.66 mol) of 3-methyl-7-(2-butyn-1-yl)-8-bromoxanthine, 7.13 kg (37.02 mol) of 2-chloromethyl-4-methylquinazoline, 3.92 kg (37.02 mol) of anhydrous sodium carbonate and 30 litres of N-methyl-2-pyrrolidone are initially charged in the reactor. The reactor contents are heated to 140°C and stirred at 140°C for 2 hours. After the reaction has ended, the reaction
 15 mixture is cooled to 80°C and diluted with 60 litres of 96% ethanol and subsequently at 70°C with 55 litres of water. At 60°C, 4.04 kg (67.32 mol) of acetic acid are metered in and flushed in with 5 litres of water. The resulting suspension is stirred at 60°C for 30 minutes, then cooled to 23°C and stirred for a further 30 minutes. Subsequently, the product is
 20 centrifuged off and washed first with a mixture of 20 litres of 96% ethanol and 20 litres of water, then with 40 litres of 96% ethanol and 40 litres of water. Drying is effected at 45°C in a drying cabinet under inertization. Yield: 11.6-12.6 kg (76-83% of theory)

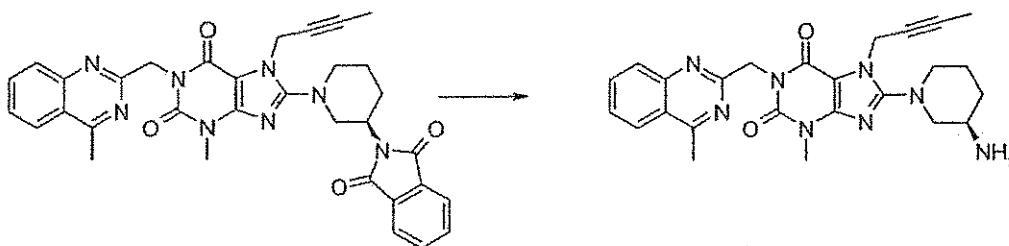
25

c. 1-[(4-Methylquinazolin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(R)-phthalimidopiperidin-1-yl)-xanthine



10.00 kg (22.06 mol) of 1-[(4-methylquinazolin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-bromoxanthine, 12.59 kg (33.09 mol) of 3-(phthalimido)piperidine D-tartrate and 17.5 litres of N-methyl-2-pyrrolidone are initially charged in the reactor. The reactor contents are heated to 140°C. After the temperature has been attained, 11.41 kg (88.24 mol) of diisopropylethylamine are metered in within 20 minutes. The feed vessel is flushed with 2.5 litres of N-methyl-2-pyrrolidone and the reaction mixture is subsequently stirred at 140°C for 2 hours. After the reaction has ended, the reaction mixture is cooled to 60°C and diluted with 80 litres of methanol. The resulting suspension is stirred at 50°C for 30 minutes, then cooled to 23°C and stirred for a further 30 minutes. Subsequently, the product is centrifuged off and washed 3 times with 20 litres each time of methanol. Drying is effected at 45°C in a drying cabinet under inertization. Yield: 12.0-12.5 kg (90-94% of theory)

d. 1-[(4-Methylquinazolin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(R)-aminopiperidin-1-yl)-xanthine



1800 kg (3 mol) of 1-[(4-methylquinazolin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(R)-phthalimidopiperidin-1-yl)-xanthine are heated to 80-85°C in 18 litres of toluene. Subsequently, 1.815 litres (30 mol) of ethanolamine are added to the suspension at 75-80°C. To complete the reaction, the mixture is stirred at 80-85°C for 2 hours, in the course of which the solids go into solution. Subsequently, the phases are separated. The ethanolamine phase is washed twice with warm toluene (4 litres each time). The combined toluene phases are washed twice with 8 litres each time of water at 75-80°C. From the toluene phase, 22 litres of toluene are distilled off under reduced pressure. 4 litres of tert.-butyl methyl ether are metered at 40-50°C to the resulting suspension and subsequently cooled to 0-5°C. The product is isolated by filtration, washed with tert.-butyl methyl ether and suction-dried. The moist crude substance is subsequently heated to reflux with 5 times the amount of absolute ethanol and the hot solution is clarified by filtration through activated carbon. After the filtrate has been

cooled to 20°C and crystallization has set in, it is diluted to double the volume with tert.-butyl methyl ether. The suspension is cooled to 2°C, stirred for a further 2 hours, filtered with suction and dried at 45°C in a vacuum drying cabinet.

5

Yield: 1174 g (83.2% of theory)

Alternative process for step d:

1400 g (2.32 mol) of 1-[(4-methylquinazolin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(*R*)-phthalimidopiperidin-1-yl)-xanthine are initially charged in 4.9 l of tetrahydrofuran and subsequently heated to 55-65°C.

Subsequently, 350 ml of water and 1433 g (2.32 mol) of ethanolamine are added to the suspension. To complete the reaction, the mixture is stirred at 60-63°C for a further 3 hours.

Subsequently, 619 ml of 45% sodium hydroxide solution and 3.85 l of water are added and the mixture is stirred at 55-65°C for 30 min.

5.6 l of toluene are then added to the reaction mixture, the mixture is stirred for 15 min and the phases are subsequently separated.

The organic phase is washed with 2.8 l of water at 55-65°C and subsequently removed. From the organic phase, 4.2 l are distilled off under reduced pressure. Subsequently, 1.4 l of methylcyclohexane are added at 65-75°C, in the course of which the product crystallizes. The suspension is stirred at 15-25°C for 8-16 h and subsequently cooled to 0-5°C. The product is isolated by filtration, washed with 4.2 l of methylcyclohexane, suction-dried and dried at 35°C under reduced pressure.

The dried crude substance (991 g) is subsequently heated to reflux with 5 times the amount of methanol, activated carbon is added and the mixture is filtered. The filtrate is reduced to a volume of 1.5 l by distilling off methanol. After the filtrate has been cooled to 45-55°C, it is diluted to four times the volume with tert.-butyl methyl ether. The suspension is cooled to 0-5°C, stirred for 2 hours, filtered with suction, washed with tert.-butyl methyl ether and dried at 35°C in a vacuum drying cabinet.

Yield: 899 g (81.9% of theory)

35

Example 3

1-[(3-Cyanopyridin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(*R*)-aminopiperidin-1-yl)-xanthine

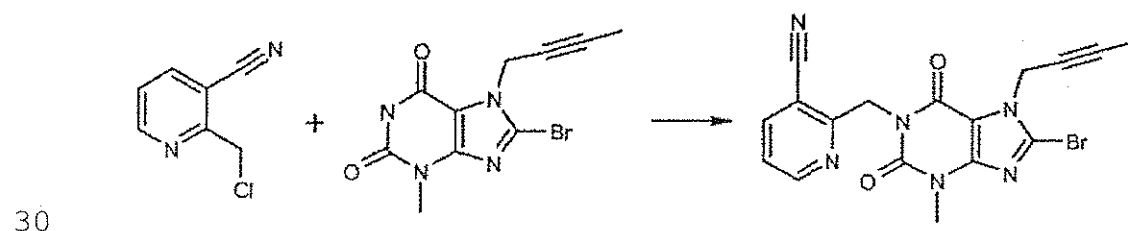
a. 3-Cyano-2-(chloromethyl)-pyridine

- 5 165.5 g (0.98 mol) of 2-hydroxymethyl-3-pyridinecarboxamide are heated together with 270 ml of phosphorus oxychloride to 90-100°C for 1 hour. The reaction mixture is cooled to room temperature and subsequently added dropwise to approx. 800 ml of water at 50-60°C. After the phosphorus oxychloride has been hydrolyzed, the mixture is neutralized
- 10 with sodium hydroxide solution with cooling, in the course of which the product precipitates out. It is filtered off, washed with 300 ml of water and subsequently dried at 35-40°C.
- Yield: 122.6 g (82% of theory)

15 Variant to process step a: 3-cyano-2-(chloromethyl)pyridine

- 20.0 g (131.45 mmol) of 2-hydroxymethyl-3-pyridinecarboxamide are suspended in 110 ml of acetonitrile and heated to 78°C. Within 15 minutes, 60.65 g (395.52 mmol) of phosphorus oxychloride are metered in and the mixture is heated to 81°C for 2 hours. After cooling at 22°C, the reaction
- 20 mixture is stirred into 200 ml of water at 40°C. After 100 ml of toluene have been added, the mixture is neutralized with sodium hydroxide solution with cooling. After phase separation, the organic phase is washed with 100 ml of water. Removal of the organic phase and evaporation of the solvent
- 25 crystallizes on standing.
- Yield: 16.66 g (83% of theory)

b. 1-[(3-Cyanopyridin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-bromoxanthine



202 g (0.68 mol) of 3-methyl-7-(2-butyn-1-yl)-8-bromoxanthine, 188.5 g (1.36 mol) of anhydrous potassium carbonate and 1.68 litres of N-methyl-2-

pyrrolidone are initially charged in the reactor and heated to 70°C.

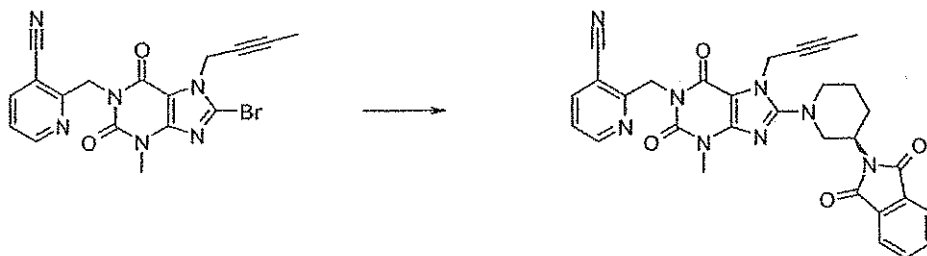
Subsequently, 119 g (0.75 mol) of 2-chloromethyl-3-cyanopyridine in 240 ml of N-methyl-2-pyrrolidone (NMP) are added dropwise. The reactor contents are stirred at 70°C for 19 hours. After the reaction has ended, 2.8

5 litres of water are added to the reaction mixture and it is cooled to 25°C.

The product is filtered off, washed with 2 litres of water and dried at 70°C in a drying cabinet under inertization.

Yield: 257.5 g (91% of theory)

10 c. 1-[(3-Cyanopyridin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(R)-phthalimidopiperidin-1-yl)-xanthine



230 g (0.557 mol) of 1-[(3-cyanopyridin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-bromoxanthine, 318 g (0.835 mol) of 3-(phthalimido)piperidine

15 D-tartrate and 1.15 litres of N-methyl-2-pyrrolidone are initially charged in the reactor. The reactor contents are heated to 140°C. After the temperature has been attained, 478 ml (2.78 mol) of diisopropylethylamine are metered in within 20 minutes and the reaction mixture is subsequently stirred at 140°C for 2 hours. Subsequently, the reaction mixture is cooled to

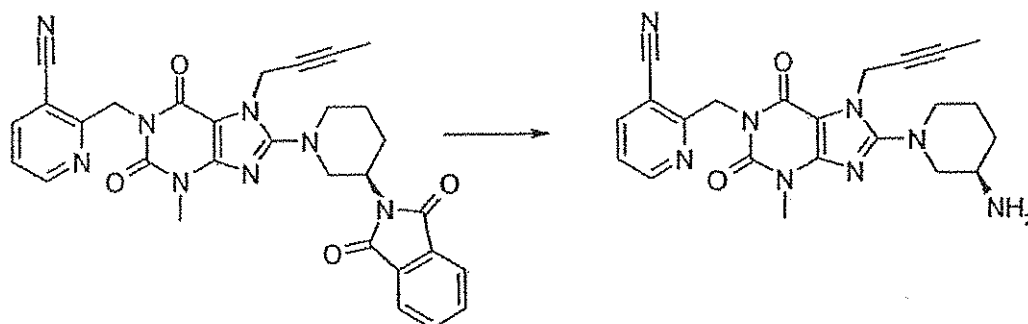
20 75°C and diluted with 720 ml of methanol. Afterwards, 2.7 litres of water are added at 68-60°C and the mixture is cooled to 25°C. The product is filtered off and washed with 2 litres of water. Drying is effected at 70°C in a drying cabinet under inertization.

The crude product thus obtained is subsequently stirred at boiling in 1 litre

25 of methanol, hot-filtered, washed with 200 ml of methanol and subsequently dried at 70°C under inertization.

Yield: 275 g (88% of theory)

d. 1-[(3-cyanopyridin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(*R*)-aminopiperidin-1-yl)-xanthine



412.5 g (0.733 mol) of 1-[(3-cyanopyridin-2-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-(3-(*R*)-phthalimidopiperidin-1-yl)-xanthine are heated to 80°C in 4125 ml of toluene. Subsequently, 445 ml of ethanolamine (7.33 mol) are added to the suspension at 75-80°C. To complete the reaction, the mixture is stirred at 80-85°C for a further 2 hours, in the course of which the solids go into solution. Subsequently, the phases are separated. The ethanolamine phase is extracted twice with warm toluene (1 litre each time). The combined toluene phases are washed twice with 2 litres each time of water at 75-80°C. The toluene phases are dried with sodium sulphate, filtered and subsequently reduced to a volume of approx. 430 ml by distillation under reduced pressure. Subsequently, 1 litre of tert.-butyl methyl ether is metered in at 50-55°C and the mixture is then cooled to 0-5°C. The product is isolated by filtration, washed with tert.-butyl methyl ether and dried at 60°C in a drying cabinet.

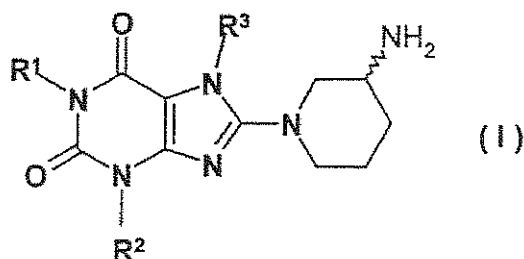
Yield: 273 g (86% of theory)

Melting point: 188 ± 3°C

Analogously to Examples 2 and 3, 1-[(3-methylisoquinolin-1-yl)methyl]-3-methyl-7-(2-butyn-1-yl)-8-((*R*)-3-aminopiperidin-1-yl)-xanthine is also prepared.

Claims

1. Process for preparing a compound of the formula (I)



or an enantiomer or salt thereof

in which R¹ is a phenylcarbonylmethyl, benzyl, naphthylmethyl, pyridinylmethyl, pyrimidinylmethyl, quinolinylmethyl, isoquinolinylmethyl, quinazolinylmethyl, quinoxalinylmethyl, naphthyridinylmethyl or phenanthridinylmethyl group in which the aromatic or heteroaromatic moiety is in each case mono- or disubstituted by R_a, where the substituents may be the same or different and

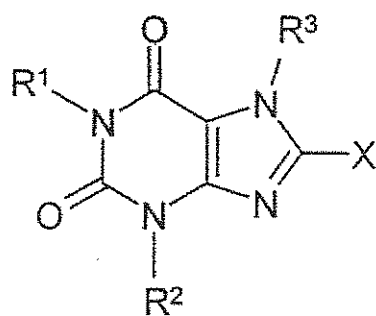
R_a is a hydrogen, cyano, methyl, trifluoromethyl, ethyl, phenyl, methoxy, difluoromethoxy, trifluoromethoxy or ethoxy group, or two R_a radicals, that are bonded to adjacent carbon atoms, may also be an -O-CH₂-O- or -O-CH₂-CH₂-O- group,

R² is a methyl, ethyl, propyl, isopropyl, cyclopropyl or phenyl group and

R³ is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, 2-butyne-1-yl, 2-fluorobenzyl, 2-chlorobenzyl, 2-bromobenzyl, 2-iodobenzyl, 2-methylbenzyl, 2-(trifluoromethyl)benzyl or 2-cyanobenzyl group,

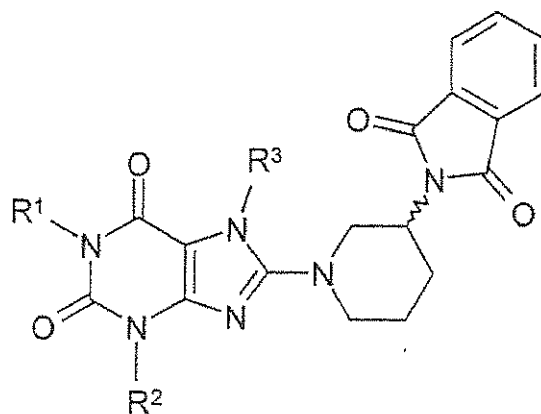
the process comprising:

reacting a compound of the formula (III) with 3-(phthalimido)piperidine or an enantiomer thereof



(III)

in which X is a leaving group selected from the group consisting of halogens, phenylsulphonyloxy, p-toluenesulphonyloxy, methylsulphonyloxy and trifluoromethylsulphonyloxy, and R¹ to R³ are each defined as mentioned above to obtain a compound of the formula (II)



(II)

in which R¹ to R³ are each defined as mentioned above; and deprotecting the obtained compound of the formula (II) to obtain the compound of formula (I).

2. The process according to claim 1, further comprising converting the compound of formula (I) to a physiologically tolerated salt.

3. Process according to Claim 1, in which X is chlorine or bromine, R¹ is a phenylcarbonylmethyl, benzyl, naphthylmethyl, pyridinylmethyl, pyrimidinylmethyl, quinolinylmethyl, isoquinolinylmethyl, quinazolinylmethyl, quinoxalinylmethyl or naphthyridinylmethyl group in which the aromatic or heteroaromatic moiety is in each case mono- or disubstituted by R_a, where the

substituents may be the same or different and

R_a is a hydrogen, cyano, methyl, ethyl, methoxy or ethoxy group,

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R^2 is a methyl, ethyl, propyl, isopropyl, cyclopropyl or phenyl group and

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R^3 is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, 2-butyne-1-yl, 2-fluorobenzyl, 2-chlorobenzyl, 2-bromobenzyl, 2-iodobenzyl, 2-methylbenzyl, 2-(trifluoromethyl)benzyl or 2-cyanobenzyl group.

4. Process according to Claim 1, in which

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X is chlorine or bromine,

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R^1 is a cyanobenzyl, (cyanopyridinyl)methyl, quinolinylmethyl, (methylquinolinyl)methyl, isoquinolinylmethyl, (methylisoquinolinyl)methyl, quinazolinylmethyl, (methylquinazolinyl)methyl, quinoxalinylmethyl, (methylquinoxalinyl)methyl, (dimethylquinoxalinyl)methyl or naphthyridinylmethyl group,

25

R^2 is a methyl, cyclopropyl or phenyl group and

R^3 is a 2-buten-1-yl, 3-methyl-2-buten-1-yl, 2-butyne-1-yl, 2-chlorobenzyl, 2-bromobenzyl or 2-cyanobenzyl group.

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5. Process according to Claim 1, in which

X is bromine,

R^1 is a (4-methylquinazolin-2-yl)methyl, (3-methylisoquinolin-1-yl)methyl or (3-cyanopyridin-2-yl)methyl group,

R^2 is a methyl group and

R^3 is a 2-butyne-1-yl group.

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6. Process according to Claim 1, in which the compound of the formula (III) is reacted with (R)-3-(phthalimido)piperidine.

7. The process according to claim 1, wherein X is a leaving group selected from the group consisting of halogens.
8. The process according to claim 5, wherein said 3-(phthalimido)piperidine is (R)-3-(phthalimido)piperidine.
9. The process according to claim 1, wherein
X is bromine,
R¹ is a (4-methylquinazolin-2-yl)methyl group,
R² is a methyl group, and
R³ is a 2-butyne-1-yl group.
10. The process according to claim 9, wherein said 3-(phthalimido)piperidine is (R)-3-(phthalimido)piperidine.
11. The process according to claim 10, wherein the solution further comprises tert-butyl methyl ether.