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(54) **DEUTERATED ANALOGS OF PRIDOPIDINE
USEFUL AS DOPAMINERGIC STABILIZERS**

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(57) **ABSTRACT**

The present invention provides novel deuterated analogs of Pridopidine, i.e. 4-(3-methanesulfonyl-phenyl)-1-propyl-piperidine. Pridopidine is a drug substance currently in clinical development for the treatment of Huntington's disease.

In other aspects the invention relates to pharmaceutical compositions comprising a deuterated analog of Pridopidine of the invention, and to therapeutic applications of these analogs.

DEUTERATED ANALOGS OF PRIDOPIDINE USEFUL AS DOPAMINERGIC STABILIZERS

FIELD OF THE INVENTION

[0001] The present invention provides novel deuterated analogs of Pridopidine, i.e. 4-(3-methanesulfonyl-phenyl)-1-propyl-piperidine. Pridopidine is a drug substance currently in clinical development for the treatment of Huntington's disease.

[0002] In other aspects the invention relates to pharmaceutical compositions comprising a deuterated analog of Pridopidine of the invention, and to therapeutic applications of these analogs.

BACKGROUND OF THE INVENTION

[0003] Deuterium, also called "heavy hydrogen", is a stable isotope of hydrogen with a natural abundance in the oceans of Earth of approximately one atom in 6,500 of hydrogen (~154 ppm). Deuterium thus accounts for approximately 0.0154% (alternately, on a mass basis: 0.0308%) of all naturally occurring hydrogen in the oceans on Earth. The nucleus of deuterium, called a deuteron, contains one proton and one neutron, whereas the hydrogen nucleus contains no neutron.

[0004] Deuterium forms bonds with carbon that vibrate at a lower frequency and are thus stronger than C—H bonds. Therefore "heavy hydrogen" versions of drugs may be more stable towards degradation and last longer in the organism. Incorporating deuterium in place of hydrogen thus may improve the pharmacodynamic and pharmacokinetic profiles of drugs, thus modifying the metabolic fate, while retaining the pharmacologic activity and selectivity of physiologically active compounds. Deuterated drugs thus may positively impact safety, efficacy and/or tolerability.

[0005] Pridopidine, i.e. 4-(3-methanesulfonyl-phenyl)-1-propyl-piperidine, a dopaminergic stabilizer currently in clinical development for the treatment of Huntington's disease. The compound is described in e.g. WO 01/46145, and in e.g. WO 2006/040155 an alternative method for its synthesis is described.

SUMMARY OF THE INVENTION

[0006] The object of the present invention is to provide analogs of Pridopidine with improved pharmacodynamic and pharmacokinetic profiles.

[0007] Therefore, in its first aspect the invention provides a partially or fully deuterated analog of 4-(3-methanesulfonyl-phenyl)-1-propyl-piperidine as represented by Formula 1, below.

[0008] In another aspect the invention provides a pharmaceutical composition, comprising a therapeutically effective amount of a deuterated analog of 4-(3-methanesulfonyl-phenyl)-1-propyl-piperidine of the invention, or a pharmaceutically acceptable salt thereof, together with at least one pharmaceutically acceptable carrier, excipient or diluent.

[0009] Viewed from another aspect the invention relates to the use of the deuterated analog of 4-(3-methanesulfonyl-phenyl)-1-propyl-piperidine of the invention as a medicament, or for the manufacture of a medicament.

[0010] In a further aspect the invention provides a method for treatment, prevention or alleviation of a dopamine mediated disorder of a living animal body, including a human, which method comprises the step of administering to such a living animal body in need thereof a therapeutically effective

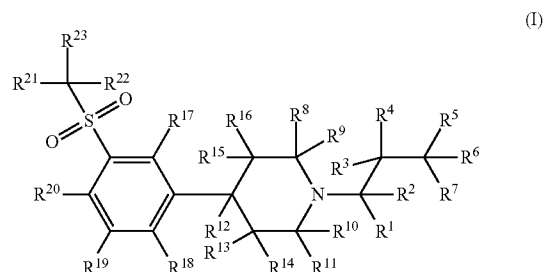
amount of a deuterated analog of 4-(3-methanesulfonyl-phenyl)-1-propyl-piperidine according to the invention, or a pharmaceutically acceptable salt thereof.

[0011] Other aspects of the invention will be apparent to the person skilled in the art from the following detailed description and examples.

DETAILED DESCRIPTION OF THE INVENTION

Deuterated Analogs of Pridopidine

[0012] In its first aspect the present invention provides deuterated analogs of Pridopidine. The deuterated analog of the invention may be a fully or partially deuterium substituted derivative. The deuterated analog of the invention may in particular be characterised by Formula I



[0013] or a pharmaceutically acceptable salt thereof, wherein

[0014] at least one of R¹-R²³ represents deuterium (D); and

[0015] the remaining of R¹-R²³ represent hydrogen (H).

[0016] In the context of this invention, when a particular position is designated as holding deuterium, it is understood that the abundance of deuterium at that position is substantially greater than the natural abundance of deuterium, which is about 0.015%.

[0017] In a preferred embodiment the abundance of deuterium at that position is at least 3340 times greater (i.e. at least 50.1% incorporation of deuterium) than the natural abundance of deuterium. In other preferred embodiments of the invention the abundance of deuterium at that position is at least 3500 (52.5% deuterium incorporation), at least 4000 (60% deuterium incorporation), at least 4500 (67.5% deuterium incorporation), at least 5000 (75% deuterium), at least 5500 (82.5% deuterium incorporation), at least 6000 (90% deuterium incorporation), at least 6333.3 (95% deuterium incorporation), at least 6466.7 (97% deuterium incorporation), at least 6600 (99% deuterium incorporation), or at least 6633.3 (99.5% deuterium incorporation).

[0018] In a preferred embodiment the deuterated analog of the invention is a compound of Formula I, or a pharmaceutically acceptable salt thereof, wherein

[0019] R¹-R² represent deuterium (D); and

[0020] all of R³-R²³ represent hydrogen (H).

[0021] In another preferred embodiment the deuterated analog of the invention is a compound of Formula I, or a pharmaceutically acceptable salt thereof, wherein

[0022] at least one of R¹-R⁷ represents deuterium (D); and

[0023] the remaining of R¹-R²³ represent hydrogen (H).

[0024] In a third preferred embodiment the deuterated analog of the invention is a compound of Formula I, or a pharmaceutically acceptable salt thereof, wherein

- [0025] all of R^1 - R^7 represent deuterium (D); and
- [0026] all of R^8 - R^{23} represent hydrogen (H).
- [0027] In a fourth preferred embodiment the deuterated analog of the invention is a compound of Formula I, or a pharmaceutically acceptable salt thereof, wherein
- [0028] R^8 , R^9 , R^{10} and R^{11} represent deuterium (D); and
- [0029] all of R^1 - R^7 and R^{12} - R^{23} represent hydrogen (H).
- [0030] In a fifth preferred embodiment the deuterated analog of the invention is a compound of Formula I, or a pharmaceutically acceptable salt thereof, wherein
- [0031] R^{12} represents deuterium (D); and
- [0032] all of R^1 - R^{11} and R^{13} - R^{23} represent hydrogen (H).
- [0033] In a sixth preferred embodiment the deuterated analog of the invention is a compound of Formula I, or a pharmaceutically acceptable salt thereof, wherein
- [0034] R^{17} R^{20} represent deuterium (D); and
- [0035] all of R^1 - R^{16} and R^{21} - R^{23} represent hydrogen (H).
- [0036] Any combination of two or more of the embodiments described herein is considered within the scope of the present invention.

Pharmaceutically Acceptable Salts

- [0037] The deuterated analog of the invention may be provided in any form suitable for the intended administration. Suitable forms include pharmaceutically (i.e. physiologically) acceptable salts, and pre- or prodrug forms of the deuterated analog of the invention.
- [0038] Examples of pharmaceutically acceptable salts include, without limitation, the non-toxic inorganic and organic acid addition salts such as the hydrochloride, the hydrobromide, the nitrate, the perchlorate, the phosphate, the sulphate, the formate, the acetate, the aconate, the ascorbate, the benzenesulphonate, the benzoate, the cinnamate, the citrate, the embonate, the enantate, the fumarate, the glutamate, the glycolate, the lactate, the maleate, the malonate, the mandelate, the methanesulphonate, the naphthalene-2-sulphonate, the phthalate, the salicylate, the sorbate, the stearate, the succinate, the tartrate, the toluene-p-sulphonate, and the like. Such salts may be formed by procedures well known and described in the art.
- [0039] Other acids such as oxalic acid, which may not be considered pharmaceutically acceptable, may be useful in the preparation of salts useful as intermediates in obtaining a deuterated analog of the invention and its pharmaceutically acceptable acid addition salt.
- [0040] Examples of pharmaceutically acceptable cationic salts of a deuterated analog of the invention include, without limitation, the sodium, the potassium, the calcium, the magnesium, the zinc, the aluminium, the lithium, the choline, the lysinium, and the ammonium salt, and the like, of a deuterated analog of the invention containing an anionic group. Such cationic salts may be formed by procedures well known and described in the art.
- [0041] The deuterated analog of the invention may be provided in dissoluble or indissoluble forms together with a pharmaceutically acceptable solvent such as water, ethanol, and the like. Dissoluble forms may also include hydrated forms such as the monohydrate, the dihydrate, the hemihydrate, the trihydrate, the tetrahydrate, and the like. In general, the dissoluble forms are considered equivalent to indissoluble forms for the purposes of this invention.

Methods of Preparation

- [0042] The deuterated analog of the invention may be prepared by conventional methods for chemical synthesis, e.g. those described in the working examples. The starting materials for the processes described in the present application are known or may readily be prepared by conventional methods from commercially available chemicals.
- [0043] Also one compound of the invention may be converted to another compound of the invention using conventional methods.
- [0044] The end products of the reactions described herein may be isolated by conventional techniques, e.g. by extraction, crystallisation, distillation, chromatography, etc.

Biological Activity

- [0045] WO 01/46145, WO 01/46146, WO 2005/121087, WO 2007/042295 WO 2008/127188 and WO 2008/155357 all describe substituted 4-phenyl-N-alkyl-piperazines and 4-phenyl-N-alkyl-piperidines, reported to be modulators of dopamine neurotransmission, and to be useful in treatment of symptoms of various disorders of the central nervous system. The deuterated analog of the invention is considered useful for the same medical indications as described in these publications, and these publications therefore are incorporated by reference.
- [0046] Neurological indications contemplated according to these publications include the treatment of Huntington's disease and other movement disorders, as well as movement disorders induced by drugs.
- [0047] Therefore, in a preferred embodiment, the invention relates to the use of the deuterated analog of the invention for use as a medicament for the treatment of Huntington's disease.

Pharmaceutical Compositions

- [0048] Viewed from another aspect the invention provides deuterated analogs for use as medicaments. Therefore, in another aspect, the invention provides novel pharmaceutical compositions comprising a therapeutically effective amount of the compound of the invention.
- [0049] While a deuterated analog of the invention for use in therapy may be administered in the form of the raw compound, it is preferred to introduce the active ingredient, optionally in the form of a physiologically acceptable salt, in a pharmaceutical composition together with one or more adjuvants, excipients, carriers, buffers, diluents, and/or other customary pharmaceutical auxiliaries.
- [0050] Pharmaceutical compositions of the invention may in particular be formulated as described in WO 01/46145.
- [0051] Further details on techniques for formulation and administration may be found in the latest edition of *Remington's Pharmaceutical Sciences* (Maack Publishing Co., Easton, Pa.).
- [0052] The dose administered must of course be carefully adjusted to the age, weight and condition of the individual being treated, as well as the route of administration, dosage form and regimen, and the result desired, and the exact dosage should of course be determined by the practitioner.
- [0053] The actual dosage depends on the nature and severity of the disease being treated, and is within the discretion of the physician, and may be varied by titration of the dosage to the particular circumstances of this invention to produce the desired therapeutic effect. However, it is presently contemplated

plated that pharmaceutical compositions containing of from about 1 to about 500 mg of active ingredient per individual dose, preferably of from about 10 to about 100 mg, most preferred of from about 25 to about 50 mg, are suitable for therapeutic treatments. The daily dose will preferably be administered in individual dosages 1 to 4 times daily.

Methods of Therapy

[0054] In another aspect the invention provides a method for the treatment, prevention or alleviation of a dopamine mediated disorder of a living animal body, including a human, which method comprises the step of administering to such a living animal body in need thereof a therapeutically effective amount of the deuterated analog of the invention.

[0055] In a preferred embodiment the dopamine mediated disorder is Huntington's disease.

EXAMPLES

[0056] The invention is further illustrated in the examples below, which in no way are intended to limit the scope of the invention.

Example 1

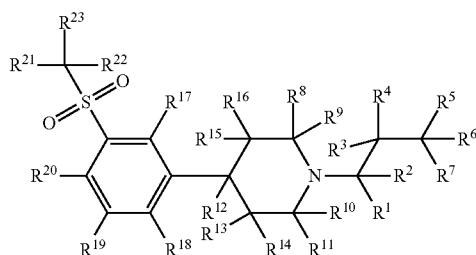
Preparatory Example

4-(3-Methanesulfonyl-phenyl)-1-propyl-d7-piperidine x HCl

[0057] 4-(3-Methanesulfonyl-phenyl)-piperidine (0.43 g), CH₃CN (4 ml), K₂CO₃ (0.49 g), and 1-Iodopropane-d7 (0.19 g) are mixed and heated in microwave oven for 30 min at 120° C. The mixture is filtered and evaporated to dryness and purified on silica column using iso-octane:EtOAc (1:1) containing 5% NEt₃ as eluent. After evaporation of the fractions with pure product, the residue is re-dissolved in EtOAc and washed with a 10% Na₂CO₃ solution. The organic phase is separated and dried with Na₂SO₄, filtered and evaporated to yield pure product (0.33 g). The amine is then converted to the HCl salt, and re-crystallized from EtOH:Et₂O. M.p. 198-199° C.

1-11. (canceled)

12. A pharmaceutical composition comprising a compound represented by Formula 1



or a pharmaceutically acceptable salt thereof, wherein at least one of R¹-R²³ represents deuterium (D); and the remaining of R¹-R²³ represent hydrogen (H); wherein the abundance of molecules of the compound having deuterium at a position designated by the at least

one of R¹-R²³ is substantially greater than the natural abundance of deuterium at that position.

13. The pharmaceutical composition of claim 12, wherein R¹-R² represent deuterium (D); and all of R³-R²³ represent hydrogen (H).

14. The pharmaceutical composition of claim 12, wherein at least one of R¹-R⁷ represents deuterium (D); and the remaining of R¹-R²³ represent hydrogen (H).

15. The pharmaceutical composition of claim 12, wherein all of R¹-R⁷ represent deuterium (D); and all of R⁸-R²³ represent hydrogen (H).

16. The pharmaceutical composition of claim 12, wherein R⁸, R⁹, R¹⁰ and R¹¹ represent deuterium (D); and all of R¹-R⁷ and R¹²-R²³ represent hydrogen (H).

17. The pharmaceutical composition of claim 12, wherein R¹² represents deuterium (D); and all of R¹-R¹¹ and R¹³-R²³ represent hydrogen (H).

18. The pharmaceutical composition of claim 12, wherein R¹⁷-R²⁰ represent deuterium (D); and all of R¹-R¹⁶ and R²¹-R²³ represent hydrogen (H).

19. The pharmaceutical composition of claim 12, wherein the compound or the pharmaceutically acceptable salt thereof is 4-(3-Methanesulfonyl-phenyl)-1-propyl-d7-piperidine hydrochloride.

20. The pharmaceutical composition of claim 12, wherein the abundance of molecules of the compound having deuterium at a position designated by the at least one of R¹-R²³ is at least 3,340 times greater than the natural abundance of deuterium at that position, at least 3,500 times greater than the natural abundance of deuterium at that position, at least 4,000 times greater than the natural abundance of deuterium at that position, at least 5,000 times greater than the natural abundance of deuterium at that position, at least 6,000 times greater than the natural abundance of deuterium at that position, at least 6,466.7 times greater than the natural abundance of deuterium at that position, or at least 6,633.3 times greater than the natural abundance of deuterium at that position.

21. The pharmaceutical composition of claim 12, comprising the pharmaceutically acceptable salt of the compound.

22. A therapeutically effective amount of the pharmaceutical composition of claim 12 together with at least one pharmaceutically acceptable carrier, excipient or diluent.

23. The pharmaceutical composition according to claim 22, wherein

R¹-R² represent deuterium (D); and all of R³-R²³ represent hydrogen (H).

24. The pharmaceutical composition according to claim 22, wherein

at least one of R¹-R⁷ represents deuterium (D); and the remaining of R¹-R²³ represent hydrogen (H).

25. The pharmaceutical composition according to claim 22, wherein

all of R¹-R⁷ represent deuterium (D); and all of R⁸-R²³ represent hydrogen (H).

26. The pharmaceutical composition according to claim 22, wherein

R⁸, R⁹, R¹⁰ and R¹¹ represent deuterium (D); and all of R²-R⁷ and R¹²-R²³ represent hydrogen (H).

27. The pharmaceutical composition according to claim 22, wherein

R¹² represents deuterium (D); and all of R¹-R¹¹ and R¹³-R²³ represent hydrogen (H).

28. The pharmaceutical composition according to claim 22, wherein

R^{17} - R^{20} represent deuterium (D); and
all of R^1 - R^{16} and R^{21} - R^{23} represent hydrogen (H).

29. A method of treating, preventing, or alleviating a symptom of, a dopamine mediated disorder in a living animal which comprises administering to the living animal a therapeutically effective amount of the pharmaceutical composition of claim **12**.

30. A method of treating, or alleviating a symptom of, Huntington's Disease in a living animal which comprises administering to the living animal a therapeutically effective amount of the pharmaceutical composition of claim **12**.

31. The pharmaceutical composition of claim **28**, wherein the pharmaceutical composition provides an in vivo plasma pridopidine concentration profile having a Mean C^{max} of about 1,400 ng/ml or less.

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