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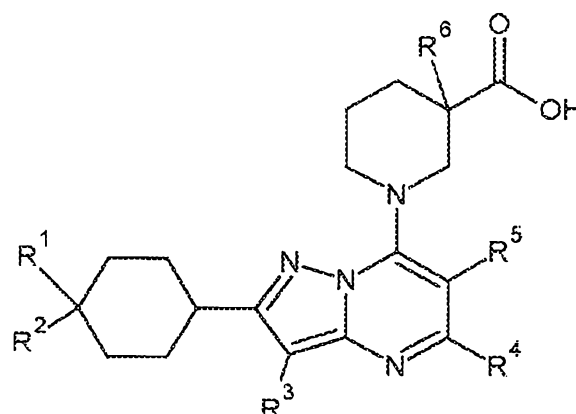
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54 Titre : Pharmacologically active alicyclic-substituted pyrazolo [1,5-a] pyrimidine derivatives.

57 Abrégé :

The present invention relates to new pyrazolo [1,5-a] pyrimidine derivatives of formula (I) or pharmaceutically acceptable salts, biologically active metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof that serve as GABA_B receptor positive allosteric modulators. The invention also relates to the process for producing such compounds. The invention further relates to pharmaceutical compositions comprising such compounds optionally in combination with two or more different therapeutic agents and the use of such compounds in methods for treating diseases and conditions mediated and modulated by the GABA_B receptor positive allosteric mechanism. The invention also provides a method for manufacture of medicaments useful in the treatment of such disorders.



Formula I

Pharmacologically active alicyclic-substituted pyrazolo[1,5-*a*]pyrimidine derivatives

FIELD OF THE INVENTION

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The present invention relates to new pyrazolo[1,5-*a*]pyrimidine derivatives of formula (I) or pharmaceutically acceptable salts, biologically active metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof that serve as GABA_B receptor positive allosteric modulators. The invention also relates to the process for producing such compounds. The invention further relates to pharmaceutical compositions comprising such compounds optionally in combination with two or more different therapeutic agents and the use of such compounds in methods for treating diseases and conditions mediated and modulated by the GABA_B receptor positive allosteric mechanism. The invention also provides a method for manufacture of medicaments useful in the treatment of such disorders.

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BACKGROUND OF THE INVENTION

Gamma-aminobutyric acid (GABA) is the main inhibitory neurotransmitter in the central nervous system and plays a key role in modulating neuronal activity. It exerts its action via three receptor systems, the related ionotropic GABA_A and GABA_C receptors, and the distinct metabotropic GABA_B receptors (Hill and Bowery, *Nature* 1981, 290, 149-152). The latter GABA_B receptors are widespreadly distributed within the mammalian central nervous system with various expression levels in different brain regions (Bovery et al, *Neuroscience* 1987, 20, 365-385). GABA_B receptors can be found both pre- and postsynaptically and play an important role in the fine-tuning of neurotransmission. Most GABA_B receptors cluster around excitatory synapses, either at the edge of the presynaptic terminal or on dendritic spines opposite to glutamatergic boutons (Ulrich and Bettler, *Curr. Opin. Neurobiol.* 2007, 17, 298-303).

GABA_B receptors belong to the Family 3 (C) of G-protein coupled receptors (GPCRs) together with metabotropic glutamate receptors (mGluRs), calcium-sensing receptors, taste receptors and a number of orphan receptors, showing highest, approximately 30% homology to mGluRs (Bettler et al, *Physiol. Rev.* 2004, 84, 835-867). GABA_B receptors are heterodimers

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consisting of two similar, yet different subunits, B1 and B2. The B1 subunit has multiple splice variants with only two (B1a and B1b) having clear physiological significance. These isoforms differ only in their extracellular domain containing two Sushi motifs that regulate the subcellular localization of the receptor (Vigot et al, *Neuron* 2006, 50, 589-601; Biermann et al, 5 J. Neurosci. 2010, 30, 1385-1394). The B1 subunit binds the endogenous neurotransmitter ligand GABA as well as other orthosteric agonists (such as baclofen, SKF97541) and antagonists (such as phaclofen, saclofen). The B2 subunit is responsible for G-protein activation-mediated intracellular signal transduction and is believed to bind allosteric modulators (Binet et al, *J. Biol. Chem.* 2004, 279, 29085-29091; Dupuis et al, *Mol. Pharmacol.* 10 2006, 70, 2027-2036). The site of action for the Novartis GABA_B positive allosteric modulator compounds CGP7930 and GS39783 is the heptahelical transmembrane domain of the B2 subunit; the exact binding site for other, unrelated positive allosteric modulator chemotypes is not known.

The main synaptic effects of GABA_B receptors are the presynaptic blockade of 15 neurotransmitter release (GABA as well as glutamate) and postsynaptic hyperpolarization (Gassmann and Bettler, in Handbook of Contemporary Neuropharmacology 2007). These effects are the result of inhibition of presynaptic calcium influx and stimulation of postsynaptic inwardly rectifying potassium (GIRK) channels, respectively. Ion channel functions are mediated in a membrane-delimited manner through the activation of $\beta\gamma$ subunits of G_i/G_o 20 proteins. In addition to these, GABA_B receptors also signal via the α subunit of the same G-proteins that inhibits adenylate cyclase and retards the recruitment of synaptic vesicles (Chalifoux and Carter, *Curr. Opin. Neurobiol.* 2011, 21, 339-442). Beside these fast cellular events, GABA_B receptors also regulate cytoplasmic kinases including mitogen-activated protein kinase and thereby influence synaptic plasticity on the longer-term.

25 In order to better understand the physiological significance of GABA_B receptors at the behavioral level, knockout mice have been generated with mutations selectively in the B1, B1a, B1b and the B2 subunits. Mice without B1 subunits displayed increased anxiety in explorative-like situations (light-dark box, staircase assays), increased panic, spontaneous seizures, hyperalgesia, hyperlocomotion, and memory impairment (Schuler et al, *Neuron* 2001, 31, 47- 30 58). Mice that do not express GABA_{B2} subunits behave similarly to B1 subunit knockouts; these animals are overanxious, show spontaneous seizure activity, hyperalgesia, hyperlocomotion, and memory impairment (Mombereau et al, *Eur. J. Pharmacol.* 2004, 497, 119-120;

Mombereau et al, *Neuroreport* 2005, 16, 307-310; Gassmann et al, *J. Neurosci.* 2004, 24, 6086-6097). Based on the above, the GABA_B receptor system seems to play a general role in the regulation of neuronal excitability with consequences on various aspects of overt behavior.

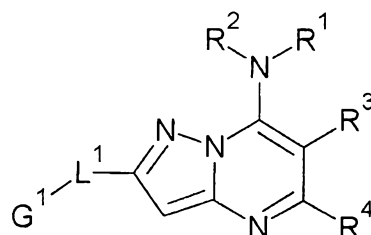
The only approved and commercialized selective GABA_B receptor ligand is the orthosteric agonist racemic baclofen. Baclofen was approved as a centrally acting muscle relaxant used to reduce spasticity associated with cerebral palsy, multiple sclerosis, and spinal cord injuries. Beside these applications, baclofen may have potential therapeutic benefits in treating conditions including asthma, pain, obesity, binge eating, drug and alcohol abuse, anxiety, posttraumatic stress disorder, cough, inflammation, gastroesophageal reflux and urinary incontinence (eg., Breslow et al, *Am. J. Psychiatry* 1989, 146, 353-356; Drake et al, *Ann. Pharmacother.* 2003, 37, 1177-1181; Leggio et al, *CNS Neurol. Disord. Drug Targets* 2010, 9, 33-44). Although baclofen has beneficial potential in a number of therapeutic indications, unfortunately it also has a range of unwanted properties including poor blood-brain-barrier penetration, narrow therapeutic window, receptor desensitization, development of tolerance against the main effects, and withdrawal upon termination of use (Vacher and Bettler, *Curr. Drug Targets CNS Neurol. Disord.* 2003, 2, 248-259; Ross et al, *Neurocrit. Care* 2011, 14, 103-108; Keegan et al, *Neuropharmacology* 2015, 95, 492-502).

Allosteric modulation is an alternative way to selectively stimulate GPCRs without the unwanted properties of orthosteric ligands (Conn et al, *Nat Rev* 2009, 8, 41-54; Wang et al, *J. Pharmacol. Exp. Ther.* 2009, 331, 340-348). Allosteric modulators bind to the receptors at sites that are different from the binding site of the endogenous (orthosteric) ligands and are effective predominantly if an agonist is also bound to the receptor. This has consequences on the temporal and spacial pattern of efficacy which in turn affects the behavioral and adaptive responses the organism gives to allosteric stimulation. In contrast to orthosteric agonism, allosteric modulation of targets is expected to show less side effects, desensitization and development of tolerance. Indeed, it has been shown for the GABA_B receptor positive allosteric modulator GS39783 in preclinical models, that this compound can have a favourable side effect profile (Cryan et al, *J. Pharmacol. Exp. Ther.* 2004, 310, 952-963), desensitization of the receptor can be prevented (Gjoni and Urwyler, *Neuropharmacology* 2008, 55:1293-1299) and tolerance may not develop upon chronic administration (Mombereau et al, *Neuropsychopharmacology* 2004, 29, 1050-1062). These results suggest that positive allosteric modulators of the GABA_B

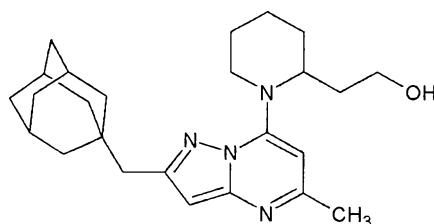
receptor may be useful novel chemical entities without the unwanted properties of the orthosteric ligands such as baclofen.

Several patents and patent applications describe positive allosteric GABA_B modulators which have different chemical structures. Pyrimidine derivatives as positive allosteric modulators of the GABA_B receptor have been disclosed in WO 2005/094828 and WO 2006/136442. Thieno[3,2-b]pyrimidine and [1,3]thiazolo[5,4-d]pyrimidine derivatives as positive allosteric modulators of the GABA_B receptor have been disclosed in WO 2015/056771 (US 2015/0111876).

A recent patent application by Faghieh et al. (US 2016/0304527 A1) describes pyrazolo-pyrimidines with *in vitro* positive allosteric activity at the GABA_B receptors measured by [³⁵S]GTPγS binding.



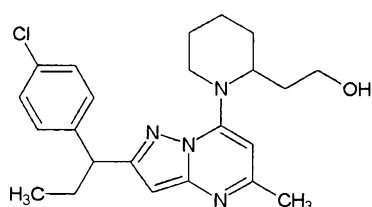
In Faghieh et al. only one alicyclic-substituted compound with high micromolar binding potency has been demonstrated (Example 7-1), other exemplified compounds are aryl-substituted and show only micro or submicromolar binding potency. Unexpectedly, we found in the present invention that compounds with cyclohexyl moieties show nano or subnanomolar potency measured in a similar assay paradigm.



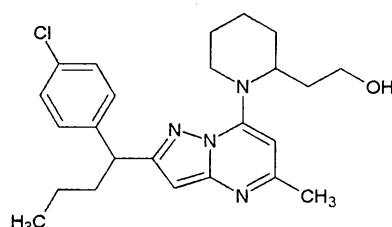
Example 7-1

EC₅₀ 1.08 μM

The invention of Faghieh et al. describes that the incorporation of linkers comprising three or four carbon atoms (L1) increases *in vitro* potency. Most of the exemplified aryl-substituted compounds with linkers comprising one or two carbon atoms show only micro or submicromolar binding potency (Example 1-1). However, only the exemplified compounds which contain a linker comprising three or four carbon atoms (Example 3-1; Example 5-1) reach nanomolar potency. Unexpectedly, we found in the present invention that compounds without any linker show nano or subnanomolar potency.



Example 3-1

EC₅₀: 8 nM

Example 5-1

EC₅₀: 3 nM

Exemplified compounds containing azetidine carboxylic acid (Example 8-10) or nipecotic acid amide (Example 1-19) moieties in Faghieh et al. show only high micromolar potency. Unexpectedly, we found in the present invention that compounds bearing simple nipecotic acid moiety show nano or subnanomolar potency. These compounds despite of possessing acidic nipecotic acid moiety are metabolically stable and unexpectedly penetrate into the brain (principles of brain penetration of drug molecules are summarized in: Kerns et al. Drug-like Properties: Concepts, Structure Design and Methods Chapter: Blood-Brain Barrier pages 122-136 “Figure 10.12: Acids poorly penetrate the BBB (Blood Brain Barrier) (CNS-)”).

The above described *in vitro* advantages are further strengthened by the unexpected finding that selected compounds of the invention were of great behavioral benefit in the prenatal valproate disease model that recapitulates the core symptoms of autism spectrum disorder. The inventors therefore showed that this compound has therapeutic potential for the treatment of core symptoms of autism spectrum disorder in humans.

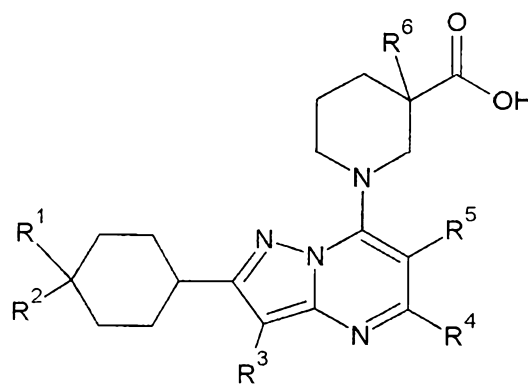
SUMMARY OF THE INVENTION

Our invention discloses nipecotic acid derivatives with a cyclohexyl-pyrazolo-
5 pyrimidine scaffold. We found that these compounds show mostly nanomolar potency, in
certain cases reaching even the subnanomolar potency range. These compounds despite of
possessing acidic nipecotic acid moiety are metabolically stable and unexpectedly penetrate
into the brain (principles of brain penetration of drug molecules are summarized in: Kerns et al.
Drug-like Properties: Concepts, Structure Design and Methods Chapter: Blood-Brain Barrier
10 pages 122-136). These compounds without having a carbon linker between the pyrazolo-
pyrimidine core and the appended cyclohexyl ring show nanomolar potency. It was identified
unexpectedly that an alkyl substituent at position 6 of the pyrazolo-pyrimidine scaffold (R3 in
US20160304527) increased *in vitro* potency at least two order of magnitude. Our compounds
show large effect sizes (reaching 80-100%) at low oral dosing (1 mg/kg) in an *in vivo* assay.

15 We have identified a class of pyrazolo[1,5-a]pyrimidine derivatives which have high
affinity for GABA_B receptors providing unique role in the treatment of psychiatric,
neurodevelopmental, neurological and other central nervous system disorders as well as
peripheral conditions where stimulation of the GABA_B receptor may offer therapeutic benefit.

We identified new compounds that are brain penetrant. The present invention relates to
20 compounds being GABA_B receptor positive allosteric modulators and the synthesis thereof.
Compounds of the present invention are useful for the treatment of psychiatric,
neurodevelopmental, neurological and other central nervous system disorders as well as
peripheral conditions where stimulation of the GABA_B receptor may offer therapeutic benefit.

25 The present invention relates to the pyrazolo[1,5-a]pyrimidine derivatives of formula
(I)



(I)

- 5 R^1 and R^2 are independently selected from hydrogen, halogen atom, C_{1-6} alkyl, halo C_{1-6} alkyl; R^3 is hydrogen, halogen atom, C_{1-6} alkyl, halo C_{1-6} alkyl, cyano group;

R^4 is C_{1-6} alkyl;

R^5 is C_{3-5} cycloalkyl;

R^5 is C_{1-6} alkyl optionally substituted by a halogen atom or halogen atom

C_{3-5} cycloalkyl, C_{1-6} alkyl, dialkylamino, C_{1-6} alkoxy, C_{1-6} alkoxy C_{1-6} alkyl

C_{1-3} alkyl, C_{1-3} alkoxy,

or R_4 and R_5 together form an unsubstituted or substituted by one or more

and sulphur;

alkoxy C_{1-6} alkyl, halo C_{1-6} alkyl,

biologically active metabolites,

thereof.

compositions containing the

biologically active metabolites,

thereof.

compounds of formula

pharmaceutical compositions

are of medicaments

of these compounds, which

arising from psychiatric,

- 10 tetrahydrofuryl, tetrahydrofuryl C_{1-6} alkyl, tetrahydropyryl, tetrahydropyryl C_{1-6} alkyl, or R_4 and R_5 together form an unsubstituted or substituted by one or more halo C_{1-3} alkyl, C_{1-3} alkylcarbonyl 3 to 7-membered saturated ring, where the ring are selected from the group consisting of carbon, nitrogen, oxygen, sulphur, and nitrogen; R^6 is hydrogen, halogen atom or C_{1-6} alkyl, hydroxyl, C_{1-6} alkoxy, C_{1-6} alkyl or amino group; or pharmaceutically acceptable salts, biological 15 pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates.

The invention also relates to the pharmaceutical compositions of compounds of formula (I) or pharmaceutically acceptable salts, biological 20 pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof.

Furthermore, the present invention relates to the synthesis of the compounds of formula (I) and optical antipodes or racemates and/or salts thereof, the pharmaceutical compositions comprising thereof and the chemical and pharmaceutical manufacturing processes containing these compounds, as well as the methods of treatment with the 25 means administering to a mammal to be treated – including human – suffering from the above-mentioned conditions.

neurodevelopmental, neurological and other central nervous system disorders as well as peripheral conditions where stimulation of the GABA_B receptor may offer therapeutic benefit, effective amount of compounds of formula (I) and optical antipodes or racemates and/or salts thereof of the present invention as such or as medicament.

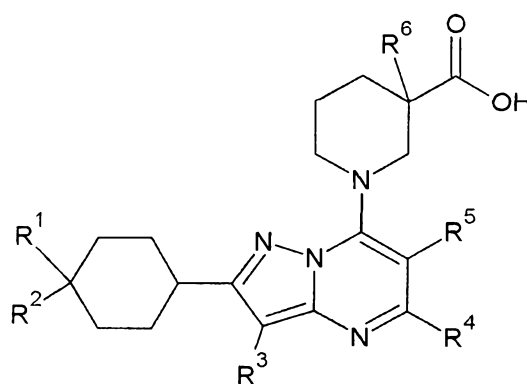
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DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to the pyrazolo[1,5-a]pyrimidine derivatives of formula

(I)

10



(I)

R¹ and R² are independently selected from hydrogen, halogen atom, C₁₋₆alkyl, haloC₁₋₆alkyl;

15 R³ is hydrogen, halogen atom, C₁₋₆alkyl, cyano group;

R⁴ is C₁₋₆alkyl;

R⁵ is C₁₋₆alkyl optionally substituted by a halogen atom or halogen atoms, C₃₋₅ cycloalkyl;

C₃₋₅ cycloalkylC₁₋₆alkyl, dialkylamino, C₁₋₆alkoxy, C₁₋₆alkoxyC₁₋₆alkyl, C₁₋₆alkylthio group, tetrahydrofuranyl, tetrahydrofuranylC₁₋₆alkyl, tetrahydropyranyl, tetrahydropyranylC₁₋₆alkyl;

20 or R₄ and R₅ together form an unsubstituted or substituted by one or more C₁₋₃alkyl, C₁₋₃alkoxy, haloC₁₋₃alkyl, C₁₋₃alkylcarbonyl 3 to 7-membered saturated ring, wherein the members of the ring are selected from the group consisting of carbon, nitrogen, oxygen, and sulphur;

R⁶ is hydrogen, halogen atom or C₁₋₆alkyl, hydroxyl, C₁₋₆alkoxy, C₁₋₆alkoxyC₁₋₆alkyl, haloC₁₋₆alkyl, amino group;

or pharmaceutically acceptable salts, biologically active metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof. The term “halogen” or “halo” as used herein alone or as a part of another group refers to chlorine, bromine, fluorine and iodine.

5 The term “C₁-C₆ alkyl” as used herein refers to branched or straight chain alkyl groups comprising one to six carbon atoms, including but not limited to methyl, ethyl, propyl, normal- and isopropyl and different butyl groups.

 The term “C₃-C₅ cycloalkyl” as used herein refers to carbocyclic groups of 3 to 5 carbons, respectively; for example, cyclopropyl, cyclobutyl, and cyclopentyl.

10 The term “C₁-C₆ alkoxy” as used herein refers to branched or straight chain alkyl groups comprising one to four carbon atoms bonded through an oxygen atom, including but not limited to, methoxy, ethoxy, n-propoxy, i-propoxy, and t-butoxy.

 The term “C₁₋₆alkylthio” as used herein refers to branched or straight chain alkyl groups comprising one to six carbon atoms bonded through a sulphur atom, including but not limited
15 to, methylthio, ethylthio, n-propylthio, i-propylthio, and t-butylthio.

 The term “mammal” as used herein refers to any members of the class “Mammalia” including, but not limited to human.

 The term “salt” means nontoxic base addition salts of the compounds of the invention which are generally prepared by reacting the acid with a suitable organic or inorganic base.

20 Included within the scope of the present invention are all stereoisomers, geometric isomers and tautomeric forms of the compounds of formula (I), including compounds exhibiting more than one type of isomerism and mixtures of one or more thereof.

 Conventional techniques for the preparation/isolation of individual enantiomers include chiral synthesis from the suitable optically pure precursor or resolution of the racemate (or
25 racemate of a salt or derivative) using, for example chiral high pressure liquid chromatography (HPLC).

 The term “pharmaceutically acceptable” describes an ingredient that is useful in preparing a pharmaceutical composition and is generally safe, non-toxic and neither

biologically nor otherwise undesirable, and includes those acceptable for veterinary use as well as human pharmaceutical use.

The term "pharmaceutical composition" refers to a mixture of a compound of the invention with other chemical components, such as pharmaceutically acceptable auxiliary materials, e.g. diluents or carriers. The pharmaceutical composition facilitates administration of the compound to the subject.

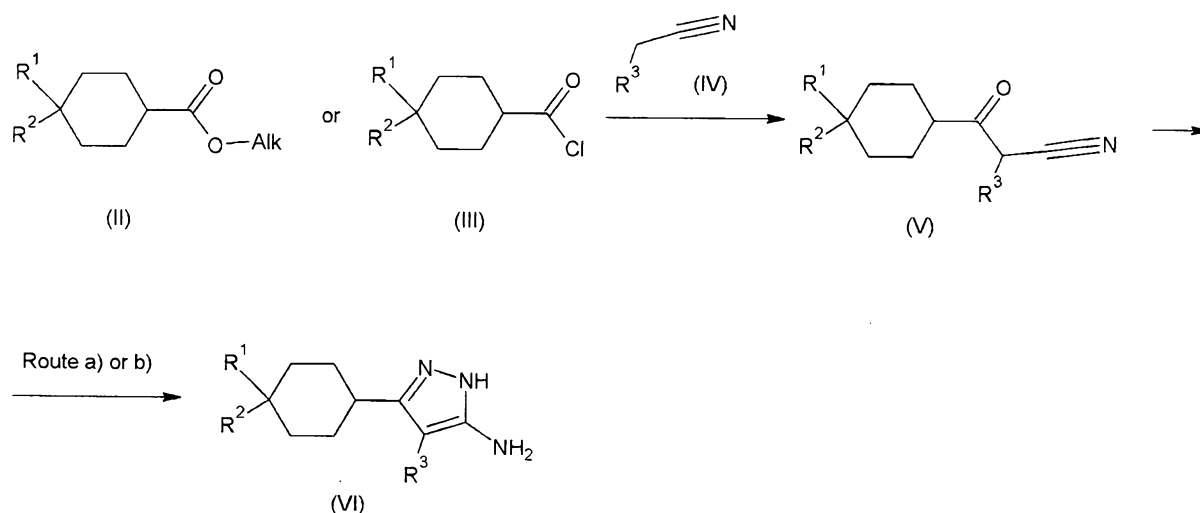
The term "excipient" defines a chemical compound that facilitates the incorporation of a compound into cells or tissues.

As used herein, the term "treatment" means using an effective therapy to reduce, alleviate or eliminate the symptoms associated with diseases and conditions mediated and modulated by the GABA_B receptor positive allosteric mechanism.

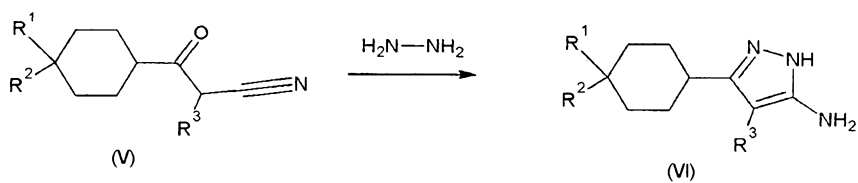
As a further aspect of the present invention there is provided the synthesis of compounds of formula (I).

Compounds according to the present invention were synthesized in line with the synthetic routes and schemes described below.

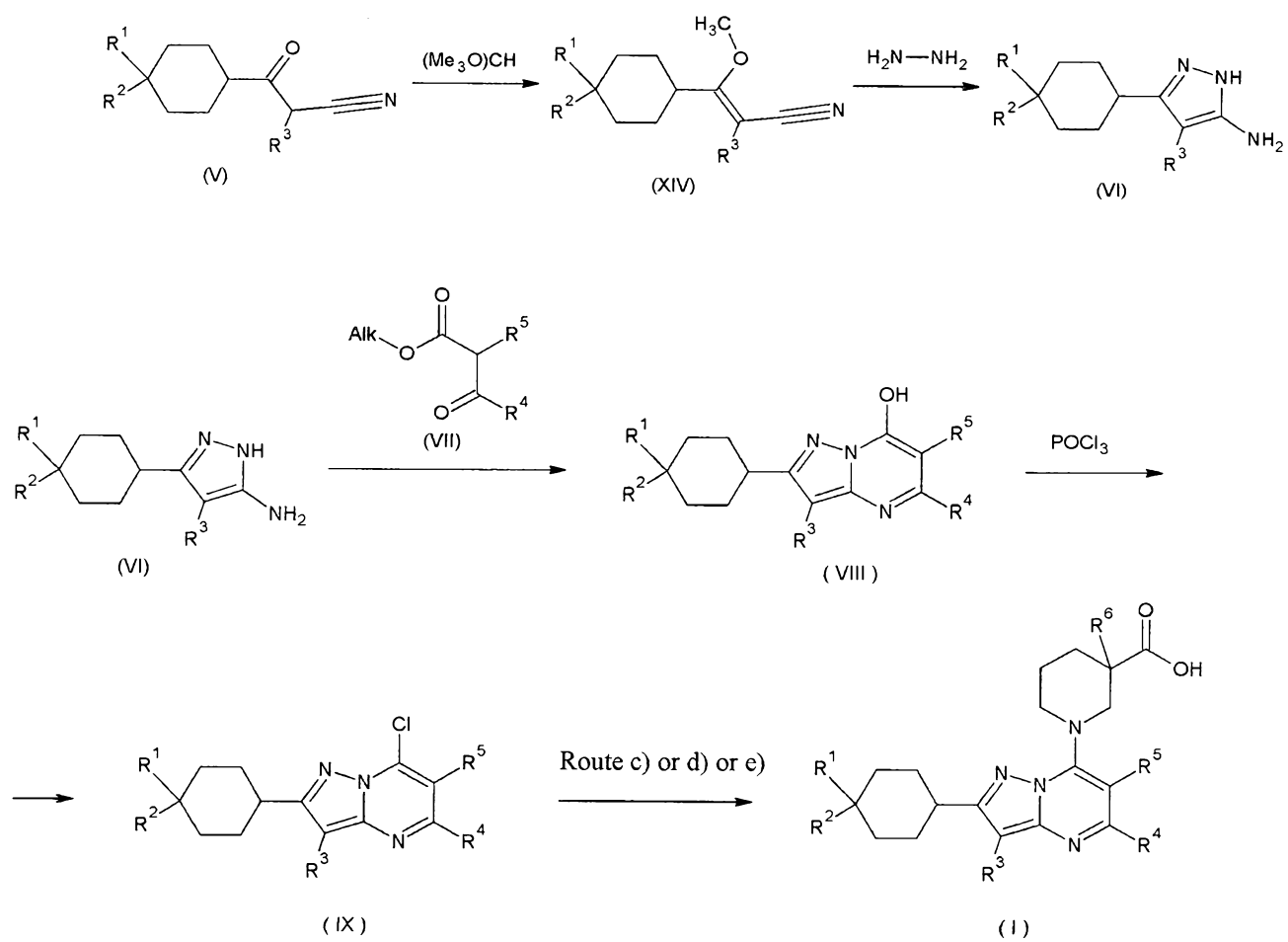
Accordingly, the compounds of formula (I) of the invention can be synthesized by one of the following routes:



Route a):

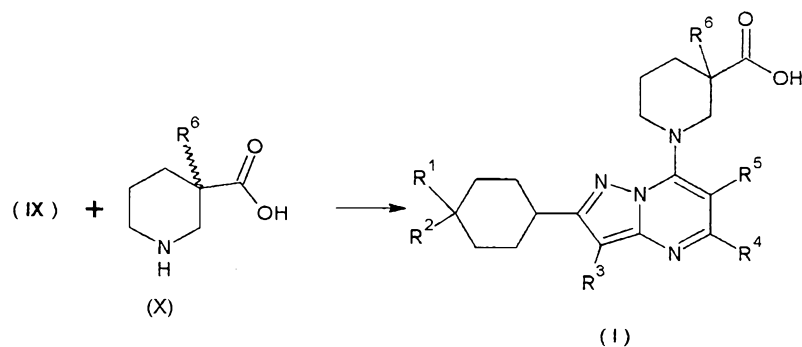


5 Route b):



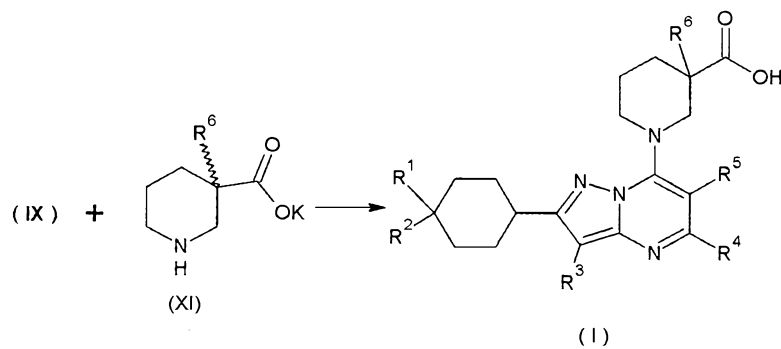
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Route c):

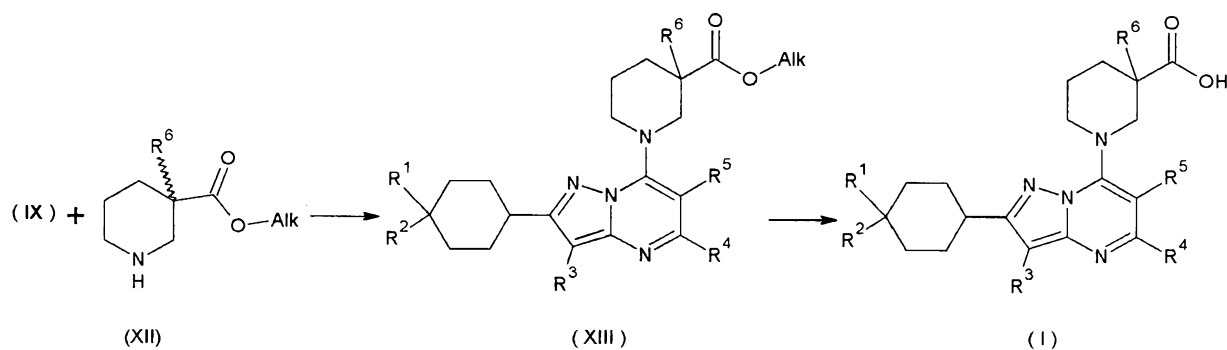


Route d):

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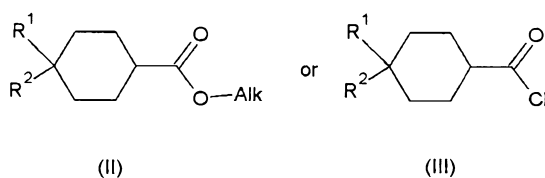
Route e):



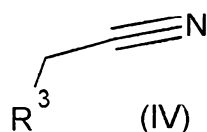
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Step 1) Reacting a carboxylic acid ester derivative of formula (II) or carboxylic acid chloride derivative of formula (III)

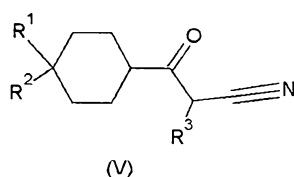
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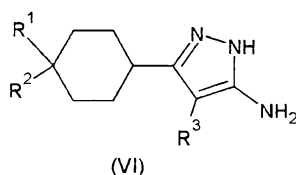
- wherein the meaning of R^1 and R^2 is described above for compound of formula (I) – with an acetonitrile derivative of formula (IV)



- 5 - wherein the meaning of R^3 is described above for compound of formula (I), then step 2) the so obtained acylacetonitrile derivative of formula (V) is reacted with



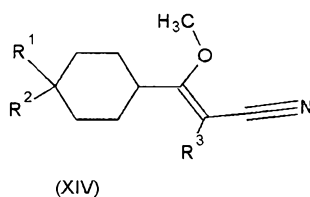
- 10 2a) hydrazine hydrate to provide a compound of formula (VI)



- wherein the meaning of R^1 , R^2 is as described above and R^3 is hydrogen, halogen atom, C_{1-6} alkyl group or

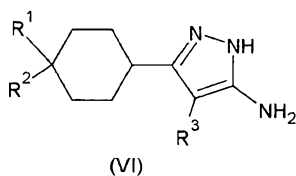
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- 2b) trimethyl orthoformate to provide the malononitrile derivative of formula (XIV)



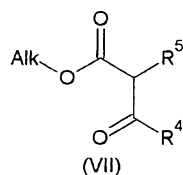
- wherein the meaning of R^1 , R^2 is as described above and R^3 is cyano group which is reacted with hydrazine hydrate to provide a compound of formula (VI)

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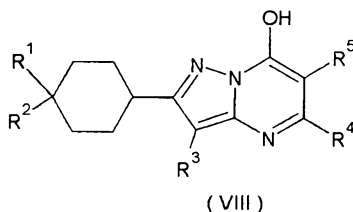
then

step 3) the compound of formula (VI) wherein the meaning of R^1 , R^2 , R^3 is as described above
 5 for the formula (I) – obtained according to the steps described in 2a) or 2b) is reacted with acylacetic ester derivative of formula (VII)



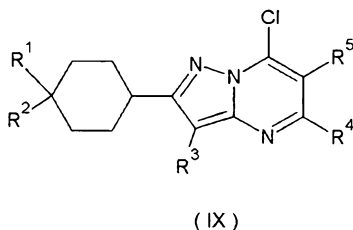
- wherein the meaning of R^4 and R^5 is as described above for the formula (I), then

step 4) the so obtained compound of formula (VIII)



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- wherein the meaning of R^1 , R^2 , R^3 , R^4 , and R^5 is as described above for the formula (I) -is chlorinated to furnish a chloro derivative of formula (IX)

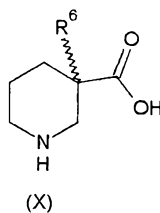


15 - wherein the meaning of R^1 , R^2 , R^3 , R^4 , and R^5 is as described above for the formula (I) - and

step 5) the latter is reacted with either

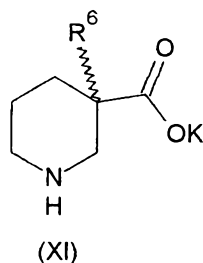
5c) a nipecotic acid derivative of formula (X)

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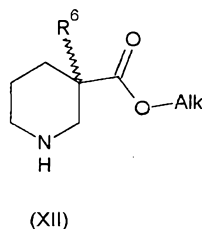
- 5 - wherein the meaning of R^6 is as described above for the formula (I) – and the obtained derivative of formula (I) and optical antipodes or racemates and/or salts thereof in given case can be transformed into an other compound of formula (I) and optical antipodes or racemates and/or salts thereof by introducing new substituents and/or modifying or removing the existing ones, or

5d) its alkali salt of formula (XI)

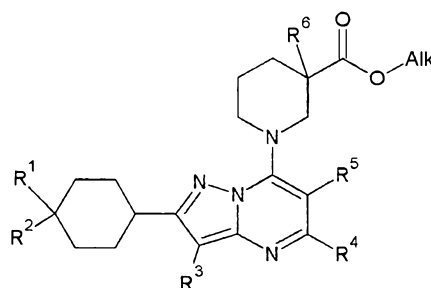


- 10 - wherein the meaning of R^6 is as described above for the formula (I) – and the obtained compound of formula (I) and optical antipodes or racemates and/or salts thereof in given case can be transformed into an other compound of formula (I) and optical antipodes or racemates and/or salts thereof by introducing new substituents and/or modifying or removing the existing ones, or

15 5e) a nipecotic acid ester derivative of formula (XII)



- wherein the meaning of R^6 is as described above for the formula (I) – to provide the ester derivative of formula (XIII)



(XIII)

- wherein the meaning of R^1 , R^2 , R^3 , R^4 , R^5 and R^6 is as described above for the formula (I) finally the latter is saponified with a strong base or acid – and the obtained derivative of formula (I) and optical antipodes or racemates and/or salts thereof optionally can be transformed into an other compound of formula (I) and optical antipodes or racemates and/or salts thereof by introducing new substituents and/or modifying or removing the existing ones.

The synthesis of acylacetonitrile derivative (V) can be carried out by different routes:

Route a):

a) The reaction of a carboxylic acid ester derivative of formula (II) with an acetonitrile derivative of formula (IV) is preferably carried out in a proper solvent, e.g. tetrahydrofuran, preferably in the presence of a strong base e.g. n-butyllithium, lithium bis(trimethylsilyl)amide. The reaction carried out at a temperature in the range of $-78\text{ }^\circ\text{C}$ to room temperature. The necessary reaction time is 1-16 h. The reactions are followed by thin layer chromatography. The reaction is quenched by addition of water and hydrochloric acid ($\sim\text{pH } 2\text{-}3$) or saturated ammonium chloride solution. The product (V) is isolated by extraction with a proper organic solvent or by filtration, after removing the organic solvent.

b) The reaction of an carboxylic acid chloride derivative of formula (III) with an acetonitrile derivative of formula (IV) is preferably carried out in a proper solvent, e.g. tetrahydrofuran, preferably in the presence of a strong base e.g. n-butyllithium, lithium bis(trimethylsilyl)amide. The reaction carried out at a temperature in the range of $-78\text{ }^\circ\text{C}$ to room temperature. The necessary reaction time is 1-16 h. The reactions are followed by thin layer chromatography. The reaction is quenched by addition of water and hydrochloric acid

(~pH 2-3) or saturated ammonium chloride solution. The product (V) is isolated by extraction with a suitable organic solvent or by filtration, after removing the organic solvent.

The cyclocondensation reaction of the acyl nitrile derivatives of formula (V) with hydrazine hydrate to pyrazole derivatives of formula (VI) is preferably carried out in a suitable solvent, e.g. ethanol. The reaction is preferably carried out at boiling point of the solvent. The necessary reaction time is 1-6 h. The reactions are followed by thin layer chromatography. The work-up of the reaction mixture can be carried out by the following routes:

a) The reaction mixture is diluted with water and the product is isolated by filtration or extraction with a suitable organic solvent and in given case purified by crystallization or column chromatography.

b) The reaction mixture is evaporated *in vacuo* and the crude product is used in the next step without further purification.

Route b):

The reaction of a carboxylic acid chloride derivative of formula (III) with malononitrile is preferably carried out in a suitable solvent, e.g. tetrahydrofuran, preferably in the presence of a base e.g. triethylamin. The reaction carried out at a temperature in the range of 0 °C to room temperature. The necessary reaction time is 1-16 h. The reactions are followed by thin layer chromatography. The reaction is quenched by addition of water. The product (V) is isolated by extraction with a suitable organic solvent.

The O-methylation of the acyl malononitrile derivative of formula (V) with trimethyl orthoformate is preferably carried out at boiling point. The necessary reaction time is 1-16 h. The reactions are followed by thin layer chromatography. The product (XIV) is purified by column chromatography.

The cyclocondensation reaction of the O-methylated acyl nitrile derivatives of formula (XIV) with hydrazine hydrate to pyrazole derivatives of formula (VI) is preferably carried out in a suitable solvent, e.g. ethanol. The reaction is preferably carried out at room temperature. The necessary reaction time is 1-6 h. The reactions are followed by thin layer chromatography. The reaction mixture is diluted with water and the product is isolated by extraction with a suitable organic solvent.

The cyclocondensation reaction of the 1*H*-pyrazol-5-amine derivative of formula (VI) with an acylacetic ester derivative of formula (VII) is preferably carried out in a suitable solvent,

e.g. toluene, by the addition of catalytic amount of p-toluenesulfonic acid, using a Dean- Stark water separator. The reaction is preferably carried out at boiling point of the solvent. The necessary reaction time is 1-16 h. The reactions are followed by thin layer chromatography. The product (VIII) is isolated by filtration.

5 Chlorination of the pyrazolo[1,5-*a*]pyrimidine derivative of formula (VIII) can be carried out in a suitable solvent, e.g. toluene using a suitable chlorinating agent, e.g. phosphorus oxychloride by the addition of triethylamine or N,N-diisopropylethylamine. The reaction is preferably carried out at boiling point of the solvent. The necessary reaction time is 24-48 h. The reactions are followed by thin layer chromatography. The reaction mixture is poured into
10 sodium hydrogen carbonate solution and crushed ice. The decomposed reaction mixture is filtered and the product is isolated from the filtrate by extraction with a suitable organic solvent and in given case purified by crystallization or column chromatography. The column chromatography is carried out on normal phase using Kieselgel 60 as adsorbent and different solvent systems, e.g. n-hexane/ethyl acetate, toluene/methanol, chloroform/methanol or
15 toluene/acetone, as eluents.

N-arylation reaction of the nipecotic acid derivative of formula (X) or (XII) with the chloro derivative of formula (IX) carried out in a suitable solvent, e.g. dimethylformamide, dimethylsulfoxide, N-methyl-pyrrolidone. The reaction is preferably carried out between 80°C and 140 °C. A suitable amine of formula (X) or (XII) is added as base or as a salt formed with
20 inorganic acid to the so obtained solution in the presence of a base, for example cesium carbonate or N,N-diisopropylethylamine, needed for the liberation of the amine or formed with inorganic base for example potassium salt of formula (XI). The reactions are followed by thin layer chromatography. The necessary reaction time is 3-20 h. The work-up of the reaction mixture can be carried out by different methods.

25 When the N-arylated product is an acid derivative of formula (I) and the reaction mixture is a suspension, the inorganic salt is filtered off, the filtrate is diluted with water and acidified with acetic acid. The product is isolated by filtration or extraction with a suitable organic solvent and in given case purified by crystallization or column chromatography. If the reaction mixture is a solution, it is diluted with water and acidified with acetic acid. The product is isolated by
30 filtration or extraction with a suitable organic solvent and in given case purified by crystallization or column chromatography.

When the N-arylated product is an ester derivative of formula (XIII), the reaction mixture is evaporated *in vacuo*. The product is isolated by crystallization or extraction with a suitable organic solvent and in given case purified by recrystallization or column chromatography.

5 The hydrolysis of the carboxylic acid ester derivative of formula (XIII) into the carboxylic acid derivative of formula (I) can be carried out with an appropriate strong inorganic base, e.g. lithium hydroxide, sodium hydroxide or with an appropriate strong inorganic acid, e.g. hydrochloric acid. The reaction is preferably carried out between room temperature and 100 °C. The reactions are followed by thin layer chromatography. The necessary reaction time
10 is 1-20 h. The reaction mixture is diluted with water and acidified with acetic acid. The product is isolated by filtration or extraction with a suitable organic solvent and in given case purified by crystallization or column chromatography. The structures of the products are determined by NMR and mass spectrometry.

15 Most of the nipecotic acid derivatives of formula (X) and (XII) are either commercially available or can be synthesized by different known methods. The syntheses of some new nipecotic acid derivatives of formula (XII) are described in the Intermediates section.

The compounds of the present invention and optical antipodes or racemates and/or salts thereof can be used as such or suitably in the form of pharmaceutical compositions.

20 The invention also relates to the pharmaceutical compositions containing the compounds of formula (I) or optical antipodes or racemates and/or salts thereof as active ingredient for the treatment of certain disorders associated with GABA_B receptor positive allosteric modulator activity.

The present compounds may be coadministered to a subject in combination with two or
25 more different therapeutic agents (eg. most preferably antipsychotics and psychostimulants; and preferably antidepressants, anxiolytics, antihypertensives, anticonvulsants, sedatives, and narcotics).

Suitable routes of administration may, for example, include oral, rectal, transmucosal,
30 transdermal or intestinal administration; parenteral delivery, including intramuscular, subcutaneous, intravenous, intramedullary injections, as well as intraarticular, intrathecal, direct intraventricular, intraperitoneal, intranasal, or intraocular injections and eye drops.

Alternatively, one may administer the compound in a local rather than systemic manner, for example, via injection of the compound directly in the renal or cardiac area, often in a depot or sustained release formulation. Furthermore, one may administer the drug in a targeted drug delivery system, for example, in a liposome coated with a tissue-specific antibody. The liposomes will be targeted to and taken up selectively by the organ.

The pharmaceutical compositions can be administered through via a variety of routes and dosage forms. The compound of the invention may be administered either alone or in combination with pharmaceutically acceptable carriers, in either single or multiple doses. The dosage required to exert the therapeutical effect can vary within wide limits and will be fitted to the individual requirements in each of the particular case, depending on the stage of the disease, the condition and the bodyweight of the patient to be treated, as well as the sensitivity of the patient against the active ingredient, route of administration and number of daily treatments.

For the sake of a simple administration it is suitable if the pharmaceutical compositions comprise dosage units containing the amount of the active ingredient to be administered once, or a few multiples or a half, third or fourth part thereof. Such dosage units are e.g. tablets, which can be powdered with grooves promoting the halving or quartering of the tablet in order to exactly administer the required amount of the active ingredient.

The pharmaceutical compositions containing the active ingredient according to the present invention usually contain 0.01 to 500 mg of active ingredient in a single dosage unit. It is, of course possible that the amount of the active ingredient in some compositions exceeds the upper or lower limits defined above.

As a further aspect of the invention there is provided the pharmaceutical manufacture of medicaments containing the compounds of formula (I) or optical antipodes or racemates and/or salts thereof.

The pharmaceutical compositions of the present invention may be formulated as different pharmaceutical dosage forms, such as but not limited to, solid oral dosage forms like tablets (e.g. buccal, sublingual, effervescent, chewable, orodispersible, freeze dried), capsules, lozenges, pastilles, pills, orodispersible films, granules, powders; liquid oral dosage forms like solutions, emulsions, suspensions, syrups, elixires, oral drops; parenteral dosage forms like intravenous injections, intramuscular injections, subcutaneous injections; other dosage forms

like eye drops, semi-solid eye preparations, transdermal dosage forms, suppositories, rectal capsules, rectal solutions, emulsions and suspensions, etc.

In one embodiment the invention relates to pharmaceutical dosage forms specifically intended for pediatric use, such as but not limited to, solutions, syrups, elixirs, suspensions,
5 powders for reconstitution as suspension, dispersible or effervescent tablets, chewable tablets, orally disintegrating tablets, tablets or coated tablets, sprinkle oral powder or granules, capsules.

The pharmaceutical compositions of the present invention may be manufactured in a manner that is itself known, e.g., by means of conventional mixing, dissolving, emulsifying, suspending, entrapping, freeze-drying, extrusion, laminating, film-casting, granulating,
10 grinding, encapsulating, dragee-making or tableting processes.

Pharmaceutical compositions for use in accordance with the present invention thus may be formulated in conventional manner using one or more physiologically acceptable carriers comprising excipients and auxiliaries which facilitate processing of the active compounds into
15 preparations which can be used pharmaceutically. Proper formulation is dependent upon the route of administration chosen. Any of the well-known techniques, carriers, and excipients may be used as suitable and as understood in the art.

Suitable excipients for the preparation of the dosage forms may be selected from the following categories, such as but not limited to, tablet and capsule fillers, tablet and capsule
20 binders, modified-release agents, disintegrants, glidants, lubricants, sweetening agents, taste-masking agents, flavoring agents, coating agents, surfactants, antioxidants, buffering agents, complexing agents, emulsifying agents, lyophilization aids, microencapsulating agents, ointment bases, penetration enhancers, solubilizing agents, solvents, suppository bases, suspending agents.

In one embodiment the invention relates to the using of specific excipients which are
25 able to improve the solubility, dissolution, penetration, adsorption or bioavailability of the active ingredient(s), such as but not limited to, hydrophilic polymers, hot melt extrusion excipients, surfactants, buffering agents, complexing agents, emulsifying agents, lyophilization aids, superdisintegrants, microencapsulating agents, penetration enhancers, solubilizing agents,
30 co-solvents, suspending agents.

The above described ingredients and different routes of manufacture are merely representative. Other materials as well as processing techniques and the like well known in the art can also be used.

The compounds are effective in the treatment of psychiatric, neurodevelopmental, neurological and other central nervous system disorders as well as peripheral conditions where stimulation of the GABA_B receptor may offer therapeutic benefit

BIOLOGICAL ACTIVITY

10

***In vitro* [³⁵S]GTPγS binding assay in rat cortical membranes**

Cortices of freshly harvested rat brains were dissected on an ice-cold surface and homogenized by a glass Dounce homogeniser immediately in ice-cold buffer containing 50 mM Tris, 5 mM MgCl₂ and 1 mM EDTA (pH=7.6). Tissue homogenates were centrifuged at 40000 g for 15 min at 4°C. Membrane pellets were resuspended in the same buffer and membranes were incubated for 10 min at 30°C in a shaking water bath to eliminate endogenous GABA. Homogenates were centrifuged again under the same conditions. The final pellets were resuspended in ice-cold buffer (pH=7.6) containing 50 mM Tris, 100 mM NaCl, 7 mM MgCl₂, 1 mM EDTA and 1 mM dithiotreitol (DTT) to yield a concentration of 20 mg tissue weight/ml and frozen at -70°C until use. The assay was done in a buffer containing 50 mM Tris (pH=7.4), 100 mM NaCl, 7 mM MgCl₂, 1 mM EDTA and 1 mM DTT. Each assay tube contained 150 μL GDP (in a final concentration of 50 μM), 100 μL ligand and 125 μL of the membrane suspension (250 μg tissue/tube). The assay tubes were preincubated for 10 min at 30°C to assure equilibrium. Nonspecific binding was determined in the presence of 10 μM GTPγS; basal binding was determined in the presence of buffer only. After addition of 50 pM [³⁵S]GTPγS in a volume of 25 μL to the tubes, membranes were incubated for an additional 60 min at 30°C. The assay was terminated by rapid filtration through Packard UniFilter GF/B using a Packard harvester and washed four times with 1 ml ice-cold buffer. After drying the filters at 40°C for 1 h, 40 μL Microscint (Packard) was added to the filters and radioactivity of the filters was determined by a TopCount NXT (PerkinElmer, Waltham, MA; Alper and Nelson, *Eur. J. Pharmacol.* 1998, 343, 303-312; Rincken et al, *Biochem. Pharmacol.* 1999, 57, 155-162). Data

30

thus gathered were used to determine PAM EC₅₀ values for each compound as primary *in vitro* activity end point.

In Table 1 compounds of this invention measured in the [³⁵S]GTP γ S binding assay are
5 listed.

Table 1

Number of example	<i>In vitro</i> PAM potency
1	++
2	++
3	+
4	++
5	++
6	++
7	+
10	++
11	++
12	++
13	+
14	++
15	++
16	+
17	++
18	+
19	+++
20	++++
21	+++
22	++++
23	++
24	+++
25	+++

26	+++
27	++
28	+++
29	+++
30	++
31	+++
32	+++
34	++
35	++
36	++++
37	++++
40	++
42	++++

+ PAM EC₅₀ < 1 nM

++ 1 nM ≤ PAM EC₅₀ < 10 nM

+++ 10 ≤ PAM EC₅₀ < 100 nM

++++ 100 ≤ PAM EC₅₀ < 1000 nM

5

Foot shock-induced ultrasonic vocalization (USV) in adult rats

Under stressful conditions, adult rats emit 22 kHz ultrasounds that can be reduced by various pharmacological treatments (De Vry et al, Eur. J. Pharmacol. 1993, 249, 331–339; Sanchez, Eur. J. Pharmacol. 2003, 463, 133–143). Previous unpublished experiments indicated that GABA_B receptor ligands can also inhibit vocalizations that are induced by electric footshocks as stressor. Therefore, a foot shock-induced vocalization paradigm in adult rats was used to assess efficacy of centrally acting GABA_B receptor ligands. Behavioral measurements were carried out on male Wistar rats (200-250 g, Toxicoop, Hungary). Rats were housed in groups of four in plastic cages with a wire grid top in a temperature and light-controlled laboratory animal care unit (22 ± 2 °C, 12-h light/dark cycle, lights on at 6:00 AM) with ad libitum access to commercial pellet rat food and tap water. Investigations were approved by the Local Ethical Committee of Gedeon Richter Plc. and were carried out in strict compliance with the European Directive 2010/63/EU regarding the care and use of laboratory animals for

experimental procedures and all efforts were made to minimize the number of animals as well as their suffering. In order to evoke emission of ultrasounds, animals were footshocked after a habituation period of 30 s (6 shocks, 1 s, 0.8 mA each, inter-shock interval 10 s) in a sound attenuated shocking chamber (Experimetria, 40x40x80 cm). Investigational compounds were administered at the dose of 1 mg/kg in a solid dispersion formulation in distilled water 1 h before shocking per os. Vocalizations were measured right after the last footshock for 10 min with a Metris Sonotrack system and the total time of vocalizations was registered. Vocalization of parallel vehicle treated animals was considered as control value and inhibition percent was calculated for each compound. At approximately 75 min after treatment and behavioral measurements, blood and brain samples were harvested in order to determine exposures associated with *in vivo* activity.

In Table 2 compounds of this invention measured in the USV assay are listed. In Table 3 plasma and brain levels of compounds of this invention are listed.

Table 2

Number of example	USV inhibition at 1 mg/kg (%)
2	85
3	100
11	71
12	59
13	97
15	89
16	100
17	79
18	75
33	63
35	57

Table 3

Number of example	plasma exposure at 1 mg/kg (ng/mL)	brain exposure at 1 mg/kg (ng/g)
2	188	74
3	58	18
11	146	68
12	121	62
13	124	31
15	170	53
16	131	36
17	135	74
18	175	30
33	172	34
35	207	35

Prenatal valproate model of autism spectrum disorder (ASD)

5 The prenatal valproate model has excellent construct and face validity, therefore it is a widely accepted disease model of ASD (Christensen et al, *JAMA* 2013, 309, 1696-1703; Rouillet et al, *Neurotox. Teratol.* 2013, 36, 45-56). In this method, time-mated female Wistar rats (Harlan UK) were administered a single dose of valproic acid (VPA, 600 mg/kg, i.p.) on gestational day 12.5. Male offspring were housed according to standard laboratory conditions

10 until time of testing at postnatal day 59. Animals were housed in groups of 4 in conventional cages and maintained at 22–24°C on a standard 12 hour light/dark cycle (07.30-19.30), with food and water available ad libitum. After investigational drug treatment, offspring were examined behaviorally in the social preference assay at postnatal day 59. The social preference test is a highly accepted assay to assess autistic behavior in rodents (Nadler et al, *Genes Brain*

15 *Behav.* 2007, 3, 303-314; Bambini-Junior et al, *Brain Res.* 2011, 1408, 8-16). Briefly, in this assay a test animal is allowed to investigate a conspecific separated by a dividing perforated wall or a similar area however, without a target conspecific. An autistic animal (such as a

prenatally valproate-exposed rat) spends little time with social investigation during a test session.

The inventors unexpectedly found that selected compounds of the invention in the oral dose range of 0.01 - 3 mg/kg were of great behavioral benefit in the present preclinical disease
5 model that recapitulates the core symptoms of ASD. The inventors therefore showed that these compounds may be of therapeutic potential for the treatment of core symptoms of ASD in humans.

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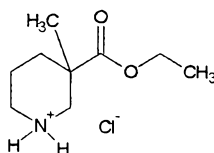
EXAMPLES

The invention is further defined in the following Examples. It should be understood that the Examples are given by way of illustration only. From the above discussion and the Examples, one skilled in the art can ascertain the essential characteristics of the invention, and
15 without departing from the spirit and scope thereof, can make various changes and modifications to adapt the invention to various uses and conditions. As a result, the invention is not limited by the illustrative examples set forth herein below, but rather defined by the claims appended hereto.

In general, the compounds of formula (I) can be prepared according to the general
20 knowledge of one skilled in the art and/or using methods set forth in the Example and/or Intermediate sections that follow. Solvents, temperatures, pressures, and other reaction conditions can readily be selected by one of ordinary skill in the art. Starting materials are commercially available and/or readily prepared by one skilled in the art.

Our patent application filed concurrently herewith titled "Process for the separation of
25 optical isomers of racemic 3-alkylpiperidine-carboxylic acid ethyl esters" discloses the preparation of certain starting materials.

The present invention will be now illustrated by the following not limiting examples.

Intermediate 1**Ethyl 3-methylpiperidine-3-carboxylate**a) 1-*Tert*-butyl 3-ethyl 3-methylpiperidine-1,3-dicarboxylate

5 Under nitrogen to a solution of 22.96 g (89 mmol) of 1-*tert*-butyl 3-ethyl piperidine-1,3-dicarboxylate in 300 mL of dry tetrahydrofuran 100 mL of 1 M lithium bis(trimethylsilyl)amide in tetrahydrofuran solution (100 mmol) was added dropwise at (-78) °C - (-65) °C. After addition the mixture was stirred at -78°C for 20 min, 6.6 mL (106 mmol) of iodomethane was added dropwise. The so obtained mixture was allowed to warm to room temperature and stirred at this

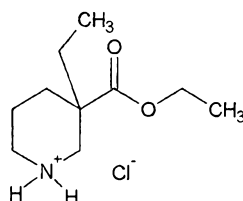
10 temperature for 18 h. The reaction was quenched by addition of 200 mL of saturated ammonium chloride solution (pH ~8) and 300 mL of water. The reaction mixture was extracted with ethyl acetate, the combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The residue was chromatographed on silica gel eluting with ethylacetate and cyclohexane (1:4) to yield 24.2 g (95%) of the title compound as

15 oil.

b) Ethyl 3-methylpiperidine-3-carboxylate

To a solution of 50 ml of 2.5 M hydrochloric acid in ethyl acetate 24.2 g (84.8 mmol) of 1-*tert*-butyl 3-ethyl 3-methylpiperidine-1,3-dicarboxylate was added. The reaction mixture was stirred for 3 h at 20 °C, then 100 mL of diethyl ether was added. The precipitated crystals were

20 filtered off, washed with diethyl ether to yield 16.28 g (97 %) of the title compound.

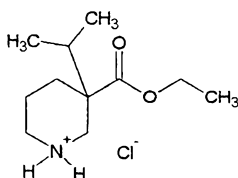
Intermediate 2

Ethyl 3-ethylpiperidine-3-carboxylatea) 1-tert-Butyl 3-ethyl 3-ethylpiperidine-1,3-dicarboxylate

The title compound is prepared from 1-*tert*-butyl 3-ethyl piperidine-1,3-dicarboxylate and iodo ethane according to the method described in Intermediate 1a.

5 b) Ethyl 3-ethylpiperidine-3-carboxylate hydrochloride

The title compound is prepared from 1-*tert*-butyl 3-ethyl 3-ethylpiperidine-1,3-dicarboxylate according to the method described in Intermediate 1b.

Intermediate 3

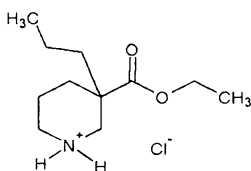
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Ethyl 3-(propan-2-yl)piperidine-3-carboxylate hydrochloridea) 1-tert-Butyl 3-ethyl 3-(propan-2-yl)piperidine-1,3-dicarboxylate

The title compound is prepared from 1-*tert*-butyl 3-ethyl piperidine-1,3-dicarboxylate and 2-iodo propane according to the method described in Intermediate 1a.

15 b) Ethyl 3-(propan-2-yl)piperidine-3-carboxylate

The title compound is prepared from 1-*tert*-butyl 3-ethyl 3-(propan-2-yl)piperidine-1,3-dicarboxylate according to the method described in Intermediate 1b.

Intermediate 4

20

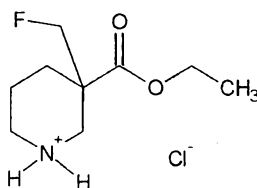
Ethyl 3-propylpiperidine-3-carboxylate hydrochloridea) 1-Tert-butyl 3-ethyl 3-propylpiperidine-1,3-dicarboxylate

Under nitrogen to a solution of 10 g (38.86 mmol) of 1-*tert*-butyl 3-ethyl piperidine-1,3-dicarboxylate in 120 mL of dry tetrahydrofuran 42 mL of 1 M lithium bis(trimethylsilyl)amide in tetrahydrofuran solution (42 mmol) was added dropwise at (-78) °C - (-65) °C. After addition the mixture was stirred at -78°C for 20 min, 3.9 mL (39.7 mmol) of 1-iodopropane was added dropwise. The so obtained mixture was allowed to warm to room temperature and stirred at this temperature for 18 h. The reaction was quenched by addition of 200 mL of saturated ammonium chloride solution (pH ~8) and 300 mL of water. The reaction mixture was extracted with ethyl acetate, the combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The residue was chromatographed on silica gel eluting with ethylacetate and cyclohexane (1:4) to obtain the title compound as oil. The crude product is used in the next step.

b) Ethyl 3-propylpiperidine-3-carboxylate hydrochloride

To the above obtained 1-*tert*-butyl 3-ethyl 3-propylpiperidine-1,3-dicarboxylate 20 ml of 2.5 M hydrochloric acid in ethyl acetate was added. The reaction mixture was stirred for 3 h at 20 °C, then concentrated *in vacuo* to yield 11.85 g of the title compound as oil.

Intermediate 5



Ethyl 3-(fluoromethyl)piperidine-3-carboxylate hydrochloride

a) 1-*tert*-Butyl 3-ethyl 3-(hydroxymethyl)piperidine-1,3-dicarboxylate

The title compound is prepared from 1-*tert*-butyl 3-ethyl piperidine-1,3-dicarboxylate and paraformaldehyde according to the method described in Intermediate 1a.

b) 1-*tert*-Butyl 3-ethyl 3-[(1,1,2-trifluoroethanesulfonyl)oxy]methyl}piperidine-1,3-dicarboxylate

Under nitrogen, to a stirred solution of 0.296 g (1.03 mmol) of ethyl 3-(hydroxymethyl) piperidine-3-carboxylate and 0.120 ml (1.48 mmol) of pyridine in 5 ml of dichloromethane

0.230 ml (1.48 mmol) of trifluoromethanesulfonic anhydride was added dropwise at (-78) °C - (-65) °C. After addition the mixture was stirred at -78°C for 5 min and allowed to warm to room temperature and stirred at this temperature for 18 h. The reaction was quenched by addition of 1M hydrochloric acid solution. The reaction mixture was extracted with dichloromethane, the combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo* to obtain the title compound as oil. The crude product is used in the next step.

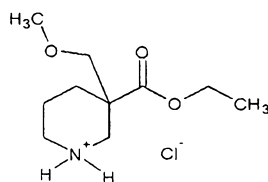
c) 1-tert-Butyl 3-ethyl 3-(fluoromethyl)piperidine-1,3-dicarboxylate

The above obtained 1-tert-butyl 3-ethyl 3-[(1,1,2-trifluoroethanesulfonyl)oxy]methyl}piperidine-1,3-dicarboxylate was solved in 4 ml of tetrahydrofuran and 1.25 ml (1.25 mmol) of 1M tetrabutylammonium fluoride in tetrahydrofuran was added. The reaction mixture was stirred for 1 h at room temperature, diluted with water and extracted with ethylacetate. The combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The residue was chromatographed on silica gel eluting with ethylacetate and cyclohexane (1:2) to yield 0.121 g (40%) of the title compound.

d) Ethyl 3-(fluoromethyl)piperidine-3-carboxylate hydrochloride

The title compound is prepared from 1-tert-Butyl 3-ethyl 3-(fluoromethyl)piperidine-1,3-dicarboxylate according to the method described in Intermediate 1b.

Intermediate 6



Ethyl 3-(methoxymethyl)piperidine-3-carboxylate hydrochloride

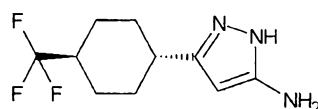
a) 1-tert-Butyl 3-ethyl 3-(methoxymethyl)piperidine-1,3-dicarboxylate

The title compound is prepared from 1-tert-butyl 3-ethyl piperidine-1,3-dicarboxylate and chloromethyl methyl ether according to the method described in Intermediate 1a.

b) Ethyl 3-(methoxymethyl)piperidine-3-carboxylate hydrochloride

The title compound is prepared from 1-*tert*-butyl 3-ethyl 3-(methoxymethyl)piperidine-1,3-dicarboxylate according to the method described in Intermediate 1b.

Intermediate 7



3-[trans-4-(Trifluoromethyl)cyclohexyl]-1H-pyrazol-5-amine

a) Methyl trans-4-(trifluoromethyl)cyclohexane-1-carboxylate

To a solution of 10 g (51 mmol) of trans 4-(trifluoromethyl)cyclohexane-1-carboxylic acid in 150 ml of methanol 10 ml (137 mmol) of thionyl chloride was added dropwise at -10 °C. After addition the mixture was allowed to warm to room temperature and stirred at this temperature for 16 h, then concentrated *in vacuo*. The residue was partitioned between ethyl acetate and water. The combined organic layer was washed with sodium hydrogen carbonate solution and water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. Dry cyclohexane was evaporated from the residue several times to yield 8.96 g of the title compound as colourless oil.

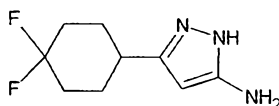
b) 3-Oxo-3-[trans-4-(trifluoromethyl)cyclohexyl]propanenitrile

Under nitrogen to a mixture of 9.1 ml (174 mmol) of acetonitrile in 260 ml of dry tetrahydrofuran 51 ml of 2.5 M *n*-butyllithium in *n*-hexane solution (127 mmol) was added dropwise at (-78) °C - (-65) °C. After addition the mixture was stirred at -78°C for 1 h, 8.96 g (42.6 mmol) of methyl trans-4-(trifluoromethyl)cyclohexane-1-carboxylate was added dropwise. The so obtained mixture was allowed to warm to room temperature and stirred at this temperature for 1 h. The reaction was quenched by addition of 150 mL of saturated ammonium chloride solution. The tetrahydrofuran was evaporated and the mixture was extracted with ethyl acetate. The combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The crude product is used in the next step.

c) 3-[trans-4-(Trifluoromethyl)cyclohexyl]-1H-pyrazol-5-amine

The above obtained 3-oxo-3-[trans-4-(trifluoromethyl)cyclohexyl]propanenitrile was solved in 187 ml of ethanol and 4.4 ml (167 mmol) of hydrazine monohydrate was added. Under inert gas atmosphere, the reaction mixture was refluxed for 16 h. The solvent was removed *in vacuo* and dry toluene was evaporated from the residue several times to yield 11.15 g of the title compound as yellow oil. LC-MS (ESI) m/z 234.2 [MH⁺]

Intermediate 8



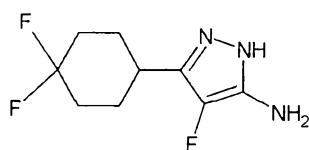
3-(4,4-Difluorocyclohexyl)-1H-pyrazol-5-amine

10 a) 3-(4,4-Difluorocyclohexyl)-3-oxopropanenitrile

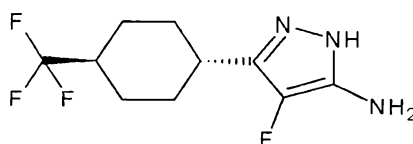
Under nitrogen to a mixture of 5 mL (95.7 mmol) of acetonitrile in 150 ml of dry tetrahydrofuran 29 ml of 2.5 M n-butyllithium in n-hexane solution (72.5 mmol) was added dropwise at (-78) °C - (-65) °C. After addition the mixture was stirred at -78°C for 1 h, 4.2 ml (24 mmol) of ethyl 4,4-difluorocyclohexane-1-carboxylate was added dropwise. The so obtained mixture was allowed to warm to room temperature and stirred at this temperature for 2 h. The reaction was quenched by addition of 150 mL of saturated ammonium chloride solution and the mixture was extracted with ethyl acetate. The combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The crude product is used in the next step.

20 b) 3-(4,4-Difluorocyclohexyl)-1H-pyrazol-5-amine

The above obtained 3-oxo-3-[trans-4-(trifluoromethyl)cyclohexyl]propanenitrile was solved in 100 ml of ethanol and 4 ml (128.4 mmol) of hydrazine monohydrate was added. Under inert gas atmosphere, the reaction mixture was refluxed for 16 h. The solvent was removed *in vacuo*. The residue was partitioned between ethyl acetate and water. The combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo* to yield 6.43 g of the title compound as yellow oil. LC-MS (ESI) m/z 202.2 [MH⁺]

Intermediate 9**3-(4,4-Difluorocyclohexyl)-4-fluoro-1H-pyrazol-5-amine**

- 5 The title compound was prepared from 4,4-difluorocyclohexane-1-carboxylic acid and fluoroacetonitrile according to the method described in Intermediate 7.

Intermediate 10**4-fluoro-3-[trans-4-(trifluoromethyl)cyclohexyl]-1H-pyrazol-5-amine**a) trans-4-(Trifluoromethyl)cyclohexane-1-carbonyl chloride

- A mixture of 5 g (25.5 mmol) of trans 4-(trifluoromethyl)cyclohexane-1-carboxylic acid, 100 ml of dichloromethane, 5 ml (68.5 mmol) of thionyl chloride and 0.1 ml of dimethylformamide was refluxed for 6 h. The reaction mixture was concentrated *in vacuo* and dry tetrahydrofuran was evaporated from the residue several times. The crude product is used in the next step.

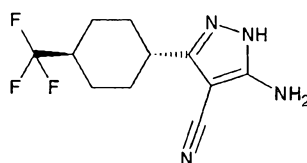
b) 2-Fluoro-3-oxo-3-[trans-4-(trifluoromethyl)cyclohexyl]propanenitrile

- Under inert gas atmosphere, to a solution of the above obtained trans-4-(trifluoromethyl)cyclohexane-1-carbonyl chloride and 1.5 ml (26.96 mmol) of fluoroacetonitrile in 50 mL of abs. tetrahydrofuran 50 mL (50 mmol) of 1M lithium bis(trimethylsilyl)amide was added dropwise at -78 °C. After addition the mixture was stirred at -78°C for 1 h, then the mixture was allowed to warm to room temperature and poured into 200 mL of water. The pH of the mixture was adjusted to 2 by the addition of 1M hydrochloric acid. The mixture was extracted with ethyl acetate, the combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The crude product is used in the next step.

c) 4-Fluoro-3-[trans-4-(trifluoromethyl)cyclohexyl]-1H-pyrazol-5-amine

The above obtained 2-fluoro-3-oxo-3-[trans-4-(trifluoromethyl)cyclohexyl]propanenitrile was dissolved in 65 ml of ethanol and 4.4 ml (77 mmol) of hydrazine monohydrate was added. Under inert gas atmosphere, the reaction mixture was refluxed for 16 h. The solvent was removed *in vacuo* to obtain the title compound as oil. LC-MS (ESI) m/z 252.2 [MH⁺]

Intermediate 11



5-amino-3-[trans-4-(trifluoromethyl)cyclohexyl]-1H-pyrazole-4-carbonitrile

10

a) 2-[trans-4-(trifluoromethyl)cyclohexanecarbonyl]propanedinitrile

To a mixture of 2.7 g (12.58 mmol) trans-4-(trifluoromethyl) cyclohexane-1-carbonyl chloride (Intermediate 10a) and 1.26 g (19.0 mmol) of malononitrile in 15 mL of abs. tetrahydrofuran 1.77 mL (50 mmol) of triethylamin was added dropwise at 0 °C. After addition the mixture was stirred at 0 °C for 1 h, then the mixture was allowed to warm to room temperature and poured into 200 mL of water. The mixture was extracted with ethyl acetate, the combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The crude product is used in the next step.

20

b) 2-{methoxy[trans-4-(trifluoromethyl)cyclohexyl]methylidene}propanedinitrile

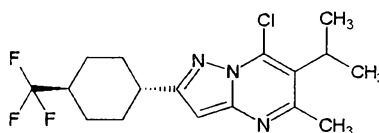
To the above obtained 2-[trans-4-(trifluoromethyl)cyclohexanecarbonyl]propanedinitrile 10 ml of trimethyl orthoformate was added. The reaction mixture was refluxed for 16 h. The reaction mixture was concentrated *in vacuo* and the residue was chromatographed on silica gel eluting with ethylacetate and cyclohexane (1:1) to yield 1.495 g (46.0 %) of the title compound as oil. LC-MS (ESI) m/z 259.1 [MH⁺]

25

c) 5-amino-3-[trans-4-(trifluoromethyl)cyclohexyl]-1H-pyrazole-4-carbonitril

The above obtained 2-{methoxy[trans-4-(trifluoromethyl)cyclohexyl]methylidene} propanedinitrile was dissolved in 17 ml of ethanol and 1.4 ml (24.5 mmol) of hydrazine monohydrate was added. The reaction mixture was stirred for 0.5 h at room temperature, diluted with water and extracted with ethylacetate. The combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo* to yield 1.04 g (69.5%) of the title compound. LC-MS (ESI) m/z 259.2 [MH⁺]

Intermediate 12



7-Chloro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo [1,5-a]pyrimidine

a) 5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-ol

A mixture of 11.156 g (47.8 mmol) of 3-[trans-4-(trifluoromethyl)cyclohexyl]-1H-pyrazol-5-amine (Intermediate 7), 8 ml (44.6 mmol) of ethyl 2-acetyl-3-methylbutanoate and 0.32 g (1.6 mmol) of p-toluenesulfonic acid monohydrate in 340 mL of toluene was refluxed for 20 h, then cooled to room temperature. The reaction mixture was concentrated *in vacuo* and the residue was chromatographed on silica gel eluting with dichloromethane and methanol (20:1) to yield 12.4 g (76%) of the title compound. LC-MS (ESI) m/z 342.2 [MH⁺]

b) 7-Chloro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]-pyrazolo[1,5-a]pyrimidine

A mixture of 12.4 g (36.35 mmol) of 5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-ol, 16.7 ml (179 mmol) of phosphorus oxychloride, 12.7 ml (72.9 mmol) of N,N-diisopropylethylamine and 733 ml of toluene was refluxed for 20 h. The reaction mixture was cooled to 20 °C, poured into a mixture of sodium hydrogen carbonate solution and ice, then stirred for 2 h. The reaction mixture was filtered, the

filtrate was extracted with ethyl acetate, the combined organic layer was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo* to yield 12.05 g (92%) of the title compound. LC-MS (ESI) m/z 360.2 $[MH^+]$

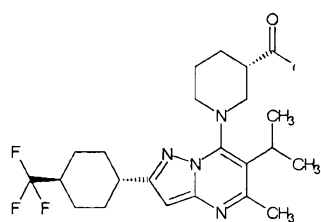
- 5 Compounds of Table 4 were prepared from the appropriate acetoacetic ester and 1*H*-pyrazol-5-amine according to the method described in Intermediate 12.

Table 4

Intermediate	Structure	Intermediate (starting material)	LC-MS (ESI) m/z $[MH^+]$
13		10	360.2
14		7	348.1
15		10	366.2
16		7	346.1
17		7	360.2
18		8	328.2
19		9	346.2
20		7	358.2

21		7	372.2
22		7	360.2
23		7	360.1
24		7	372.2
25		11	385.2
26		7	376.2

Route c)

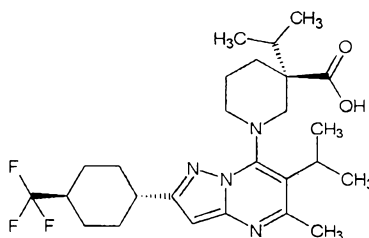
Example 1

(3S)-1-[5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid

5
10
A mixture of 0.8 g (2.22 mmol) of 7-chloro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidine (Intermediate 12), 0.5 g (3.87 mmol) of S-nipecotic acid and 0.7 ml (4 mmol) of N,N-diisopropylethylamine in 20 mL of N-methylpyrrolidone was heated at 130 °C for 20 h, then cooled and diluted with water. The reaction mixture was extracted with ethylacetate, the combined organic layer was washed with water,

dried over anhydrous sodium sulphate, filtered and concentrated *in vacuo*. The residue was chromatographed on silica gel eluting with ethylacetate and cyclohexane (1:2) to yield 0.422 g (42.0 %) of the title compound. LC-MS (ESI) m/z 453.2 $[MH^+]$

5

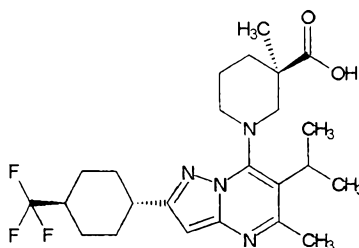
Route d)**Example 2**

(3S)-1-[5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]-pyrazolo[1,5-a]pyrimidin-7-yl]-3-(propan-2-yl)piperidine-3-carboxylic acid

10

A mixture of 0.66 g (2.79 mmol) of ethyl (3S)-3-(propan-2-yl)piperidine-3-carboxylate hydrochloride, 0.66 g (5.88 mmol) of potassium tert-butoxide in 15 mL of dimethyl sulfoxide was heated at 100 °C for 16 h. Then 1.0 g (2.77 mmol) 7-chloro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidine (Intermediate 12) was added to the mixture and heated at 120 °C for 16 h. The reaction mixture was cooled and acidified with acetic acid. The precipitated crystals were filtered off, washed with water. The crude product was chromatographed on silica gel eluting with ethylacetate and cyclohexane (1:2) to yield 0.506 g (36.8 %) of the title compound. LC-MS (ESI) m/z 495.3 $[MH^+]$

20

Route e)**Example 3**

(3R)-3-methyl-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]-pyrazolo [1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid

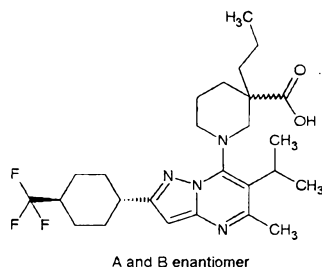
a) Ethyl (3R)-3-methyl-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylate

A mixture of 1.0 g (3.06 mmol) of 7-chloro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidine (Intermediate 12), 0.76 g (4.43 mmol) of ethyl (3R)-3-methylpiperidine-3-carboxylate and 0.8 mL (4.592 mmol) of N,N-diisopropylethylamine in 20 mL of N-methyl-pyrrolidone was heated at 130 °C for 20 h, then cooled and diluted with water. The reaction mixture was extracted with ethylacetate, the combined organic layer was washed with water, dried over anhydrous sodium sulphate, filtered and concentrated *in vacuo*. The residue was chromatographed on silica gel eluting with toluene and acetone (10:1) to yield 1.44 g (95.3 %) of the title compound. LC-MS (ESI) m/z 495.3 [MH⁺]

b) (3R)-3-methyl-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo [1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid

A mixture of 1.443 g (2.91 mmol) of ethyl (3R)-3-methyl-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylate and 5 mL of 20% sodium hydroxide solution in 40 mL of ethanol was refluxed for 5 h, then cooled and acidified with acetic acid. The reaction mixture was extracted with dichloromethane, the combined organic layer was washed with water, dried over anhydrous sodium sulphate, filtered and concentrated *in vacuo*. The residue was chromatographed on silica gel eluting with ethylacetate and cyclohexane (1:2) to yield 0.934 g (68.6 %) of the title compound. LC-MS (ESI) m/z 467.3 [MH⁺]

Example 4 and Example 5



(3R)-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]-3-propylpiperidine-3-carboxylic acid

and

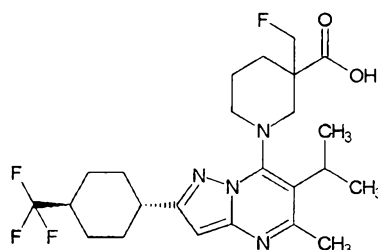
(3S)-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]-3-propylpiperidine-3-carboxylic acid

5

The racemic form of the title compounds were prepared from 7-chloro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidine (Intermediate 12), and racem ethyl 3-propylpiperidine-3-carboxylate hydrochloride (Intermediate 4b) according to the methods described in Example 2a and 2b. LC-MS (ESI) m/z 495.3 $[MH^+]$. The A and B enantiomers were separated using chiral preparative HPLC (Kromasil Cellucoat RP 5 μ m 150x4.6mm; F=1ml/min; eluents:A: H₂O+30mM AmAc B:80ACN+30mM AmAc; isocratic70%B t=25°C) obtaining **enantiomer A** (T_r 10.464, Example 4), and **enantiomer B** (T_r 11.584, Example 5). Their absolute configuration is not determined.

15

Example 6 and Example 7



A and B enantiomer

(3R)-3-(Fluoromethyl)-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid

and

(3S)-3-(Fluoromethyl)-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid

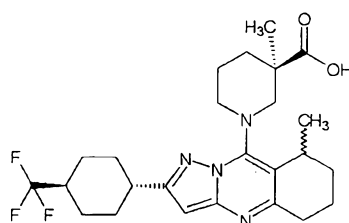
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The racemic form of the title compounds were prepared from 7-chloro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidine (Intermediate 12), and racem Ethyl 3-(fluoromethyl)piperidine-3-carboxylate hydrochloride (Intermediate 5) according to the methods described in Example 2a and 2b. LC-MS (ESI) m/z 485.3 [MH⁺].

5 The A and B enantiomers were separated using chiral preparative HPLC (Lux Amylose-1 5 μ m 250 \times 21.1 mm ; F=21ml/min; eluents: n-Heptane : EtOH 80 : 20 + 0,1% TFA t= 40°C) obtaining enantiomer A (Tr 5.9, Example 6), and enantiomer B (Tr 6.7, Example 7). Their absolute configuration is not determined.

10

Example 8 and Example 9



A and B diastereomer

(3R)-3-methyl-1-[(8S)-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl]piperidine-3-carboxylic acid

15

and

(3R)-3-methyl-1-[(8R)-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl]piperidine-3-carboxylic acid

a) Ethyl (3R)-3-methyl-1-[(8S)-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl]piperidine-3-carboxylate

20

and

Ethyl (3R)-3-methyl-1-[(8R)-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl]piperidine-3-carboxylate

The racemic form of the title compounds were prepared from racem 9-chloro-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazoline

25 (Intermediate 24), and ethyl (3R)-3-methylpiperidine-3-carboxylate hydrochloride according to

the methods described in Example 2a. The A and B diastereomer esters were separated using column chromatography on silica gel eluting with dichloromethane-diisopropyl ether 10-1, obtaining **diastereomer A ester** (TLC in the same system $r_f = 0.5$) and **diastereomer B ester** (TLC in the same system $r_f = 0.45$).

5 b) (3R)-3-Methyl-1-[(8S)-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl]piperidine-3-carboxylic acid

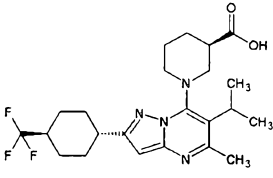
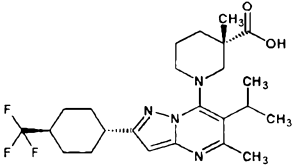
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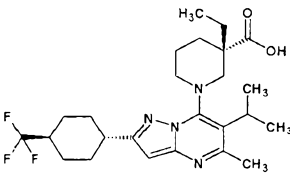
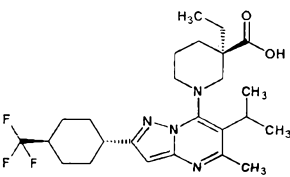
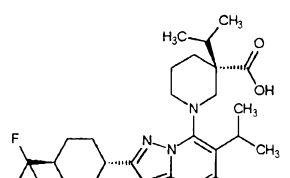
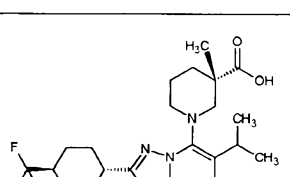
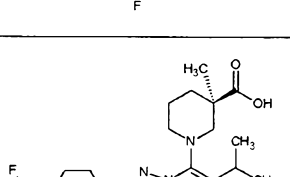
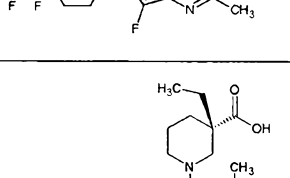
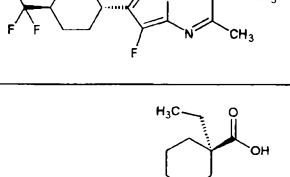
(3R)-3-Methyl-1-[(8R)-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl]piperidine-3-carboxylic acid

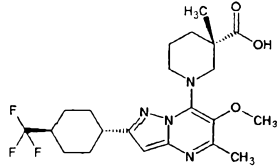
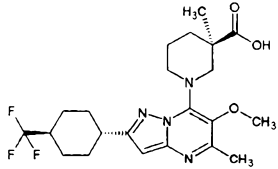
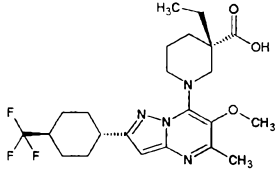
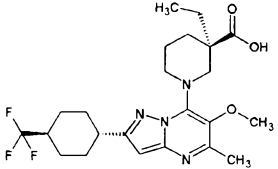
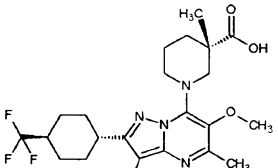
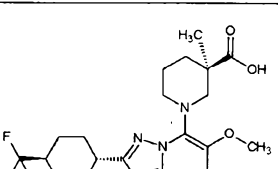
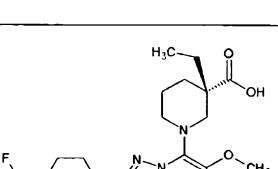
10 The title compounds were prepared from above **diastereomer A ester** (Example 8, LC-MS (ESI) m/z 479.2 $[MH^+]$) and **diastereomer B ester** (Example 9, LC-MS (ESI) m/z 479.2 $[MH^+]$) according to the methods described in Example 2b. Their absolute configuration is not determined.

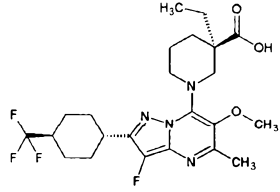
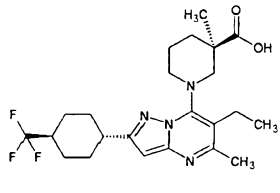
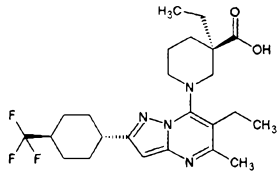
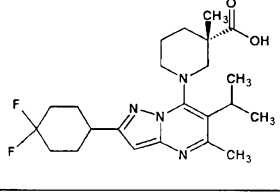
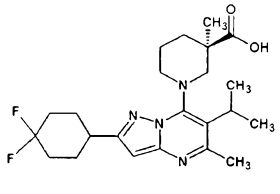
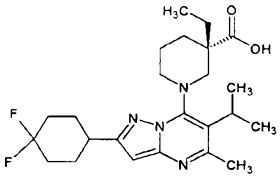
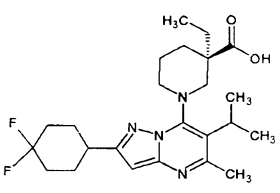
15 Examples 10 - 42 were prepared using analogues methods to those Examples described above and are exemplified below in Table 5.

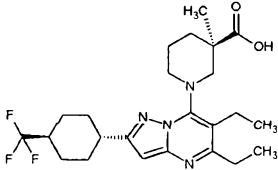
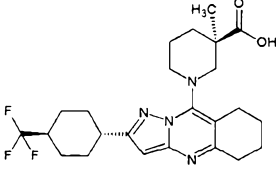
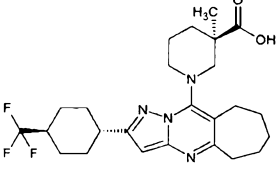
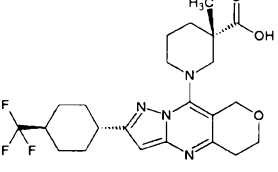
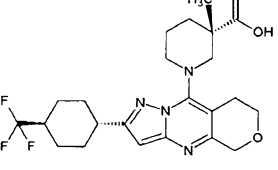
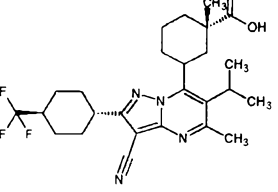
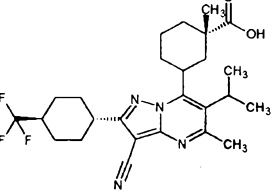
Table 5

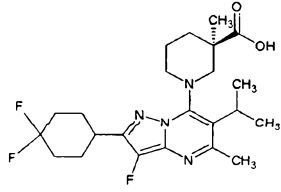
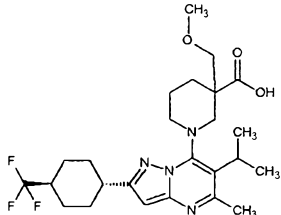
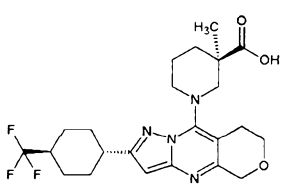
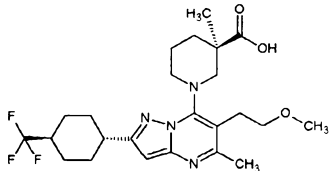
Example	Structure	LC-MS (ESI) m/z $[MH^+]$	Intermediate	Route
10		453.2	12	c
11		467.3	12	e

12		481.4	12	e
13		481.4	12	e
14		495.3	12	d
15		485.3	13	e
16		485.3	13	e
17		499.3	13	e
18		499.3	13	e

19		455.2	14	d
20		455.2	14	d
21		469.2	14	d
22		469.2	14	d
23		473.2	15	e
24		473.2	15	e
25		487.2	15	d

26		487.2	15	e
27		453.2	16	d
28		467.3	16	d
29		435.2	18	e
30		435.2	18	e
31		449.3	18	e
32		449.3	18	e

33		467.3	17	e
34		465.2	20	e
35		479.2	21	e
36		467.2	22	e
37		467.2	23	e
38		492.3	25	e
39		492.3	25	e

40		453.2	18	e
41		497.2	12	e
42		467.2	23	e
43		483.3	26	e

Preparation of pharmaceutical compositions

The following formulation examples illustrate representative pharmaceutical compositions of this invention. The present invention however is not limited to the following pharmaceutical compositions.

5

A) Solid oral dosage forms***I., Tablets***

	Active ingredient(s)	0.01 – 90%
10	Filler	1 – 99.9%
	Binder	0 – 20%
	Disintegrant	0 – 20%
	Lubricant	0 – 10%
	Other specific excipient(s)	0 – 50%

15

II., Orodispersible films

	Active ingredient(s)	0.01 – 90%
	Film forming agent	1 – 99.9%
	Plasticizer	0 – 40%
20	Other specific excipient(s)	0 – 50%

B) Liquid oral dosage forms***III., Oral suspensions***

25	Active ingredient(s)	0.01 – 50%
	Liquid vehicle	10 – 99.9%
	Wetting agent	0 – 50%
	Thickener	0 – 50%
	Buffering agent	q.s.
30	Osmotic agent	0 – 50%
	Preservatives	q.s.

IV., Syrups

	Active ingredient(s)	0.01 – 50%
35	Solvent	10 – 99.9%
	Sugar component	1 – 20%
	Flavouring agents	0 – 10%

C) Parenteral dosage forms*V., Intravenous injections*

	Active ingredient(s)	0.01 – 50%
5	Solvent	10 – 99.9%
	Co-solvent	0 – 99.9%
	Osmotic agent	0 – 50%
	Buffering agent	q.s.

10 **D) Other dosage forms***VI., Suppositories*

	Active ingredient(s)	0.01 – 50%
	Suppository base	1 – 99.9%
15	Surface-active agents	0 – 20%
	Lubricants	0 – 20%
	Preservatives	q.s.

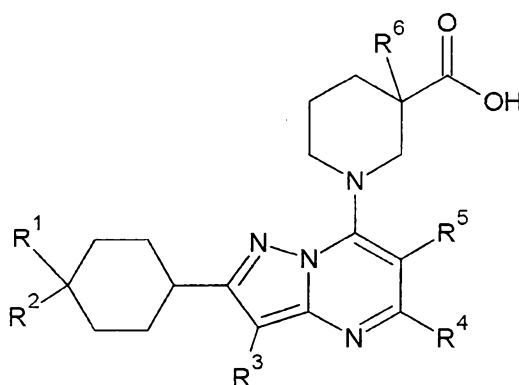
VII., Eye drops

20	Active ingredient(s)	0.01 – 50%
	Water	0 – 99.9%
	Solvent	0 – 99.9%
	Osmotic agent	0 – 20%
	Viscosity enhancer	0 – 20%
25	Buffering agent	q.s.
	Preservatives	q.s.

Claims

1. A compound of formula (I) wherein:

5



(I)

- 10 R^1 and R^2 are independently selected from hydrogen, halogen atom, C_{1-6} alkyl, halo C_{1-6} alkyl;
 R^3 is hydrogen, halogen atom, C_{1-6} alkyl, cyano group;
 R^4 is C_{1-6} alkyl;
 R^5 is C_{1-6} alkyl optionally substituted by a halogen atom or halogen atoms, C_{3-5} cycloalkyl;
 C_{3-5} cycloalkyl C_{1-6} alkyl, dialkylamino, C_{1-6} alkoxy, C_{1-6} alkoxy C_{1-6} alkyl, C_{1-6} alkylthio group,
15 tetrahydrofuranyl, tetrahydrofuranyl C_{1-6} alkyl, tetrahydropyranyl, tetrahydropyranyl C_{1-6} alkyl;
or R_4 and R_5 together form an unsubstituted or substituted by one or more C_{1-3} alkyl, C_{1-3} alkoxy,
halo C_{1-3} alkyl, C_{1-3} alkylcarbonyl 3 to 7-membered saturated ring, wherein the members of the
ring are selected from the group consisting of carbon, nitrogen, oxygen, and sulphur;
 R^6 is hydrogen, halogen atom or C_{1-6} alkyl, hydroxyl, C_{1-6} alkoxy, C_{1-6} alkoxy C_{1-6} alkyl, halo C_{1-}
20 C_{1-6} alkyl, amino group; or pharmaceutically acceptable salts, biologically active metabolites, pro-
drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof.

2. A compound according to claim 1 wherein

- R^1 and R^2 are independently selected from hydrogen, halogen atom, C_{1-6} alkyl, halo C_{1-6} alkyl;
25 R^3 is hydrogen, halogen atom, C_{1-6} alkyl, cyano group;
 R^4 is C_{1-6} alkyl;

R⁵ is C₁₋₆alkyl optionally substituted by a halogen atom or halogen atoms, C₃₋₅ cycloalkyl; C₃₋₅ cycloalkylC₁₋₆alkyl, dialkylamino, C₁₋₆alkoxy, C₁₋₆alkoxyC₁₋₆alkyl, C₁₋₆alkylthio group, tetrahydrofuranyl, tetrahydrofuranylC₁₋₆alkyl, tetrahydropyranyl, tetrahydropyranylC₁₋₆alkyl; R⁶ is hydrogen, halogen atom or C₁₋₆alkyl, hydroxyl, C₁₋₆alkoxy, C₁₋₆alkoxyC₁₋₆alkyl, haloC₁₋₆alkyl, amino group; or pharmaceutically acceptable salts, biologically active metabolites, pro-
 5 drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof.

3. A compound according to claim 1 wherein

R¹ and R² are independently selected from hydrogen, halogen atom, C₁₋₆alkyl, haloC₁₋₆alkyl;

10 R³ is hydrogen, halogen atom, C₁₋₆alkyl, cyano group;

R₄ and R₅ together form an unsubstituted or substituted by one or more C₁₋₃alkyl, C₁₋₃alkoxy, haloC₁₋₃alkyl, C₁₋₃alkylcarbonyl 3 to 7-membered saturated ring, wherein the members of the ring are selected from the group consisting of carbon, nitrogen, oxygen, and sulphur;

15 R⁶ is hydrogen, halogen atom or C₁₋₆alkyl, hydroxyl, C₁₋₆alkoxy, C₁₋₆alkoxyC₁₋₆alkyl, haloC₁₋₆alkyl, amino group or pharmaceutically acceptable salts, biologically active metabolites, pro-
 drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof.

4. A compound according to claim 1 wherein R⁴ is methyl; and R⁵ is isopropyl or C₁₋₆alkoxyC₁₋₆alkyl.

20

5. A compound according to claim 1 selected from the group of

(3S)-1-[5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-
 a]pyrimidin-7-yl]piperidine-3-carboxylic acid

25 (3S)-1-[5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-
 a]pyrimidin-7-yl]-3-(propan-2-yl)piperidine-3-carboxylic acid

(3R)-3-Methyl-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo
 [1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid

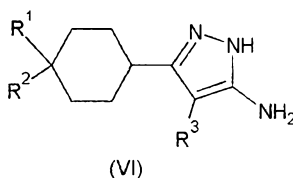
(3R)-1-[5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-
 a]pyrimidin-7-yl]-3-propylpiperidine-3-carboxylic acid

30 (3S)-1-[5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-
 a]pyrimidin-7-yl]-3-propylpiperidine-3-carboxylic acid

- (3R)-3-(Fluoromethyl)-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid
- (3S)-3-(Fluoromethyl)-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid
- 5 (3R)-3-Methyl-1-[(8S)-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl]piperidine-3-carboxylic acid
- (3R)-3-Methyl-1-[(8R)-8-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl]piperidine-3-carboxylic acid
- (3R)-1-[5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-
- 10 a]pyrimidin-7-yl]piperidine-3-carboxylic acid
- (3S)-3-Methyl-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid
- (3S)-3-Ethyl-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid
- 15 (3R)-3-Ethyl-1-[5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid
- (3R)-1-[5-Methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]-3-(propan-2-yl)piperidine-3-carboxylic acid
- (3S)-1-[3-Fluoro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo
- 20 [1,5-a]pyrimidin-7-yl]-3-methylpiperidine-3-carboxylic acid
- (3R)-1-[3-Fluoro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]-3-methylpiperidine-3-carboxylic acid
- (3S)-3-Ethyl-1-[3-fluoro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid
- 25 (3R)-3-Ethyl-1-[3-fluoro-5-methyl-6-(propan-2-yl)-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl]piperidine-3-carboxylic acid
- (3S)-1-{3-Fluoro-6-methoxy-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}-3-methylpiperidine-3-carboxylic acid
- (3R)-1-{3-Fluoro-6-methoxy-5-methyl-2-[trans-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-
- 30 a]pyrimidin-7-yl}-3-methylpiperidine-3-carboxylic acid
- (3S)-3-Ethyl-1-{6-methoxy-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}piperidine-3-carboxylic acid

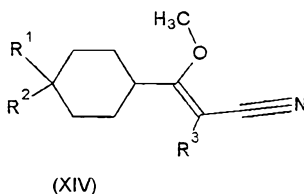
- (3R)-3-Ethyl-1-{6-methoxy-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}piperidine-3-carboxylic acid
- (3S)-1-{3-Fluoro-6-methoxy-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}-3-methylpiperidine-3-carboxylic acid
- 5 (3R)-1-{3-Fluoro-6-methoxy-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}-3-methylpiperidine-3-carboxylic acid
- (3S)-3-Ethyl-1-{3-fluoro-6-methoxy-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}piperidine-3-carboxylic acid
- (3R)-3-Ethyl-1-{3-fluoro-6-methoxy-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}piperidine-3-carboxylic acid
- 10 (3R)-1-{6-Ethyl-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}-3-methylpiperidine-3-carboxylic acid
- (3R)-3-Ethyl-1-{6-ethyl-5-methyl-2-[trans-4-(trifluoromethyl)cyclohexyl]pyrazolo[1,5-a]pyrimidin-7-yl}piperidine-3-carboxylic acid
- 15 (3S)-1-[2-(4,4-Difluorocyclohexyl)-5-methyl-6-(propan-2-yl)pyrazolo[1,5-a]pyrimidin-7-yl]-3-methylpiperidine-3-carboxylic acid
- (3R)-1-[2-(4,4-Difluorocyclohexyl)-5-methyl-6-(propan-2-yl)pyrazolo[1,5-a]pyrimidin-7-yl]-3-methylpiperidine-3-carboxylic acid
- (3S)-1-[2-(4,4-Difluorocyclohexyl)-5-methyl-6-(propan-2-yl)pyrazolo[1,5-a]pyrimidin-7-yl]-3-ethylpiperidine-3-carboxylic acid
- 20 (3R)-1-[2-(4,4-Difluorocyclohexyl)-5-methyl-6-(propan-2-yl)pyrazolo[1,5-a]pyrimidin-7-yl]-3-ethylpiperidine-3-carboxylic acid
- (3R)-1-[2-(4,4-Difluorocyclohexyl)-5,6-diethylpyrazolo[1,5-a]pyrimidin-7-yl]-3-methylpiperidine-3-carboxylic acid
- 25 (3R)-3-Methyl-1-{2-[trans-4-(trifluoromethyl)cyclohexyl]-5H,6H,7H,8H-pyrazolo[3,2-b]quinazolin-9-yl}piperidine-3-carboxylic acid
- (3R)-3-Methyl-1-{5-[trans-4-(trifluoromethyl)cyclohexyl]-2,6,7-triazatricyclo[7.5.0.0^{3,7}]trideca-1,3,5,8-tetraen-8-yl}piperidine-3-carboxylic acid
- (3R)-3-Methyl-1-{5-[trans-4-(trifluoromethyl)cyclohexyl]-11-oxa-2,6,7-triazatricyclo[7.4.0.0^{3,7}]trideca-1,3,5,8-tetraen-8-yl}piperidine-3-carboxylic acid
- 30 (3S)-3-Methyl-1-{5-[trans-4-(trifluoromethyl)cyclohexyl]-12-oxa-2,6,7-triazatricyclo[7.4.0.0^{3,7}]trideca-1,3,5,8-tetraen-8-yl}piperidine-3-carboxylic acid

2a) with hydrazine hydrate to provide a compound of formula (VI)

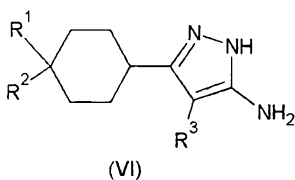


- 5 - wherein the meaning of R^1 , R^2 is as described above and R^3 is hydrogen, halogen atom, C_{1-6} alkyl group or

2b) with trimethyl orthoformate to provide the malononitrile derivative of formula (XIV)

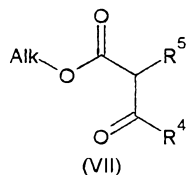


- 10 - wherein the meaning of R^1 , R^2 is as described above and R^3 is cyano group which is reacted with hydrazine hydrate to provide a compound of formula (VI)



15 then

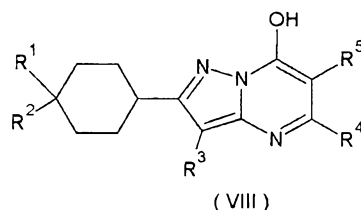
step 3) the compound of formula (VI) wherein the meaning of R^1 , R^2 , R^3 is as described above for the formula (I) – obtained according to the steps described in 2a) or 2b) is reacted with acylacetic ester derivative of formula (VII)



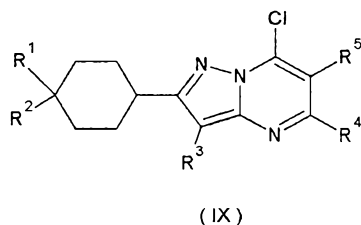
20

- wherein the meaning of R⁴ and R⁵ is as described above for the formula (I), then

step 4) the so obtained compound of formula (VIII)



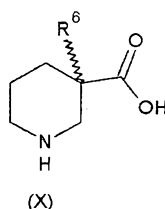
5 - wherein the meaning of R¹, R², R³, R⁴, and R⁵ is as described above for the formula (I) - is chlorinated to furnish a chloro derivative of formula (IX)



- wherein the meaning of R¹, R², R³, R⁴, and R⁵ is as described above for the formula (I) - and

10 step 5) the latter is reacted with either

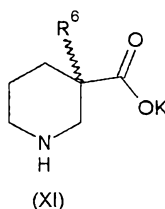
5c) a nipecotic acid derivative of formula (X)



- wherein the meaning of R⁶ is as described above for the formula (I) – and the obtained derivative of formula (I) and optical antipodes or racemates and/or salts thereof in given case can be transformed into an other compound of formula (I) and optical antipodes or racemates and/or salts thereof by introducing new substituents and/or modifying or removing the existing ones, or

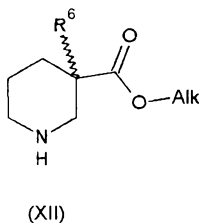
15

5d) its alkali salt of formula (XI)

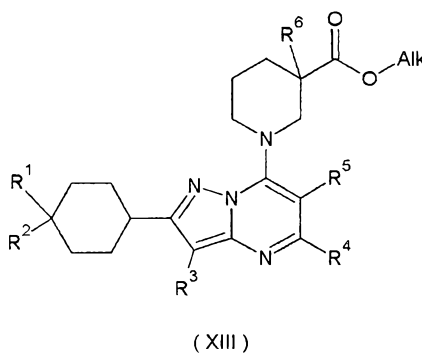


- 5
- wherein the meaning of R^6 is as described above for the formula (I) – and the obtained compound of formula (I) and optical antipodes or racemates and/or salts thereof optionally can be transformed into an other compound of formula (I) and optical antipodes or racemates and/or salts thereof by introducing new substituents and/or modifying or removing the existing ones, or

5e) a nipecotic acid ester derivative of formula (XII)



- 10
- wherein the meaning of R^6 is as described above for the formula (I) – to provide the ester derivative of formula (XIII)



- 15
- wherein the meaning of R^1 , R^2 , R^3 , R^4 , R^5 and R^6 is as described above for the formula (I) finally the latter is saponified with a strong base or acid – and the obtained derivative of formula (I) and optical antipodes or racemates and/or salts thereof optionally can be transformed into an other compound of formula (I) and optical antipodes or racemates and/or salts thereof by introducing new substituents and/or modifying or removing the existing ones.

7. A pharmaceutical composition comprising a therapeutically effective amount of a compound of formula (I) or pharmaceutically acceptable salts, biologically active metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof according to claim 1 as
5 active ingredient and pharmaceutically acceptable carrier.
8. A combination comprising a therapeutically effective amount of a compound of formula (I) or pharmaceutically acceptable salts, biologically active metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof according to claim 1 and one or more
10 therapeutically active co-agents.
9. Process for manufacturing pharmaceutical composition having GABA_B receptor positive allosteric modulator effect characterized by mixing a therapeutically effective amount of a compound of formula (I) or pharmaceutically acceptable salts, biologically active metabolites,
15 pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof according to claim 1 and optical antipodes or racemates and/or salts thereof as active ingredients and pharmaceutically acceptable excipients.
10. A compound of formula (I) or pharmaceutically acceptable salts, biologically active
20 metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof according to claim 1 for use as GABA_B receptor positive allosteric modulator.
11. A compound of formula (I) or pharmaceutically acceptable salts, biologically active metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof
25 according to claim 1 for use in the treatment or prevention of disorders associated with GABA_B receptor positive allosteric modulator activity.
12. A compound of formula (I) or pharmaceutically acceptable salts, biologically active metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof
30 according to claim 1 for use according to claim 11 wherein the disorder is selected from the group of psychiatric disorders (such as anxiety, panic disorder, posttraumatic disorder, depression, schizophrenia), neurodevelopmental disorders (such as autism spectrum disorder,

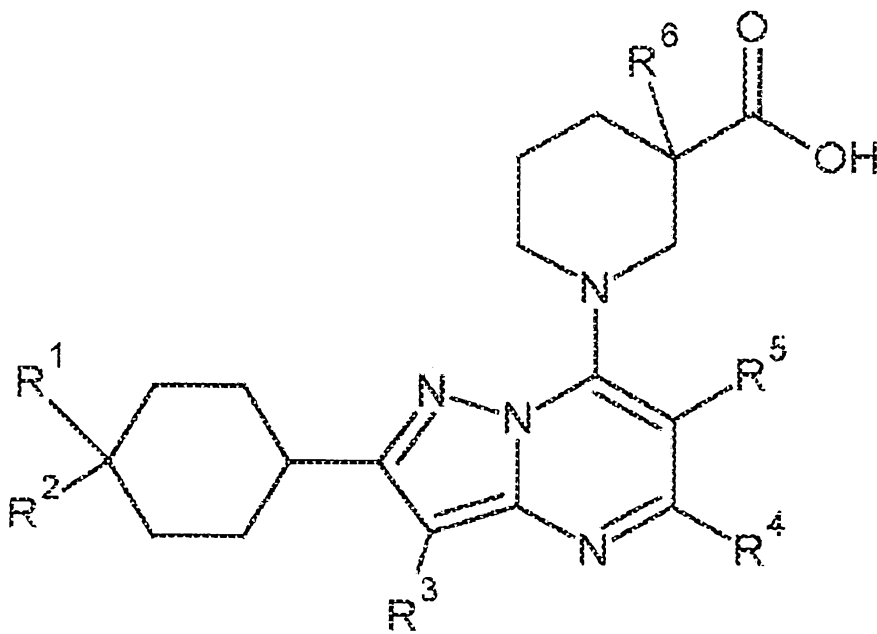
obsessive-compulsive disorder, Fragile X syndrome), cognitive disorders, epilepsy, spasticity, skeletal muscle rigidity, spinal cord injury, multiple sclerosis, amyotrophic lateral sclerosis, cerebral palsy, essential tremor, pain (neuropathic, visceral, osteoarthritic), substance abuse (cocaine, nicotine, alcohol), obesity, binge eating, asthma, cough, urinary incontinence, gastroesophageal reflux disease, transient lower esophageal sphincter relaxation, irritable bowel syndrome.

13. Method of treatment and/or prevention of a disorder which requires positive allosteric modulation of the GABA_B receptor characterized by administering an effective amount of a compound of formula (I) as claimed in claim 1 and optical antipodes or racemates and/or salts thereof as such or combined with pharmaceutically acceptable auxiliary materials and the like usually applied in pharmaceuticals to the mammal to be treated.

14. Method according to claim 13 wherein disorder is selected from the group of psychiatric disorders (such as anxiety, panic disorder, posttraumatic disorder, depression, schizophrenia), neurodevelopmental disorders (such as autism spectrum disorder, obsessive-compulsive disorder, Fragile X syndrome), cognitive disorders, epilepsy, spasticity, skeletal muscle rigidity, spinal cord injury, multiple sclerosis, amyotrophic lateral sclerosis, cerebral palsy, essential tremor, pain (neuropathic, visceral, osteoarthritic), substance abuse (cocaine, nicotine, alcohol), obesity, binge eating, asthma, cough, urinary incontinence, gastroesophageal reflux disease, transient lower esophageal sphincter relaxation, irritable bowel syndrome.

ABSTRACT

The present invention relates to new pyrazolo[1,5-a]pyrimidine derivatives of formula (I) or pharmaceutically acceptable salts, biologically active metabolites, pro-drugs, racemates, enantiomers, diastereomers, solvates and hydrates thereof that serve as GABA_B receptor positive allosteric modulators. The invention also relates to the process for producing such compounds. The invention further relates to pharmaceutical compositions comprising such compounds optionally in combination with two or more different therapeutic agents and the use of such compounds in methods for treating diseases and conditions mediated and modulated by the GABA_B receptor positive allosteric mechanism. The invention also provides a method for manufacture of medicaments useful in the treatment of such disorders.



(I)