Title: SUBSTITUTED PYRIMIDINES AS LIGANDS OF ADENOSINE RECEPTORS

![Chemical Structure](image)

Abstract: The invention provides a compound of formula (I) wherein R and R' are selected from hydrogen, alkyl, alkenyl, alkynyl, or aryl; R" and R"" are selected from hydrogen, acyl, thio-acyl, seleno-acyl, alkyl, alkenyl, alkynyl, or aryl; or a pharmaceutically acceptable salt thereof, to interact with the adenosine receptors in the beneficial treatment and/or prevention of a disorder arising from the said receptors. The invention further provides pharmaceutical compositions comprising said compounds. The invention also relates to the use of said compositions for treating and/or preventing a variety of diseases.
SUBSTITUTED PYRIMIDINES AS LIGANDS OF ADENOSINE RECEPTORS

FIELD OF INVENTION
The present invention relates to a particular novel category of 2,4,6-trisubstituted pyrimidines, pharmaceutical compositions containing them and the use of said compounds and compositions.

BACKGROUND OF THE INVENTION
The endogenous neuromodulator adenosine acts extracellularly via activation of specific membrane-bound receptors called P1-purinoceptors. These adenosine receptors are divided into four subclasses, A1, A2A, A2B and A3 receptors. All four classes are coupled to the enzyme adenylate cyclase. Activation of the adenosine A1 and A3 receptors can lead to an inhibition of adenylate cyclase, while activated A2A and A2B receptors can stimulate adenylate cyclase. The adenosine receptors are ubiquitously distributed throughout the body, and can modulate diverse physiological functions, including induction of sedation, relaxation of smooth muscle and vasodilation. Activation of these receptors by adenosine can therefore be of importance in many disease states. Accordingly, blocking these receptors can produce an effect leading to the prevention or treatment of many diseases. For example, the A2A adenosine receptor antagonists are reported to have a beneficial effect on neurodegenerative diseases such as Parkinson’s disease.1 In recent years, a number of new and interesting ligands, which block the various adenosine receptor subtypes, have been synthesised. These ligands encompass bi- and tricyclic heteroaromatic systems - featuring 3-nitrogen tri-cyclic systems (e.g., the imidazoquinolines);2 4-nitrogen tri-cyclic systems (e.g., triazoloquinoxalines);3 6-nitrogen tri-cyclic systems (e.g., the pyrazolotriazolopyrimidines);4 2-nitrogen bi-cyclic systems (e.g., the naphthyridines);5 and 3-nitrogen bi-cyclic systems (e.g., deazaadenines).6
SUMMARY OF THE INVENTION

It has now been found that a particular novel category of 2,4,6-trisubstituted pyrimidines can very attractively be used to treat adenosine receptor mediated conditions.

Accordingly, the present invention relates to a compound of the general formula (I):

![Chemical structure image]

(I)

or a salt thereof,

wherein

R represents hydrogen (except when R' = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkylnyl, or (substituted) -(CH₂)ₙ-aryl;
R' represents hydrogen (except where R = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkylnyl, or (substituted) -(CH₂)ₙ-aryl;
R" represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkylnyl, or (substituted) -(CH₂)ₙ-aryl;
R"" represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkylnyl, or (substituted) -(CH₂)ₙ-aryl;
R" and R"" can also together form a substituted or unsubstituted heterocyclic ring or heterocyclic rings;
and n is a number in the range of from 0 to 10.

The compounds in accordance of the present invention block various adenosine receptor subtypes, thus establishing that diseases such as amongst...
others cardiovascular, neurological, and immunological disorders, can very attractively be treated and/or prevented.

In the context of the present invention the term ‘adenosine receptor mediated conditions’ is intended to include disease states or conditions characterised by their responsiveness to treatment with an adenosine receptor mediating compound, e.g. a 2,4,6-trisubstituted pyrimidine derivative as described by general formula (I), where the treatment causes a significant diminishment of at least one symptom or effect of the state achieved with an adenosine receptor mediating compound of the invention.

In the context of the present invention by the term ‘alkyl’ it is meant any saturated hydrocarbon, either branched or unbranched comprising from 1 to about 30 carbon atoms. This includes straight-chained alkyl groups, branched-chained alkyl groups, cycloalkyl (alicyclic) groups, alkyl-substituted cycloalkyl groups, and cycloalkyl-substituted alkyl groups. This term further includes alkyl groups, which can further include oxygen, nitrogen, sulphur or phosphorous atoms replacing one or more carbons of the hydrocarbon backbone. In preferred embodiments, a straight or branched chain has 30 or less carbon atoms in its backbone, and more preferably 20 carbon atoms or less. Likewise, preferred cycloalkyls have from 3-10 carbons, and more preferably 3-7 carbons in the ring-structure.

In the context of the present invention the terms ‘acyl’, ‘thio-acyl’ and ‘seleno-acyl’ refer to compounds of the kind ‘C(O)X’, ‘C(S)X’, and ‘C(Se)X’, respectively, where X in turn represents hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl.
In the context of the present invention the term ‘\((\text{CH}_2)_n\)-aryl’ means a short straight alkyl chain between the (substituted) aryl group and the drawn structure, where \(n\) can range of from 0 up to and including 10.

In the context of the present invention the term ‘aryl’ as used herein, refers to aromatic groups which can include 5- and 6-membered single-ring groups, with 0 to 4 heteroatoms, for example benzene, pyrrole, furan, thiophene, imidazole, triazole, tetrazole, pyrazole, pyridine, pyrazine, pyridazine and pyrimidine, and the like. The aryl groups can suitably include polycyclic fused aromatic groups such as naphthyl, quinolyl, indolyl, benzoazazole, benzothiazole and the like. Those aryl groups containing heteroatoms may also be referred to as heteroaryls or heteroaromatics. The aromatic ring may be substituted at one or more ring positions, with such substituents as described herein. Aryl groups can also be fused or bridged with alicyclic or heteroalicyclic rings which are not aromatic.

In the context of the present invention the term ‘substituted’ is intended to include substituents replacing hydrogen on one or more of the carbons of a moiety. Such substituents suitably include, for example, halogen, hydroxyl, alkylcarboxyloxy, arylcarboxyloxy, alkoxybenzyloxy, aryloxybenzyloxy, carboxylate, alkyldimethyl, alkyloxybenzyl, aminocarbonyl, alkylthiocarbonyl, alkoxy, phosphate, phosphonate, phosphinato, cyano, amino (including alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino), acylamino, (including alkylcarbonylamino, arylcarbonylamino, carbamyl and ureido), amidino, imino, sulfhydryl, alkylthio, arylthio, thiocarboxylate, sulfates, sulfonato, sulfamoyl, sulfonamido, nitro, trifluoromethyl, azido, heterocyclyl, alkylaryl, or an aromatic or heteroaromatic moiety. It will be understood to those skilled in the art that the moieties substituted on the (unsaturated and saturated) carbon chain can themselves be substituted, if appropriate.
In the context of the present invention the term 'heteroatom' refers to an atom of any element other than carbon or hydrogen. Preferred heteroatoms are oxygen, nitrogen, sulphur and phosphorus.

In the context of the present invention the terms 'alkenyl' and 'alkynyl' refer to unsaturated aliphatic groups analogous in length and possible substitution to the alkyls described above, but that contain at least one double or triple bond, respectively.

In the context of the present invention salts of the compound of the present invention are meant to include any physiologically acceptable salt. The term 'physiologically acceptable salt' refers to any non-toxic alkali metal, alkaline earth metal, and ammonium salts commonly used in the pharmaceutical industry, including the sodium, potassium, lithium, calcium, magnesium, barium ammonium and protamine zinc salts, which can be prepared by methods known in the art. The term also includes non-toxic acid addition salts, which are generally prepared by reacting the compounds of the present invention with a suitable organic or inorganic acid. The acid addition salts are those which retain the biological effectiveness and properties of the free bases and which are not biologically or otherwise undesirable. Examples include those derived from mineral acids, and include, inter alia, hydrochloride, hydrobromic, sulphuric, nitric phosphoric, metaphosphoric and the like. Organic acids include, inter alia, tartaric, acetic, proprionic, citric, malic, malonic, lactic, fumaric, benzoic, cinnamic, mandelic, glycolic, gluconic, pyruvic, succinic, salicylic and arylsulfonic, e.g. p-toluenesulfonic, acids. According to one embodiment of the invention, the substituent R represents hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl; R' represents hydrogen, (substituted) alkyl,
(substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl; R" represents hydrogen, acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl; R"" represents hydrogen, acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, (substituted) or -(CH₂)ₙ-aryl; and R" and R"" can also together form a substituted or unsubstituted heterocyclic ring or heterocyclic rings.

In a preferred embodiment, the present invention relates to a pharmaceutical composition comprising as active ingredient one or more compounds of the general formula (I):

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  R  
 N  
 R' N R" R""
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(I)

or a salt of said compound(s), wherein R, R', R", R"" have the meaning as defined herein before.

**DETAILED DESCRIPTION OF THE INVENTION**

The present invention further relates to compounds of the general formula (I):

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  R  
 N  
 R' N R" R""
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(I)
or a salt thereof,
wherein
R represents hydrogen (except when R' = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH$_2$)$_n$-aryl;
R' represents hydrogen (except where R = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, (substituted) -(CH$_2$)$_n$-aryl;
R" represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, (substituted) -(CH$_2$)$_n$-aryl;
R"" represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, (substituted) -(CH$_2$)$_n$-aryl;
R" and R"" can also together form a substituted or unsubstituted heterocyclic ring or heterocyclic rings; and
n is a number in the range of from 0 to 10.

More particularly, the present invention relates to compounds of general formula (I) or salts thereof,
R represents a hydrogen (except when R' = H), alkyl, or (substituted) -(CH$_2$)$_n$-aryl;
R' represents a hydrogen (except when R' = H), alkyl, or (substituted) -(CH$_2$)$_n$-aryl;
R" represents a hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, or (substituted) -(CH$_2$)$_n$-aryl;
R"" represents a hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, or (substituted) -(CH$_2$)$_n$-aryl; and R" and R"" can also together form a substituted or unsubstituted heterocyclic ring or heterocyclic rings;

According to another preferred embodiment of the present invention,
R represents a substituted) -(CH$_2$)$_n$-aryl;
R' represents a (substituted) -(CH$_2$)$_n$-aryl;
R" represents a hydrogen or methyl;
and R”” represents an acyl, thio-acyl or seleno-acyl.

Preferably, R represents a (substituted) -(CH₂)ₙ-aryl; R’ represents a (substituted) -(CH₂)ₙ-aryl; R” represents an acyl, thio-acyl or seleno-acyl; and R”” represents a hydrogen or methyl.

In a more preferred embodiment, R represents a phenyl; R’ represents a phenyl; R” represents a hydrogen or methyl; and R”” represents an acyl.

In another preferred embodiment, R represents a phenyl; R’ represents a phenyl; R” represents an acyl; and R”” represents a hydrogen or methyl.

In yet another preferred embodiment, R represents a (substituted) alkyl; R’ represents a (substituted) alkyl; R” represents a hydrogen or methyl; and R”” represents an acyl.

In another preferred embodiment, R represents a (substituted) alkyl; R’ represents a (substituted) alkyl; R” represents an acyl, thio-acyl or seleno-acyl; and R”” represents a hydrogen or methyl.

Preferably, the compound according to the present invention is chosen from the group consisting of N-(2,6-diphenyl-pyrimidin-4-yl)-benzamide, N-(2,6-diphenyl-pyrimidin-4-yl)-4-methoxy-benzamide, N-(2,6-diphenyl-pyrimidin-4-yl)-formamide, N-(2,6-diphenyl-pyrimidin-4-yl)-acetamide, N-(2,6-diphenyl-pyrimidin-4-yl)-propionamide, N-(2,6-diphenyl-pyrimidin-4-yl)-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-isobutyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-3-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2-ethyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2,2-dimethyl-propionamide, N-(2,6-diphenyl-pyrimidin-4-yl)-3,3-dimethyl-butyramide, cyclopropanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide, cyclobutanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide, cyclopentanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide,
cyclohexanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide or a salt thereof.

More preferably, the compound according to the present invention is chosen from the group consisting of N-(2,6-diphenyl-pyrimidin-4-yl)-formamide, N-(2,6-diphenyl-pyrimidin-4-yl)-acetamide, N-(2,6-diphenyl-pyrimidin-4-yl)-propionamide, N-(2,6-diphenyl-pyrimidin-4-yl)-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-isobutyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-3-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2-ethyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2,2-dimethyl-propionamide, N-(2,6-diphenyl-pyrimidin-4-yl)-3,3-dimethyl-butyramide, cyclopentanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide, cyclohexanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide or a salt thereof.

Most preferably, the compound comprises N-(2,6-diphenyl-pyrimidin-4-yl)-2-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2,2-dimethyl-propionamide, or cyclopentanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide.

The compounds of the present invention may be prepared by several synthetic procedures. For example, the synthesis route to obtain some 2,4,6-trisubstituted derivatives is depicted in the scheme herein below:
Scheme 1: (a) NaOH, EtOH; (b) POCl₃; (c) NHR"; sealed vessel, 140°C; (d) aldehyde, NaBH(OAc)₃; or hydrocarbon halide, base; or carboxylic acid derivative, coupling agent, base.

According to this scheme, the synthesis began with the reaction of a β-ketoester with an amidine in the presence of sodium hydroxide in ethanol at room temperature to create the pyrimidinone (3) in a 60% yield.⁹ This was in turn reacted with phosphorous oxychloride to give the halogenated pyrimidine (4).¹⁰ Displacement of the chloride with an amine gave, in the case of ammonia gas, the primary amine (5), and the substituted secondary amines (6) in the case of primary amines. Compound (6) could also be obtained with reductive alklylation with the appropriate aldehyde from compound (5); as could compound (7) from (6). To create acyl derivatives of (7), the appropriate carboxylic acid/acid chloride was used, in the presence of a base (and in some cases a coupling agent), to react with the amines (6) and/or (5). Where R" = R"", then compound (7) could be made from compound (5) with 2 equivalents of the appropriate alkyl iodide and base, or 2 equivalents of the appropriate carboxylic acid (derivative) with base or coupling agent.

The present invention also relates to a process for preparing a compound according to the present invention, which process comprises the steps of:

(a) reacting a compound having the structure of RCOCH₂COOA, wherein A represents (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)ₙ-aryl, wherein n is a number in the range of from 0 to 10, with a compound consisting of structure R'C(NH)NH₂, or a salt thereof, to form a product having the structure

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R
|   |
|---|---
|   |   
|   |   
|   |   
N |   |
|   |
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SUBSTITUTE SHEET (RULE 26)
or its tautomer, wherein \( R \) represents hydrogen (except when \( R' = H \)), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH\(_2\))\(_n\)-aryl; \( R' \) represents hydrogen (except when \( R = H \)), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH\(_2\))\(_n\)-aryl; and wherein \( n \) has the meaning as defined hereinbefore;

(b) subjecting the product formed in step (a) to a treatment wherein the oxygen atom is replaced by a chlorine atom to form a product having the structure

\[
\begin{array}{c}
N \quad \text{Cl} \\
R' \quad R \\
\end{array}
\]

(c) reacting the product formed in step (b) with ammonia to form a product having structure

\[
\begin{array}{c}
N \quad \text{NH}_2 \\
R' \quad R \\
\end{array}
\]

(d) reacting the product formed in step (c) with a compound having the structure of \( R' \) aldehydes, \( R' \) halide, or \( R' \) carboxylic acid or a derivative thereof, to form a product having the structure

\[
\begin{array}{c}
N \quad \text{NH} \\
R' \quad R'' \\
\end{array}
\]
wherein R' represents, acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)ₙ-aryl, wherein n has the meaning as defined hereinbefore; and

(e) reacting the product formed in step (c) with a compound having the structure of R''aldehyde, R''halide or R''carboxylic acid or a derivative thereof, to form a product having the structure

![Chemical Structure](image)

wherein R'' represents, acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl, and wherein n has the meaning as defined hereinbefore.

Suitably, step (c) can be carried out in a sealed vessel.

The present invention also relates to a process for preparing a compound according to the present invention. This process comprises the steps of:

(a) reacting a compound having the structure of RCOCH₂COOA, wherein A represents (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)ₙ-aryl, wherein n is a number in the range of from 0 to 10, with a compound consisting of structure R'C(NH)NH₂, or a salt thereof, having the structure to form a product having the structure

![Chemical Structure](image)
or its tautomer, wherein R represents hydrogen (except when R' = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)ₙ-aryl; R' represents hydrogen (except when R = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)ₙ-aryl; and wherein n has the meaning as defined hereinbefore;

(b) subjecting the product formed in step (a) to a treatment wherein the oxygen atom is replaced by a chlorine atom to form a product having the structure

(c) reacting the product formed in step (b) with a compound having the structure R"NH₂ to form a product having structure

wherein R" represents (substituted) alkyl, (substituted) alkenyl, substituted alkynyl or (substituted) -(CH₂)ₙ-aryl, and n has the meaning as defined hereinbefore; and

(d) reacting the product formed in step (c) with a compound having the structure of R"aldehyde, R"halide or R"carboxylic acid or a derivative thereof, to form a product having the structure

SUBSTITUTE SHEET (RULE 26)
wherein $R''$ represents acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) $-(CH_2)_n$-aryl, and wherein $n$ has the meaning as defined hereinbefore.

Suitably, steps a, b, c, d and e can be carried out at temperatures ranging from ambient to 300 °C.

Derivatives of the carboxylic acid can be, but are not exclusively, carboxylic acid chlorides, carboxylic acid fluorides, carboxylic acid anhydrides or esters.

Preferably, the present invention relates to a process for preparing the compound of the present invention, wherein the process comprises the steps of:

(a) reacting a compound having the structure of ethyl benzoyl acetate with a compound consisting of benzamidine having the structure to form a product having the structure of 2,6-diphenyl-3H-pyrimidin-4-one, which is also in tautomerism with 2,6-diphenyl-pyrimidin-4-ol;

(b) reacting the product formed in step (a) with phosphorous oxychloride to form a product having the structure 4-chloro-2,6-diphenyl-pyrimidine;

(c) reacting the product formed in step (b) with ammonia to form a product having the structure 4-amino-2,6-diphenylpyrimidine; and

(d) reacting the product formed in step (c) with a carboxylic acid or a carboxylic acid derivative to form a product having the structure of a 4-amido-2,6-diphenylpyrimidine.

Most preferably, the present invention relates to a process for preparing the compound of the present invention, wherein the process comprises the steps of:
(a) reacting a compound having the structure of ethyl benzoyl acetate with a compound consisting of benzamidine having the structure to form a product having the structure of 2,6-diphenyl-3H-pyrimidin-4-one, which is also in tautomerism with 2,6-diphenyl-pyrimidin-4-ol;
(b) reacting the product formed in step (a) with phosphorous oxychloride to form a product having the structure 4-chloro-2,6-diphenyl-pyrimidine;
(c) reacting the product formed in step (b) with ammonia to form a product having the structure 4-amino-2,6-diphenylpyrimidine; and
(d) reacting the product formed in step (c) with cyclopentyl carbonyl chloride to form a product having the structure of cyclopentanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide.

The present invention also relates to a pharmaceutical composition comprising as active ingredient one or more compounds according to the present invention. The compound according to the present invention can be used as such. However, also a salt or a solvate of the compound may be used. It will be understood that such salt or solvate should be pharmaceutically acceptable. The skilled person will further understand that the pharmaceutical composition will also comprise a suitable pharmaceutical carrier.

The present invention further relates to the use of a compound according to the present invention for treating and/or preventing a disorder in which the adenosine receptors are involved.

The present invention also relates to the use of a compound according to the present invention for the manufacture of a medicament for the treatment and/or prevention of a disorder in which the adenosine receptors are involved.
In addition, the present invention relates to a method for treating and/or preventing a disorder in which the interaction with the adenosine receptors is beneficial which method comprises administering to a subject in need of such treatment an effective dose of a pharmaceutical composition in accordance with the present invention.

Suitably, the disorder can be chosen from the group of diseases consisting of amongst others cardiovascular, neurological, immunological disorders, cancers and infection conditions. The compounds according to the present invention are particularly effective for treating and/or preventing kidney, heart and central nervous system (CNS) afflictions.

As will be detailed in Table 2, the compounds of the present invention are biologically active.

The term 'biologically active' indicates that the compound of the present invention has some sort of a biological activity, for example, a measurable effect on a target receptor. As will be detailed hereinafter, the compound of the present invention may block the biological action of adenosine receptors, thus acting as adenosine receptor antagonists.

The term 'antagonist' used herein refers to a molecule that binds to a receptor without activating the receptor. It competes with the endogenous ligand for this binding site and, thus reduces the ability of the endogenous ligand to stimulate the receptor.
Thus, the present invention also relates to pharmaceutical compositions comprising as active ingredient one or more of a compound of the general formula (I):

![Chemical structure formula](image)

(I)

or a salt thereof

wherein

R represents hydrogen (except when R' = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH$_2$)$_n$-aryl;

R' represents hydrogen (except where R = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH$_2$)$_n$-aryl;

R'' represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH$_2$)$_n$-aryl;

R''' represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH$_2$)$_n$-aryl;

R'' and R''' can also together form a substituted or unsubstituted heterocyclic ring or heterocyclic rings;

and n is a number in the range of from 0 to 10.

In the pharmaceutical composition according to the present invention the active ingredient is present in an effective amount. The term ‘effective amount’ for the purposes described herein is that determined by such considerations as are known to those versed in the art. The amount must be sufficient to achieve a desired therapeutic effect, e.g. to treat a disease or disorder.
The terms 'treat', 'treating' and 'treatment' refer to the administering of a therapeutic amount of the compound or pharmaceutical composition of the present invention which is effective to ameliorate undesired symptoms associated with a disease, to prevent the manifestation of such symptoms before they occur, to slow down the progression of a disease, to slow down the deterioration of symptoms, to slow down the irreversible damage caused by the chronic stage of a disease, to lessen the severity of, or cure a disease, to improve survival rate or more rapid recovery, to prevent the disease from occurring, or a combination of two or more of the above.

The terms 'modulate', 'modulation', and 'modulation' are intended to include preventing, eradicating, or inhibiting the resulting increase of undesired physiological activity associated with the stimulation of an adenosine receptor, e.g. in the context of the therapeutic methods of this invention. In another embodiment, the term 'modulate' includes antagonistic effects, e.g. diminishment of the activity or production of mediators which result from the (over)-stimulation of adenosine receptor(s).

The disease is preferably associated with the biological action of one or more adenosine receptors wherein the compound of the present invention acts as an adenosine receptor antagonist. For example antagonists of A₁ receptors have been implicated as compounds that may be used in the treatment of cardiac, renal and sleep disorders.

The pharmaceutical composition of the present invention may further comprise pharmaceutically acceptable additives. Further, the term 'pharmaceutically acceptable additives' used herein refers to any substance combined with said compound and include, without
being limited thereto, diluents, excipients, carriers, solid or liquid fillers or encapsulating materials which are typically added to formulations to give them a form or consistency when it is given in a specific form, e.g. in tablet form, as a simple syrup, aromatic powder, and other various elixirs. The additives may also be substances for providing the formulation with stability, sterility and isotonicity (e.g. antimicrobial preservatives, antioxidants, chelating agents and buffers), for preventing the action of microorganisms (e.g. antimicrobial and antifungal agents, such as parabens, chlorobutanol, phenol, sorbic acid and the like) or for providing the formulation with an edible flavour, etc.

Preferably, the additives are inert, non-toxic materials, which do not react with the active ingredient of the invention. Yet, the additives may be designed to enhance the binding of the agent to its receptor. Further, the term additive may also include adjuvants, which, by definition, are substances affecting the action of the active ingredient in a predictable way. The additive can be any of those conventionally used and are only limited by chemico-physical considerations, such as solubility and lack of reactivity with the compound of the invention, and by route of administration. The active agent of the invention may be administered orally to the patient. Conventional methods such as administering the compound/s in tablets, suspensions, emulsions, capsules, powders, syrups and the like are usable. For oral administration, the composition of the invention may contain additives for facilitating oral delivery of the compound/s of the invention. Formulations suitable for oral administration can consist of (a) liquid solutions, such as an effective amount of the compound dissolved in diluents, such as water, saline, or orange juice; (b) capsules, sachets, tablets, lozenges, and troches, each containing a predetermined amount of the active ingredient, as solids or granules; (c) powders; (d) suspensions in an appropriate liquid; and (e) suitable emulsions. Liquid formulations may include diluents, such as water and alcohols, for example, ethanol, benzyl alcohol, and the polyethylene alcohols, either with or
without the addition of a pharmaceutically acceptable surfactant, suspending agent, or emulsifying agent. Capsule forms can be of the ordinary hard- or soft-shelled gelatine type containing, for example surfactants, lubricants, and inert fillers, such as lactose, sucrose, calcium phosphate, and corn starch. Tablet forms can include one or more of lactose, sucrose, mannitol, corn starch, potato starch, alginic acid, microcrystalline cellulose, acacia, gelatine, guar gum, colloidal silicon dioxide, croscarmellose sodium, talc, magnesium stearate, calcium stearate, zinc stearate, stearic acid, and other excipients, colorants, diluents, buffering agents, and pharmacologically compatible carriers. Lozenge forms can comprise the active agent in a flavour, usually sucrose and acacia or tragacanth, as well as pastilles comprising the active ingredient in an inert base, such as gelatine and glycerine, or sucrose and acacia, emulsions, gels, and the like. Such additives are as such known in the art. Alternatively, the compound/s may be administered to the patient parenterally. In this case, the composition will generally be formulated in a unit dosage injectable form (solution, suspension, emulsion). Pharmaceutical formulation suitable for injection may include sterile aqueous solutions or dispersions and sterile powders for reconstitution into sterile injectable solutions or dispersions. The carrier can be a solvent or dispersing medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, lipid polyethylene glycol and the like), suitable mixtures thereof and vegetable oils. Proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. Non-aqueous vehicles such as cottonseed oil, sesame oil, olive oil, soybean oil, corn oil, sunflower oil, or peanut oil and ester, such as isopropyl myristate, may also be used as solvent systems for the composition of the present invention.
Suitable fatty acids for the use in parenteral formulations include oleic acid, stearic acid, and isostearic acid. Ethyl oleate and isopropyl myristate are examples of suitable fatty acid esters.

Suitable detergents for use in parenteral formulations include fatty alkali metal, ammonium, and triethanolamine salts, and suitable detergents include (a) cationic detergents such as, for example, dimethyl dialkyl ammonium halides, and alkyl pyridinium halides, (b) anionic detergents such as, for example, alkyl, aryl, and olefinic sulfonates, alkyl, olefin, ether and monoglyceride sulfates, and sulfosuccinates, (c) non-ionic detergents such as, for example, fatty amine oxides, fatty acid alkanolamides, and polyoxyethylenepolypropylene copolymers, (d) amphoteric detergents such as, for example, alkyl-β-aminopropionates, and 2-alkyl-imidazoline quarternary ammonium salts, and mixtures thereof.

Further, in order to minimise or eliminate irritation at the site of injection, the compositions may contain one or more non-ionic surfactants having a hydrophile-lipophile balance (HLB) from about 12 to about 17. Suitable surfactants include polyethylenesorbitan fatty acid esters, such as sorbitan monooleate and the high molecular weight adducts of ethylene oxide with a hydrophobic base, formed by the condensation of propylene oxide with propylene glycol.

The choice of an additive will be determined in part by the particular compound of the present invention, as well as by the particular method used to administer the composition.

Notwithstanding the above, the composition of the present invention may include one or more of the compounds of the present invention and may compromise other biologically active substances, to provide a combined therapeutic effect.

The compounds and compositions of the present invention as set forth hereinabove and below are administered and dosed in accordance with good medical practice, taking into account the clinical conditions of the individual
patient, the site and method of administration, scheduling of administration, individual's age, sex, body weight and other factors known to medical practitioners.

The dose may be single doses or multiple doses over a period of several days. The treatment generally has a length proportional to the length of the disease process and drug effectiveness and the individual species being treated. Suitable doses and dosage regimens can be determined by conventional range-finding techniques known to those of ordinary skill in the art. Generally, treatment is initiated with smaller dosages, which are less than the optimum dose of the compound. Thereafter, the dosage is increased by small increments, until the optimum effect under the circumstances is reached. Exemplary dosages range from about 0.01mg/kg body weight to about 10 mg/kg body weight of the subject being treated per day.

The invention has been described in an illustrative manner, and it is to be understood that the terminology which has been used, is intended to be in the nature of words of description rather than of limitation. Obviously, many modifications and variations of the present invention are possible in light of the above teaching. It is therefore, to be understood that within the scope of the appended claims, the invention may be practised otherwise than as specifically described hereinafter.

Throughout this application various publications are referred to by a number. Full citations for the publications are listed hereinafter. The disclosure of these publications in their entireties is hereby incorporated by reference into the application in order to more fully describe the state of the art to which this invention pertains.

SPECIFIC EXAMPLES – 2,6-Diphenyl-4-carboxamidopyrimidines
This invention is further described in the following specific examples, which do not limit the scope of the invention described in the claims.
The examples detailed here of the general formula (II) are synthesised according to the route detailed below in Scheme 2.

**Scheme 2:**
(a) NaOH, EtOH, H₂O; (b) POCls, PCl₃; (c) NH₃ in EtOH, sealed vessel, 140 °C; (d) RC(O)Cl, Et₃N, 1,4-dioxane.
Chemistry – General

**Chemicals and Solvents** All reagents were obtained from commercial sources and all solvents were of an analytical grade.

**Chromatography** Thin-layer chromatography (TLC) was carried out using Merck silica gel plastic backed F₂₅₄ plates, visualised under UV (254 nm).

**Instruments and Analysis** Elemental analyses were performed for C,H,N (Leiden Institute of Chemistry, Leiden University, The Netherlands). \(^1\)H and \(^13\)C NMR spectra were recorded on a Bruker AC 200 (\(^1\)H NMR, 200MHz; \(^13\)C NMR, 50.29 MHz) spectrometer with tetramethylsilane (TMS) as an internal standard. Chemical shifts are reported in ppm (δ) relative to this. Melting points were determined on a Büchi melting point apparatus and are uncorrected. Mass Spectra were measured on a Finnigan MAT TSQ-70 spectrometer equipped with an electrospray interface for ESI experiments. Spectra were collected by constant infusion of the analyte dissolved in methanol. ESI is a soft ionisation technique resulting in protonated, sodiated species in positive ionisation mode and deprotonated species in the negative ionisation mode.

**Synthetic Procedures**

2,6-Diphenyl-3H-pyrimidin-4-one (10)

Benzamidine hydrochloride (3.9 g, 24.9 mmol) was dissolved in a minimal amount of H₂O (10 mL), to this was added sodium hydroxide pellets (1.0 g, 24.9 mmol, 1 eq.) dissolved in H₂O (2 mL), followed by ethylbenzoate (4.53 mL, 26.1 mmol, 1.05 eq.). Ethanol was then added until a clear solution was obtained. The reaction mixture was then allowed to stir at room temperature overnight yielding a thick suspension, which was then filtered to give a white solid. After
washing with diethyl ether to remove unreacted/excess β-ketoester the solid was dried \textit{in vacuo} to give 57% of the desired product. $^1$H NMR δ (DMSO-d6): 8.31-8.18 (m, 5H, Ar), 7.60-7.54 (m, 5H, Ar), 6.92 (s, 1H, Ar).

\textbf{4-Chloro-2,6-diphenyl-pyrimidine (11)$^8$}
Phosphorous oxychloride (9.30 mL, 99.8 mmol, 7.5 eq.) was added dropwise to 2,6-diphenyl-3H-pyrimidin-4-one (10) (3.3 g, 13.3 mmol) in a vigorous reaction. To this mixture was added slowly phosphorous pentachloride (2.77 g, 13.3 mmol, 1 eq.) and the reaction mixture was stirred at reflux for 3 hours. The reaction mixture was then quenched by pouring into ice-water, and extracted with ethyl acetate (3 × 150 mL). The combined organic layers were washed with water and brine, dried (MgSO$_4$) and then concentrated to give a yellow solid. This was recrystallised from hot ethanol to give fine white needles (65%). $^1$H NMR δ (CDCl$_3$): 8.60-8.18 (m, 5H, Ar), 7.63 (s, 1H, Ar), 7.51-7.57 (m, 5H, Ar).

\textbf{2,6-Diphenyl-pyrimin-4-ylamine (12)}
Ethanol (50 mL) was saturated with NH$_3$$_{aq}$ at 0 °C and added to 4-chloro-2,6-diphenyl-pyrimidine (11) (2.30 g, 8.63 mmol) in a sealed vessel. This was then stirred at 140 °C for 24 h. Upon cooling and concentrating, the residues were extracted with hot chloroform (3 × 50 mL) and the solvent evaporated \textit{in vacuo}. The crude product was purified by column chromatography on SiO$_2$ eluting with CH$_2$Cl$_2$ to give an off-white solid (80%). $^1$H NMR δ (DMSO-d6): 8.47-8.42 (m, 2H, Ar), 8.16-8.13 (m, 2H, Ar), 7.57-7.5 (m, 6H, Ar), 7.02 (br s, 2H, NH$_2$), 6.88 (s, 1H, Ar).

\textbf{General Procedure for the Preparation of 4-Amido-2,6-diphenylpyrimidines (13-25)}
To a solution of 4-amino-2,6-diphenylpyrimidine (0.202 mmol, 1 eq.) in 1,4-dioxane (5mL) was added triethylamine (0.223 mmol, 1.1 eq.), followed by the appropriate acid chloride (0.304 mmol, 1.5 eq.). This was then stirred at reflux until no starting material was visible by TLC. Upon completion, the reaction mixture was separated between ethyl acetate (20 mL) and water (20 mL). The aqueous layer was further extracted with ethyl acetate (2 × 20 mL) and the combined organics washed with water and brine. After drying over MgSO₄ and evaporation under reduced pressure, the crude product was purified by column chromatography, eluting with a petroleum ether-ethyl acetate or a dichloromethane-methanol solvent system. Recrystallisation with ethanol or petroleum ether-ethyl acetate gave the corresponding amide in crystalline form.

**N-(2,6-Diphenyl-pyrimidin-4-yl)-benzamide (13).** Yield 48%; white solid; mp 120-123 °C; ¹H NMR δ (CDCl₃): 8.78 (bs, 1H, N-H), 8.72 (s, 1H, pyrimidine-H), 8.58-8.54 (m, 2H, phenyl-H), 8.34-8.29 (m, 2H, phenyl-H), 7.99-7.96 (m, 2H, phenyl-H), 7.64-7.48 (m, 9H, phenyl-H). ¹³C-NMR δ(CDCl₃): 166.2, 165.9, 164.0, 158.4, 137.3, 137.1, 133.4, 132.6, 130.8, 130.7, 128.9, 128.7, 128.3, 128.1, 127.4, 127.2, 103.3. MS (ES⁺): 351.57, 373.55 Da. Anal. (C₂₉H₁₇N₅O.0.25H₂O) C, H, N.

**N-(2,6-Diphenyl-pyrimidin-4-yl)-acetamide (14).** Yield 43%; white solid; mp 140 °C; ¹H NMR δ (CDCl₃): 8.54-8.49 (m, 3H, phenyl-H + pyrimidinyl-H) 8.45 (s, 1H, N-H), 7.55-7.49 (m, 6H, phenyl-H), 2.20 (s, 3H, CH₃)ppm. ¹³C-NMR δ(CDCl₃): 165.9, 158.1, 154.3, 140.7, 130.74, 130.68, 128.7, 128.4, 128.0, 127.4, 103.0, 35.7ppm. MS (ES⁺): 289.89 Da. Anal. (C₁₈H₁₅N₅O.0.5EtOH) C, H, N.

**N-(2,6-Diphenyl-pyrimidin-4-yl)-propionamide (15).** Yield 77%; white solid;
mp 125-126 °C; 1H-NMR δ(CDCl₃): 8.58 (s, 1H, pyrimidinyl-Η), 8.55-8.50 (m, 2H, phenyl-Η), 8.36 (bs, 1H, NH), 8.30-8.25 (m, 2H, phenyl-Η), 7.54-7.49 (m, 6H, phenyl-Η), 7.45(t, 2H, -CH₂CH₃) ppm. 13C-NMR δ(CDCl₃): 173.2, 165.8, 163.9, 137.3, 137.0, 130.7, 128.7, 128.0, 127.4, 121.5, 103.1, 30.7, 8.87 ppm. MS (ES⁺): 303.8 Da. Anal. calc. for C₁₉H₁₇N₃O (C 75.23; H 5.65; N 18.85) found (C 75.32; H 6.23; N 14.04) %.

N-(2,6-Diphenyl-pyrimidin-4-yl)-butyramide (16). Yield 53%; white solid; mp.102-103 °C. 1H-NMR δ(CDCl₃): 8.60 (bs, 2H, pyrimidine-Η + NH), 8.56-8.51 (m, 2H, phenyl-Η), 8.31-8.26 (m, 2H, phenyl-Η), 7.45-7.50 (m, 6H, phenyl-Η), 2.29 (t, 2H, J = 7.48 Hz, CH₂CH₂CH₃), 1.71 (sextet, 2H, J = 7.39 Hz, CH₂CH₂CH₃), 0.95 (t, 3H, J = 7.30 Hz, CH₂CH₂CH₃) ppm. 13C-NMR δ(CDCl₃): 172.9, 165.8, 163.8, 158.5, 137.4, 137.0, 130.8, 130.7, 128.6, 128.4, 128.1, 127.3, 103.3, 39.2, 18.3, 13.5 ppm. MS (ES⁺): 317.87 Da. Anal. (C₂₀H₁₉N₃O. 0.14H₂O) C, H, N.

N-(2,6-Diphenyl-pyrimidin-4-yl)-isobutyramide (17). Yield 48%; white solid; mp 116-117 °C. 1H-NMR δ(CDCl₃): 8.59 (s, 1H, pyrimidine-Η), 8.55-8.50 (m, 2H, phenyl-Η), 8.30-8.25 (m, 2H, phenyl-Η), 8.05 (bs, 1H, NH), 7.54-7.49 (m, 6H, phenyl-Η), 2.64 (septet, 1H, J = 6.85 Hz, CH(CH₃)₂), 1.33 (d, 6H, J = 6.94 Hz, CH(CH₃)₂) ppm. 13C-NMR δ(CDCl₃): 176.5, 165.8, 158.3, 137.4, 137.1, 130.7, 128.7, 128.4, 128.0, 127.4, 103.4, 36.8, 19.2, 19.1 ppm. MS (ES⁺): 317.94, 634.75 Da. Anal. (C₂₀H₁₉N₃O. 0.1H₂O).

N-(2,6-Diphenyl-pyrimidin-4-yl)-3-methyl-butyramide (18). Yield 52%, white solid. mp. 127°C. 1H-NMR δ(CDCl₃): 8.59 (s, 1H, pyrimidinyl-Η), 8.56-8.51 (m, 2H, phenyl-Η), 8.35 (bs, 1H, NH), 8.31-8.26 (m, 2H, phenyl-Η), 7.56-7.49 (m, 6H, phenyl-Η), 2.25-2.24 (m, 3H, CH₂CH(CH₃)₂), 1.02-0.99 (d, 6H,
CH₂CH(CH₃)₂) ppm. ¹³C-NMR δ(CDCl₃): 172.1, 165.9, 158.2, 137.4, 137.1, 130.7, 130.6, 128.6, 128.4, 128.0, 127.4, 113.5, 103.2, 46.8, 25.8, 22.3 ppm. MS (ES⁺): 331.8 Da. Anal. (C₂₁H₂₁N₃O).

N-(2,6-Diphenyl-pyrimidin-4-yl)-2-ethyl-butyramide (19). Yield 58%, white solid. mp. 137-138 °C. ¹H-NMR δ(CDCl₃): 8.64 (s, 1H, pyrimidine-H), 8.55-8.50 (m, 2H, phenyl-H), 8.31-8.26 (m, 2H, phenyl-H), 8.09 (bs, 1H, NH), 7.54-7.49 (m, 6H, phenyl-H), 2.23-2.11 (m, 1H, CH(CH₂CH₃)₂), 1.86-1.56 (m, 4H, CH(CH₂CH₃)₂), 0.99 (t, 6H, J = 7.31 Hz, CH(CH₂CH₃)₂) ppm. ¹³C-NMR δ(CDCl₃): 175.8, 165.9, 158.3, 130.8, 130.7, 128.7, 128.4, 128.1, 127.4, 121.6, 103.2, 52.2, 25.5, 11.8 ppm. MS (ES⁺): 345.86, 690.56 Da. Anal. (C₂₂H₂₃N₃O₂. 0.1H₂O).

N-(2,6-Diphenyl-pyrimidin-4-yl)-2-methyl-butyramide (20), Yield 89%, white solid. mp.: 102 °C. ¹H-NMR δ(CDCl₃): 8.71 (br s, 1H, N-H), 8.67 (s, 1H, pyrimidyl-H), 8.59-8.54 (m, 2H, aromatic-H), 8.33-8.28 (m, 2H, aromatic-H), 7.53-7.50 (m, 6H, aromatic-H), 2.29-2.19 (m, 1H, CH), 1.82-1.86 (m, 1H, 0.5*CH₂), 1.55-1.41 (m, 1H, 0.5*CH₂), 1.16 (d, J = 6.58 Hz, 3H, CH₃), 0.90 (t, J=7.30Hz, 3H, CH₃) ppm. ¹³C-NMR δ(CDCl₃): 176.4, 165.9, 163.9, 158.5, 137.4, 137.1, 130.8, 130.7, 128.7, 128.4, 128.1, 127.4, 103.3, 44.0, 27.0, 16.9, 11.6 ppm. MS (ES⁺): 331.8 (M+) Da. Anal. (C₂₁H₂₁N₃O).

N-(2,6-Diphenyl-pyrimidin-4-yl)-2,2-dimethyl-propionamide (21). Yield 66%, white solid. mp. 52 °C. ¹H-NMR δ(CDCl₃): 8.63 (s, 1H, pyrimidinyl-H), 8.58-8.51 (m, 2H, phenyl-H), 8.30-8.27 (m, 2H, phenyl-H), 8.21 (s, 1H, N-H), 7.54-7.51 (m, 6H, phenyl-H), 1.40 (s, 9H, CH₃) ppm. ¹³C-NMR δ(CDCl₃): 178.0, 165.8, 163.8, 158.4, 137.3, 137.1, 130.7, 130.6, 128.6, 128.3, 128.1, 127.4, 103.2, 40.0, 27.2 ppm. MS (ES⁺): 331.92 Da. Anal. (C₂₁H₂₁N₃O).
N-(2,6-Diphenyl-pyrimidin-4-yl)-3,3-dimethyl-butyramide (22). Yield 62%, white solid. mp.: 134 °C. $^1$H-NMR δ(CDC$_3$): 8.73 (br s, 1H, N-H), 8.64 (s, 1H, pyrimidyl-H), 8.55-8.50 (m, 2H, aromatic-H), 8.32-8.27 (m, 2H, aromatic-H), 7.54-7.49 (m, 11H, aromatic-H), 2.20 (s, 2H, CH$_2$), 1.08 (s, 9H, 3°CH$_3$) ppm. $^{13}$C-NMR δ(CDC$_3$): 171.7, 165.9, 163.9, 158.4, 137.4, 137.1, 130.8, 130.7, 128.7, 128.4, 128.2, 127.4, 103.2, 51.0, 31.2, 30.0 ppm. MS (ES$^+$): 367.6 (MNa$^+$), 345.9 (MH$^+$) Da. Anal. (C$_{22}$H$_{33}$N$_3$O).

Cyclobutanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide (23). Yield 90%, white solid. mp.: 121-122 °C. $^1$H-NMR δ(CDC$_3$): 8.62 (s, 1H, pyrimidinyl-H), 8.56-8.51 (m, 2H, phenyl-H), 8.32-8.27 (m, 3H, phenyl-H + N-H), 7.54-7.48 (m, 6H, phenyl-H), 3.13 (pentet, 1H, -CHCH$_2$CH$_2$CH$_2$-), 2.45-1.90 (m, 6H, -CHCH$_2$CH$_2$CH$_2$-) ppm. $^{13}$C-NMR δ(CDC$_3$): 174.6, 165.8, 163.9, 158.4, 137.1, 130.7, 128.7, 128.4, 128.0, 127.4, 103.2, 86.9, 40.7, 24.9, 17.9 ppm. MS (ES$^+$): 329.7 Da. Anal. (C$_{21}$H$_{19}$N$_3$O. 0.01H$_2$O).

Cyclopentanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide (24). Yield 69%, white solid. mp.: 126.5-127 °C. $^1$H-NMR δ(CDC$_3$): 8.60 (s, 1H, pyrimidinyl-H), 8.56-8.51 (m, 2H, phenyl-H), 8.32-8.26 (m, 3H, phenyl-H + NH), 7.53-7.50 (m, 6H, phenyl-H), 2.77-2.65 (m, 1H, -CHCH$_2$CH$_2$CH$_2$CH$_2$-), 1.98-1.60 (m, 8H, -CHCH$_2$CH$_2$CH$_2$CH$_2$-) ppm. $^{13}$C-NMR δ(CDC$_3$): 175.9, 165.8, 158.4, 137.4, 137.1, 130.7, 130.6, 128.7, 128.4, 128.0, 127.4, 103.2, 46.8, 30.2, 25.9 ppm. MS (ES$^+$): 343.7 Da. Anal. (C$_{22}$H$_{21}$N$_3$O. 0.04H$_2$O).

Cyclohexanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide (25). Yield 87%, white solid. mp.: 142-143 °C. $^1$H-NMR δ(CDC$_3$): 8.60 (s, 1H, pyrimidinyl-H), 8.57-8.52 (m, 2H, phenyl-H), 8.34 (bs, 1H, NH), 8.30-8.25 (m, 2H, phenyl-H), 7.53-7.49 (m, 6H, phenyl-H), 2.31-2.18 (m, 1H, -
CH\textsubscript{2}CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{2}) ppm.

\textsuperscript{13}C-NMR \delta (CDCl\textsubscript{3}): 175.7, 165.8, 163.8, 158.4, 137.1, 130.7, 130.6, 128.6, 128.3, 127.3, 113.6, 103.2, 46.4, 29.2, 25.3 ppm. MS (ES\textsuperscript{+}): 357.7, 358.7 Da. Anal.

(C\textsubscript{23}H\textsubscript{25}N\textsubscript{3}O. 0.15H\textsubscript{2}O).

\textbf{Table 1 – Elemental Analysis}

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\textbf{SUBSTITUTE SHEET (RULE 26)}
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    76.47  6.84  11.85  

**BIOLOGY**

A primary function of certain cell surface receptors is to recognise appropriate ligands. Accordingly, we performed radioligand binding studies to establish the degree to which the compound binds to the receptor.

**Radioligand Binding Studies** [³H]DPCPX was purchased from Amersham. All compounds made were tested in radioligand binding assays to determine their affinities at the human adenosine A₁ receptor. The affinities at the A₁ receptors were determined on CHO cells expressing the human receptors, using [³H]DPCPX as the radioligand according to a previously described method.⁹

**Data Analysis** Competition binding data were fit to a single-site binding model and plotted using the software package Prism (Graph Pad, San Diego, CA, USA). The Cheng-Prusoff equation $K_i = IC_{50}/(1+[I]/K_d)$ was used to calculate $K_i$ values, where $K_i$ is the affinity constant for the competing ligand, $[I]$ is the concentration of the free radioligand, and $K_d$ is the affinity constant for the radioligand.

**Structure Activity Relationships**

In Table 2 results of the radioligand binding assays at the A₁ receptor are displayed, the substituents are defined hereinabove and below with reference to the compound of general formula (II). The reported literature focuses generally on bi-, and tri-cyclic heterocycles as the core structure about which
substituents are varied. This monocyclic core with the 2,4,6-trisubstitution pattern has surprising efficacy at the adenosine A₁ receptor, as can be seen in Table 2. The compounds shown in Table 2 were also tested at the adenosine A₂A and A₃ receptors and were shown to be generally selective for the adenosine A₁ receptor.

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<td>15.5±8.4</td>
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</table>
Displacement of specific [³H]DPCPX binding in CHO cells expressing human adenosine A₁ receptors. \( K_t \) (nM) ± SEM (n = 3).
LIST OF REFERENCES


Claims

1. A compound having the structure of general formula (I):

\[
\begin{array}{c}
\text{R} \\
\text{N}
\end{array}
\]
\[
\begin{array}{c}
\text{R} \\
\text{N}
\end{array}
\]
\[
\begin{array}{c}
\text{R'} \\
\text{NR''R''''}
\end{array}
\]

or a salt thereof,

wherein

\( R \) represents hydrogen (except when \( R' = H \)), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH\(_2\))\(_n\)-aryl;

\( R' \) represents hydrogen (except when \( R = H \)), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH\(_2\))\(_n\)-aryl;

\( R'' \) represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH\(_2\))\(_n\)-aryl;

\( R''' \) represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH\(_2\))\(_n\)-aryl;

\( R' \) and \( R''' \) can also together form a substituted or unsubstituted heterocyclic ring or heterocyclic rings;

and \( n \) is a number in the range of from 0 to 10.

2. A compound according to claim 1, having the structure:

\[
\begin{array}{c}
\text{R} \\
\text{N}
\end{array}
\]
\[
\begin{array}{c}
\text{R} \\
\text{N}
\end{array}
\]
\[
\begin{array}{c}
\text{R'} \\
\text{NR''R''''}
\end{array}
\]

\( X \) is

25
or a salt thereof,

wherein

R represents hydrogen (except when R'=H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl;

R' represents hydrogen (except when R=H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl;

R" represents hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl;

R"" represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl;

X represents oxygen, sulfur or selenium;

and n is a number in the range of from 0 to 10.

3. A compound according to claim 1, having the structure:

```
R

N

N

R"R""

```

or a salt thereof,

wherein

R represents hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl;

R" represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl;

R"" represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl; and

n is a number in the range of from 0 to 10.
4. A compound according to claim 1, having the structure:

![Chemical structure diagram]

or a salt thereof,

wherein

R' represents hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl;

R'' represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl,

(substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl;

R''' represents hydrogen, acyl, thio-acyl, seleno-acyl, (substituted) alkyl,

(substituted) alkenyl, (substituted) alkynyl, or (substituted) -(CH₂)ₙ-aryl; and n is a number in the range of from 0 to 10.

5. The compound according to any one of claims 1, 2 or 4, having the structure:

![Chemical structure diagram]

or a salt thereof,

wherein
R represents hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) (CH₂)n-aryl;
R' represents hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, (substituted) (CH₂)n-aryl, alkoxy, thioalkyl, halo, NR₁R₂, NR₃COR₄, or NR₅CONR₆R₇;
R" represents hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, (substituted) (CH₂)n-aryl, alkoxy, thioalkyl, halo, NR₁R₂, NR₃COR₄, or NR₅CONR₆R₇; wherein R₁, R₂, R₃, R₄, R₅, R₆ and R₇ are independently selected from hydrogen, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl, or (substituted) (CH₂)n-aryl; and whereby when R₁ and R₂ are in a NR₁R₂ or when R₆ and R₇ are in a NR₅R₇ R₁ and R₂ may be linked to form a heterocyclic group, and R₆ and R₇ may be linked to form a heterocyclic group; X represents oxygen, sulfur or selenium; and n is a number in the range of from 0 to 10.

6. A compound according to any one of claims 1-5, which compound is selected from the group consisting of N-(2,6-diphenyl-pyrimidin-4-y1)-benzamide, N-(2,6-diphenyl-pyrimidin-4-y1)-4-methoxy-benzamide, N-(2,6-diphenyl-pyrimidin-4-y1)-formamide, N-(2,6-diphenyl-pyrimidin-4-y1)-acetamide, N-(2,6-diphenyl-pyrimidin-4-y1)-propionamide, N-(2,6-diphenyl-pyrimidin-4-y1)-butyramide, N-(2,6-diphenyl-pyrimidin-4-y1)-isobutyramide, N-(2,6-diphenyl-pyrimidin-4-y1)-3-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-y1)-2-ethyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-y1)-2-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-y1)-2,2-dimethyl-propionamide, N-(2,6-diphenyl-pyrimidin-4-y1)-3,3-dimethyl-butyramide, cyclopropanecarboxylic acid (2,6-diphenyl-pyrimidin-4-y1)-amide, cyclobutanecarboxylic acid (2,6-diphenyl-pyrimidin-4-y1)-amide, cyclopentanecarboxylic acid (2,6-diphenyl-pyrimidin-4-y1)-amide, cyclohexanecarboxylic acid (2,6-diphenyl-pyrimidin-4-y1)-amide or a salt thereof.
7. A compound according to claim 6, wherein the compound is selected from the group consisting of N-(2,6-diphenyl-pyrimidin-4-yl)-propionamide, N-(2,6-diphenyl-pyrimidin-4-yl)-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-isobutyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-3-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2-ethyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2,2-dimethyl-propionamide, N-(2,6-diphenyl-pyrimidin-4-yl)-3,3-dimethyl-butyramide, cyclopentanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide, cyclohexanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide or a salt thereof.

8. A compound according to claim 6, which compound comprises N-(2,6-diphenyl-pyrimidin-4-yl)-2-methyl-butyramide, N-(2,6-diphenyl-pyrimidin-4-yl)-2,2-dimethyl-propionamide, or cyclopentanecarboxylic acid (2,6-diphenyl-pyrimidin-4-yl)-amide.

9. A process for preparing a compound according to any one of claims 1-8, which process comprises the steps of:
(a) reacting a compound having the structure of $\text{RCOCH}_2\text{COOA}$, wherein $A$ represents (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH$_2$)$_n$-aryl, wherein $n$ is a number in the range of from 0 to 10, with a compound consisting of structure $\text{R'C(NH)NH}_2$, or a salt thereof, to form a product having the structure

![Chemical Structure](image-url)
or its tautomer, wherein R represents hydrogen (except when R' = H),
(substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted)
-(CH₂)n-aryl; R' represents hydrogen (except when R = H), (substituted) alkyl,
(substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)n-aryl; and

wherein n has the meaning as defined hereinbefore;

(b) subjecting the product formed in step (a) to a treatment wherein the
oxygen atom is replaced by a chlorine atom to form a product having the

\[
\begin{array}{c}
\text{R} \\
\text{N} \\
\text{N} \\
\text{Cl} \\
\text{R'} \\
\end{array}
\]

structure

10 (c) reacting the product formed in step (b) with ammonia to form a product
having structure

\[
\begin{array}{c}
\text{R} \\
\text{N} \\
\text{N} \\
\text{NH₂} \\
\text{R'} \\
\end{array}
\]

(d) reacting the product formed in step (c) with a compound having the
structure of R"aldehyde, R"halide, or R"carboxylic acid or a derivative thereof,

15 to form a product having the structure

\[
\begin{array}{c}
\text{R} \\
\text{N} \\
\text{N} \\
\text{NH} \\
\text{R'} \\
\text{R''} \\
\end{array}
\]
wherein R'' represents, acyl, (substituted) alkyl, (substituted) alkenyl,
(substituted) alkynyl, or (substituted) -(CH)_n-aryl, wherein n has the meaning
as defined herein before; and
5 (e) reacting the product formed in step (c) with a compound having the
structure of R''aldehyde, R''halide or R''carboxylic acid or a derivative thereof,
to form a product having the structure

\[
\begin{align*}
\text{N} & \quad \text{N} \\
\text{R'} & \quad \text{R''} \\
\end{align*}
\]

wherein R''' represents, acyl, (substituted) alkyl, (substituted) alkenyl,
(substituted) alkynyl, or (substituted) -(CH)_n-aryl, and wherein n has the
10 meaning as defined hereinbefore.

10. A process for preparing a compound according to any one of claims 1-8,
which process comprises the steps of:
(a) reacting a compound having the structure of RCOCH_2COOA, wherein A
15 represents (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or
(substituted) -(CH)_n-aryl, wherein n is a number in the range of from 0 to 10,
with a compound consisting of structure R'C(NH)NH_2, or a salt thereof, to form
a product having the structure

\[
\begin{align*}
\text{R} & \\
\text{R'} & \quad \text{N} \\
\end{align*}
\]

20
or its tautomer, wherein R represents hydrogen (except when R' = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)ₙ-aryl; R' represents hydrogen (except when R = H), (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)ₙ-aryl; and wherein n has the meaning as defined hereinbefore;

(b) subjecting the product formed in step (a) to a treatment wherein the oxygen atom is replaced by a chlorine atom to form a product having the structure

![Structure Image]

(c) reacting the product formed in step (b) with a compound having the structure R"NH₂ to form a product having structure

![Structure Image]

wherein R" represents (substituted) alkyl, (substituted) alkenyl, substituted alkynyl or (substituted) -(CH₂)ₙ-aryl, wherein n has the meaning as defined hereinbefore; and

(d) reacting the product formed in step (c) with a compound having the structure of R"aldehyde, R"halide, or R"carboxylic acid or derivative thereof, to form a product having the structure

![Structure Image]
wherein R" represents acyl, (substituted) alkyl, (substituted) alkenyl, (substituted) alkynyl or (substituted) -(CH₂)n-aryl, and wherein n has the meaning as defined hereinbefore.

11. A pharmaceutical composition comprising as active ingredient one or more compounds according to any one of claims 1-8.

12. The use of a compound according to any one of claims 1-8 for treating and/or preventing a disorder in which the adenosine receptors are involved.

13. The use of a compound according to any one of claims 1-8 for treating and/or preventing a disorder in which the adenosine receptors are blocked.

14. The use of a compound according to any one of claims 1-8 for the manufacture of a medicament for the treatment and/or prevention of a disorder in which the adenosine receptors are involved.

15. The use of a compound according to any one of claims 1-8 for the manufacture of a medicament for the treatment and/or prevention of a disorder in which the adenosine receptors are blocked.

16. The use according to claims 12 - 15, wherein the disorder is chosen from the group of diseases consisting of amongst others cardiovascular, neurological, immunological disorders, cancers and infection conditions.

17. The use according to claims 12 - 16, wherein the disorder is chosen from the group of diseases consisting of kidney, heart and central nervous system (CNS) afflictions.
18. A method for treating and/or preventing a disorder in which the interaction with the adenosine receptors is beneficial which method comprises administering to a subject in need of such treatment an effective dose of a pharmaceutical composition according to claim 11.

19. The method according to claim 18, wherein the disorder is chosen from the group of diseases consisting of amongst others cardiovascular, neurological, immunological disorders, cancers and infection conditions.

20. The method according to claim 19, wherein the disorder is chosen from the group of diseases consisting of kidney, heart and central nervous system (CNS) afflictions.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C07D239/42 A61K31/505 A61P9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C07D A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, CHEM ABS Data, WPI Data, BEILSTEIN Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 6 586 441 B2 (BORRONI EDILIO MAURIZIO ET AL) 1 July 2003 (2003-07-01) column 1, line 14 - column 3, line 32</td>
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<td>A</td>
<td>WO 03/035639 A (KABASAWA YASUHIRO; ASANO OSAMU (JP); UEDA MASATO (JP); EISAÏ CO LTD () 1 May 2003 (2003-05-01) claim 1</td>
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

Special categories of cited documents:
*A* document defining the general state of the art which is not considered to be of particular relevance
*E* earlier document but published on or after the international filing date
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
*O* document referring to an oral disclosure, use, exhibition or other means
*P* document published prior to the international filing date but later than the priority date claimed
*O* document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*O* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
*Z* document member of the same patent family

Date of the actual completion of the international search: 16 December 2004

Date of mailing of the international search report: 27/12/2004

Name and mailing address of the ISA
European Patent Office, P.B. 5816 Patentlaan 2 NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016

Authorized officer
Usueilli, A
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| P,A      | & EP 1 439 175 A (EISAI CO LTD)  
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& J. BIOL. CHEM.,  
vol. 3, 1907, page 288, | 1                     |
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BEILSTEIN INSTITUTE FOR ORGANIC CHEMISTRY,  
FRANKFURT–MAIN, DE;  
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& J. AMER. CHEM. SOC.,  
vol. 79, 1957, page 2230, | 1                     |
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XP002309854  
Database accession no. BRN: 165376  
abstract  
& BULL. SOC. CHIM. FR., 1971, page 1858, | 1                     |
**INTERNATIONAL SEARCH REPORT**

**Box II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. **X** Claims Nos.; because they relate to subject matter not required to be searched by this Authority, namely:

   Although claims 12,13,18-20 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compounds.

2. **☐** Claims Nos.; because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. **☐** Claims Nos.; because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. **☐** As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. **☐** As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. **☐** As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. **☐** No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- **☐** The additional search fees were accompanied by the applicant's protest.
- **☐** No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2004)
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