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(54) Title: CHROMENE DERIVATIVES AS PHOSHOINOSITIDE 3-KINASES INHIBITORS

(57) Abstract: The invention relates to compounds inhibiting phosphoinositide 3-kinases (PI3K), to pharmaceutical compositions comprising them and therapeutic use thereof in the treatment of disorders associated with PI3K enzymes.



CHROMENE DERIVATIVES AS PHOSHOINOSITIDE 3-KINASES INHIBITORS

FIELD OF THE INVENTION

The present invention relates to compounds inhibiting Phosphoinositide 3-kinases (hereinafter PI3K); particularly the invention relates to compounds that are chromene derivatives, methods of preparing such compounds, pharmaceutical
5 compositions containing them and therapeutic use thereof.

More particularly, the compounds of the invention are inhibitors of the activity or function of the Class I of PI3K and more specifically, they are inhibitors of the activity or function of PI3K α , PI3K β , PI3K δ and/or PI3K γ isoforms of the Class I PI3K.

10 Therefore, the compounds of the invention may be useful in the treatment of many disorders associated with PI3K enzymes mechanisms, such as respiratory diseases including asthma, chronic obstructive pulmonary disease (COPD) and cough; allergic diseases including allergic rhinitis and atopic dermatitis; autoimmune diseases including rheumatoid arthritis and multiple sclerosis; inflammatory disorders including
15 inflammatory bowel disease; cardiovascular diseases including thrombosis and atherosclerosis; hematologic malignancies; cystic fibrosis; neurodegenerative diseases; pancreatitis; multiorgan failure; kidney diseases; platelet aggregation; cancer; sperm motility; organ transplantation and in particular in transplant rejection; graft rejection; lung injuries; and pain including pain associated with rheumatoid arthritis or
20 osteoarthritis, back pain, general inflammatory pain, post hepatic neuralgia, diabetic neuropathy, inflammatory neuropathic pain, trigeminal neuralgia, and central pain.

BACKGROUND OF THE INVENTION

In biochemistry, a kinase is a type of enzyme that transfers phosphate groups from high-energy donor molecules, such as ATP, to specific substrates, a process
25 referred to as phosphorylation. Specifically, PI3K enzymes are lipid enzyme kinases

that can phosphorylate Phosphoinositides (PIs) at the 3'-hydroxyl group of the inositol ring (Panayotou et al, Trends Cell Biol 2:358-60 (1992)). It is well known that PIs, localised in the plasma membranes, can act as second messengers in signaling cascades by docking proteins containing pleckstrin-homology (PH), FYVE, PX and other phospholipid-binding domains (Vanhaesebroeck B et al, Annu. Rev. Biochem 70, 535-602, 2001; Katso R et al, Annu. Rev. Cell Dev. Biol. 17, 615-675, 2001).

Therefore, PIs can act as second messengers in many cellular processes including signal transduction, regulation of membrane trafficking and transport, cytoskeleton organization, cell survival and death, and many other functions.

PIs may be bound to the lipid bilayer of the cell membrane via two fatty acids that are attached to the cytosolic inositol ring via a glycerol phosphate linker. PIs inositol ring can be phosphorylated by PI3K enzymes, leading to the regulation of cellular growth, survival and proliferation. For this reason, PIs phosphorylation by PI3K enzymes is one of the most relevant signal transduction events associated with mammalian cell surface receptor activation (Cantley LC, Science 296, 1655-7, 2002; Vanhaesebroeck B et al, Annu. Rev. Biochem 70, 535-602, 2001).

The PI3K enzymes have been divided into three classes: Class I PI3K, Class II PI3K and Class III PI3K, on the basis of sequence homology, structure, binding partners, mode of activation, and substrate preference (Vanhaesebroeck B et al, Exp. Cell Res. 253(1), 239-54, 1999; and Leslie NR et al, Chem. Rev. 101(8), 2365-80, 2001).

Class I PI3K convert phosphoinositide-(4,5)-diphosphate (PI(4,5)P₂) to phosphoinositide-(3,4,5)-triphosphate (PI(3,4,5)P₃), which functions as a second messenger. The signaling cascade activated by the increase in intracellular levels of PI(3,4,5)P₃ is negatively regulated through the action of 5'-specific and 3'-specific phosphatases (Vanhaesebroeck B et al., Trends Biochem. Sci. 22(7), 267-72, 1997; Katso R et al, Annu. Rev. Cell Dev. Biol. 17, 615-75, 2001; and Toker A, Cell. Mol. Life Sci. 59(5), 761-79, 2002).

Class II PI3K enzymes are the most recently identified class of PI3K and their exact function is still unclear.

Class III PI3K enzymes consists of a single family member which is structurally related to Class I PI3K enzymes and appears to be important in endocytosis and vesicular trafficking. However, there are some evidences showing that Class III PI3K may be relevant in immune cell processes, such as phagocytosis and Toll-like receptor (TLR) signalling.

Class I PI3K enzymes can be further divided in class IA and class IB on the basis of their activation mechanisms.

In more detail, Class IA PI3K enzymes comprises three closely related isoforms: PI3K α , PI3K β and PI3K δ , while Class IB comprises only the PI3K γ isoform. These enzymes are heterodimers composed of a catalytic subunit known as p110, with four types: alpha (α), beta (β), delta (δ) and gamma (γ) isoforms, constitutively associated with a regulatory subunit. The first two p110 isoforms (α and β) are ubiquitously expressed and involved in cellular differentiation and proliferation. Consequently, PI3K α and PI3K β enzymes have been extensively studied as targets for the development of new chemotherapeutic agents.

Otherwise, p110 δ and p110 γ isoforms are mainly expressed in leukocytes and are important in the activation of the immune response, such as leukocytes migration, B and T cells activation and mast cells degranulation. Therefore, PI3K δ and PI3K γ isoforms are very relevant in inflammatory respiratory diseases.

Presently, the inhibitors derivatives of PI3K enzymes known in the art could generally inhibit said isoforms (alpha α , beta β , delta δ and gamma γ isoforms) and they could act on the individual roles played in various diseases by said specific isoforms.

Therefore, specific activity assays of Class IA inhibitors for one specific PI3K α , PI3K β , PI3K δ and PI3K γ isoform over another have been extensively developed in order to discern the suitable profile for the treatment of disorders

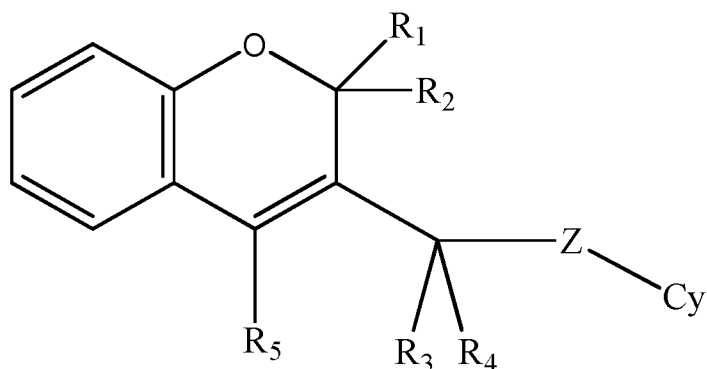
associated with PI3K enzymes mechanisms. Such disorders could, for example, include respiratory diseases selected from idiopathic chronic cough, cough-variant asthma, cough associated with thoracic tumour or lung cancer, viral or post-viral cough, upper airways cough syndrome (UACS) or post nasal drip cough, or cough
5 associated with gastro-oesophageal reflux disease both acid and non acid, asthma, chronic bronchitis, chronic obstructive pulmonary disease (COPD), interstitial lung disease, idiopathic pulmonary fibrosis (IPF), congestive heart disease, sarcoidosis, infections (such as whooping cough), viral infections including viral respiratory tract infections and viral exacerbation of respiratory diseases; non-viral respiratory
10 infections including aspergillosis and leishmaniasis; allergic diseases including allergic rhinitis and atopic dermatitis; autoimmune diseases including rheumatoid arthritis and multiple sclerosis; inflammatory disorders including inflammatory bowel disease; cardiovascular diseases including thrombosis and atherosclerosis; hematologic malignancies; neurodegenerative diseases; pancreatitis; multiorgan
15 failure; kidney diseases; platelet aggregation; cancer; sperm motility; transplantation rejection; graft rejection; lung injuries; and pain including pain associated with rheumatoid arthritis or osteoarthritis, back pain, general inflammatory pain, post hepatic neuralgia, diabetic neuropathy, inflammatory neuropathic pain (trauma), trigeminal neuralgia and central pain.

20 In view of the number of pathological responses which are mediated by PI3K enzymes, there is a continuing need for inhibitors of PI3K enzymes which can be useful in the treatment of many disorders. Thus, the present invention relates to novel compounds which are inhibitors of PI3K α , PI3K β , PI3K δ and PI3K γ isoforms of Class I PI3K enzymes that, for the above reasons, may often have therapeutically desirable
25 characteristics.

Particularly, compounds of the invention may have much more selectivity for the δ isoform or for both the γ and the δ isoforms of PI3K enzyme over other isoforms of the same enzyme.

SUMMARY OF THE INVENTION

The present invention is directed to compounds of formula (I)



(I)

wherein R₁, R₂, R₃, R₄, R₅, CY, Z are as reported below in the detailed description of the invention, acting as inhibitors of phosphoinositide 3- kinases, to processes for the preparation thereof, pharmaceutical compositions comprising them either alone or in combination with one or more active ingredient, in admixture with one or more pharmaceutically acceptable carrier.

The invention further provides a suitable device for the delivery of a pharmaceutical composition of a compound of the invention.

In one aspect the present invention provides the use of a compound of the invention for the manufacture of a medicament.

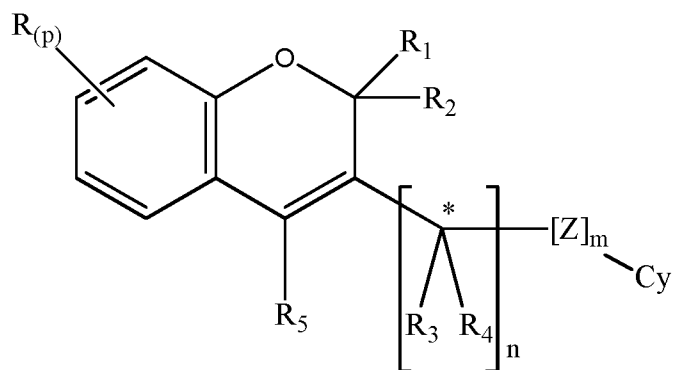
In a further aspect the present invention provides the use of a compound of the invention for the preparation of a medicament for the prevention and/or treatment of any disease characterized by phosphoinositide-3-kinase (PI3K) enzyme overactivity and/or wherein an inhibition of PI3K activity is desirable and in particular through the selective inhibition of the delta or of both the delta and the gamma enzyme isoforms over the alfa and beta ones.

Moreover the present invention provides a method for prevention and/or treatment of any disease wherein a PI3K enzyme inhibition is desirable, said method comprises administering to a patient in need of such treatment a therapeutically

effective amount of a compound of the invention.

In particular the compounds of the invention alone or combined with other active ingredients may be administered for the prevention and/or treatment of a disease of the respiratory tract characterized by inflammatory airway obstruction such as, for example, cough, asthma, COPD and IPF.

It is understood that the compounds according to the invention fall in the more general formula:



(A)

wherein m is zero or 1; n is 1; p is zero;

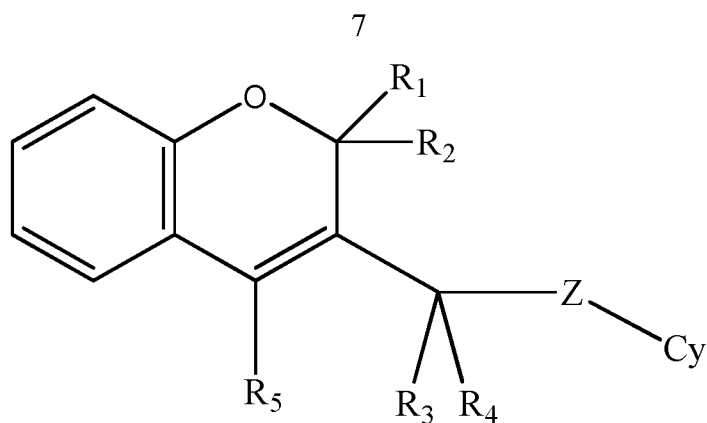
Compounds falling in such broader formula are known in the art for example in the International patent Application WO 2014/164942 and in the US patent Application 2014/0005247.

DETAILED DESCRIPTION OF THE INVENTION

The invention is directed to a class of compounds acting as inhibitors of Phosphoinositide 3 Kinases (PI3K).

Said class of compounds inhibits the activity or function of the Class I of PI3K and more specifically, they are inhibitors derivatives of the activity or function of PI3K α , PI3K β , PI3K γ , and/or PI3K δ isoforms of the Class I PI3K.

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



(I)

wherein:

R₁ and R₂ are both H or are combined to form an oxo group (=O);

5 R₃ and R₄, the same or different, in each occurrence are independently selected from the group consisting of H, (C₁-C₆) alkyl and (C₁-C₆) haloalkyl;

R₅ is selected from the group consisting of substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl;

Z is absent or NH;

10 Cy is selected from the group consisting of substituted or unsubstituted heteroaryl;

or pharmaceutically acceptable salts thereof.

The term “pharmaceutically acceptable salts”, as used herein, refers to derivatives of compounds of formula (I) wherein the parent compound is suitably
15 modified by converting any of the free acid or basic group, if present, into the corresponding addition salt with any base or acid conventionally intended as being pharmaceutically acceptable.

Suitable examples of said salts may thus include mineral or organic acid addition salts of basic residues such as amino groups, as well as mineral or organic
20 basic addition salts of acid residues such as carboxylic groups.

Cations of inorganic bases which can be suitably used to prepare salts within the invention comprise ions of alkali or alkaline earth metals such as potassium, sodium, calcium or magnesium.

Those obtained by reacting the main compound, functioning as a base, with an inorganic or organic acid to form a salt comprise, for example, salts of hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, methane sulfonic acid, camphor sulfonic acid, acetic acid, oxalic acid, maleic acid, fumaric acid, succinic acid and citric acid.

DEFINITIONS

The term “halogen atoms” as used herein includes fluorine, chlorine, bromine, and iodine, preferably chlorine or fluorine.

The term “(C₁-C_x) alkyl” where x is an integer greater than 1, refers to straight-chained or branched-chained alkyl groups wherein the number of constituent carbon atoms is in the range 1 to x. Particularly preferred alkyl groups are methyl, ethyl, n-propyl, isopropyl, and tert-butyl.

The expressions “(C₁-C_x) haloalkyl” refer to the above defined “(C₁-C_x)alkyl” groups wherein one or more hydrogen atoms are replaced by one or more halogen atoms, which can be the same or different from each other.

Examples of said (C₁-C_x) haloalkyl groups may thus include halogenated, poly-halogenated and fully halogenated alkyl groups, e.g. trifluoromethyl or difluoromethyl groups.

By way of analogy, the terms “(C₁-C_x) hydroxyalkyl” or “(C₁-C_x) aminoalkyl” refer to the above defined “(C₁-C_x) alkyl” groups wherein one or more hydrogen atoms are replaced by one or more hydroxy (OH) or amino group respectively.

In the present description, unless otherwise provided, the definition of aminoalkyl encompasses alkyl groups substituted by one or more amino groups -NR₁₀R₁₁.

With reference to the substituent R₁₀ and R₁₁ as below defined, it is here further explained that when either R₁₀ and R₁₁ are taken together with the nitrogen atom they are linked to form a 5 to 6 membered heterocyclic radical, at least one further ring carbon atom in the said heterocyclic radical may be replaced by at least one

heteroatom or hetero-group (e.g. N, NH, S or O) or may bear an -oxo (=O) substituent group. The said heterocyclic radical might be further optionally substituted on the available points in the ring, namely on a carbon atom, or on an heteroatom or hetero-group available for substitution. Thus, Examples of said heterocyclic radicals are 1-pyrrolidinyl, 1-piperidinyl, 1-piperazinyl, 4-morpholinyl, piperazin-4-yl-2-one, 4-methylpiperazine-1-yl and 3-(hydroxymethyl)azetidin-1-yl.

The term “(C₃-C_y)cycloalkyl”, where y is an integer greater than 3, refers to saturated cyclic hydrocarbon groups containing from 3 to y ring carbon atoms. Non limiting examples include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, and cycloheptyl.

The term “aryl(C₁-C_x)alkyl” refers to an aryl ring linked to a straight-chained or branched alkyl groups wherein the number of constituent carbon atoms is in the range 1 to x, e.g. phenylmethyl (i.e. benzyl), phenylethyl or phenylpropyl.

The derived expression “(C₃-C_z)heterocycloalkyl” refers to saturated or partially unsaturated mono-, bi- or tri-cyclic (C₃-C_z)cycloalkyl groups, wherein z is an integer greater than 3, preferably from 5 to 11 ring atoms in which at least one ring carbon atom is replaced by at least one heteroatom or hetero-group (e.g. N, NH, S or O); included in the definition are bridged mono-, bi- or tri-cyclic ring systems. Non limiting examples of (C₃-C_z) heterocycloalkyl are represented by: pyrrolidinyl, imidazolidinyl, thiazolidinyl, piperazinyl, piperidinyl, morpholinyl, thiomorpholinyl, dihydro- or tetrahydro-pyridinyl, tetrahydropyranyl, pyranyl, 2H- or 4H-pyranyl, dihydro- or tetrahydrofuranlyl, 1,3-dioxolan-2-yl, 8-azabicyclo[3.2.1]oct-2-en-3-yl radicals and the like. (C₃-C_z)heterocycloalkyl groups, as above defined, might be optionally further substituted on the available points in the ring, namely on a carbon atom, or on an heteroatom or hetero-group available for substitution. For example, tetrahydro-pyridinyl groups, when further substituted, might be substituted on the -NH group such as in the following examples: 1-benzyl-1,2,3,6-tetrahydropyridin-4-yl, 1-(cyclopropylmethyl)-1,2,3,6-tetrahydropyridin-4-yl, 1-acetyl-1,2,3,6-

tetrahydropyridin-4-yl, 1-(pyridin-4-ylmethyl)-1,2,3,6-tetrahydropyridin-4-yl;

The term “(C₂-C_x)alkenyl” refers to straight or branched, conjugated or not conjugated, carbon chains with one or more double bonds, in cis or trans configuration, wherein the number atoms is in the range 2 to x.

5 By way of analogy, the terms “(C₅-C_y) cycloalkenyl”, where y is an integer greater than 5, refers to cyclic hydrocarbon groups containing from 5 to y ring carbon atoms and one or two double bonds, wherein the cycloalkenyl might be further optionally substituted by one or more groups, e.g. by amino groups.

The term “(C₂-C_x)alkynyl” refers to straight or branched carbon chains with one
10 or more triple bonds wherein the number atoms is in the range 2 to x.

By way of analogy, the term “(C₂-C_x) aminoalkynyl” refer to the above defined “(C₂-C_x) alkynyl” groups wherein one or more hydrogen atoms are replaced by one or more amino group and wherein the amino group might be further optionally substituted by one or more (C₁-C₆) alkyl groups.

15 The expression “aryl” refers to mono, bi- or tri-cyclic ring systems which have 6 to 20, preferably from 6 to 15 ring atoms, wherein at least one ring is aromatic.

The expression “heteroaryl” refers to mono-, bi- or tri-cyclic ring systems with 5 to 20, preferably from 5 to 15 ring atoms, in which at least one ring is aromatic and in which at least one ring atom is a heteroatom or heteroaromatic group (e.g. N, NH,
20 S or O).

Examples of suitable aryl or heteroaryl monocyclic ring systems include, for instance, phenyl, thienyl (herein also named thiophen-yl or thiophen-yl), pyrrolyl, pyrazolyl, imidazolyl, isoxazolyl, oxazolyl, isothiazolyl, thiazolyl, pyridinyl, pyrimidinyl, pyrazinyl, furanyl radicals and the like.

25 Examples of suitable aryl or heteroaryl bicyclic ring systems include naphthalenyl, biphenylenyl, purinyl, pteridinyl, pyrazolopyrimidinyl, benzotriazolyl, quinolinyl, isoquinolinyl, indolyl, isoindolyl, benzothiophenyl, benzodioxinyl, dihydrobenzodioxinyl, indenyl, dihydro-indenyl, dihydrobenzodioxepinyl,

benzooxazinyl radicals and the like.

Examples of suitable aryl or heteroaryl tricyclic ring systems include fluorenyl radicals as well as benzocondensed derivatives of the aforementioned heteroaryl bicyclic ring systems.

5 The term “(C₁-C_x) alkanoyl”, refers to alkylcarbonyl groups (e.g. (C₁-C_x)alkyl(CO) where x is an integer greater than 1) wherein the group “alkyl” has the meaning above defined. Non limiting examples include acetyl, propanoyl, butanoyl.

10 The expression “arylcarbonyl” refers to aryl-(CO)- groups wherein the group “aryl” has the meaning above defined. Non limiting example is represented by benzoyl.

15 The term “aryl (C₂-C_x) alkanoyl” refers to an aryl(C₂-C_x)alkylcarbonyl group where x is an integer greater than 2 wherein aryl and alkyl have the meaning above defined. Non limiting examples are represented by phenylacetyl, phenylpropanoyl or phenylbutanoyl radicals;

By way of analogy the expressions “aryl(C₁-C_x)alkyl”, “heteroaryl(C₁-C_x)alkyl” and“(C₃-C_y)cycloalkyl(C₁-C_x)alkyl” refer to a “(C₁-C_x)alkyl” respectively substituted by one or more aryl, heteroaryl or (C₃-C_y)cycloalkyl groups, as defined above.

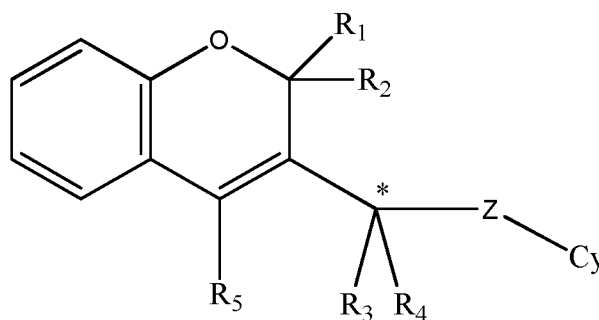
20 Examples of e.g aryl(C₁-C₆)alkyl include phenylmethyl herein also named benzyl. Examples of e.g heteroaryl(C₁-C₆)alkyl include pyridin-4-ylmethyl. Examples of e.g. (C₃-C₇)cycloalkyl(C₁-C₆)alkyl include cyclopropylmethyl.

25 As used herein, the expression “ring system” refers to mono- or bicyclic ring systems which may be saturated, partially unsaturated or unsaturated, such as aryl, (C₃-C₇) cycloalkyl, (C₃-C₆) heterocycloalkyl or heteroaryl.

As used herein an oxo moiety is represented by (O) as an alternative to the other common representation, e.g. (=O). Thus, in terms of general formula, the carbonyl group is herein preferably represented as C(O) as an alternative to the other common

representations such as CO, (CO) or C(=O). In general the bracketed group is a lateral group, not included into the chain, and brackets are used, when deemed useful, to help disambiguating linear chemical formulas; e.g. the sulfonyl group -SO₂- might be also represented as -S(O)₂- to disambiguate e.g. with respect to the sulfinic group -S(O)O-.

5 It will be apparent to those skilled in the art that compounds of formula (I) can contain at least one stereogenic center when R₃ and R₄ are different, namely represented in formula (IA) by the carbon atom (*) with an asterisk, and therefore may exist as optical stereoisomers.



10

(IA)

Where the compounds according to the invention have such at least one stereogenic center, they may accordingly exist as enantiomers. Where the compounds according to the invention possess two or more stereogenic centers, they may additionally exist as diastereoisomers. It is to be understood that all such single enantiomers, diastereoisomers and mixtures thereof in any proportion are encompassed within the scope of the present invention. The absolute configuration (R) or (S) for carbon (*), when it is a stereogenic center, is assigned on the basis of Cahn-Ingold-Prelog nomenclature rules based on groups' priorities.

20 Atropisomers are stereoisomers resulting from hindered rotation about single bonds where the steric strain barrier to rotation is high enough to allow for the isolation of the conformers (Bringmann G et al, Angew. Chemie Int. Ed. 44 (34), 5384–5427, 2005).

Oki defined atropisomers as conformers that interconvert with a half-life of

more than 1000 seconds at a given temperature (Oki M, Topics in Stereochemistry 14, 1-82, 1983).

Atropisomers differ from other chiral compounds in that in many cases they can be equilibrated thermally whereas in the other forms of chirality isomerization is usually only possible chemically.

Separation of atropisomers is possible by chiral resolution methods such as selective crystallization. In an atropo-enantioselective or atroposelective synthesis one atropisomer is formed at the expense of the other. Atroposelective synthesis may be carried out by use of chiral auxiliaries like a Corey Bakshi Shibata (CBS) catalyst, an asymmetric catalyst derived from proline, or by approaches based on thermodynamic equilibration when an isomerization reaction favors one atropisomer over the other.

Racemic forms of compounds of formula (I) as well as the individual atropisomers (substantially free of its corresponding enantiomer) and stereoisomer-enriched atropisomers mixtures are included in the scope of the present invention.

In a preferred embodiment, the present invention is directed to compounds of formula (IA) as above defined wherein R_3 has the same meaning as above except H, R_4 is H and the absolute configuration of the chiral carbon (*) is (R).

In another embodiment the preferred configuration of the carbon (*) is (S).

In a preferred embodiment, the compounds of formula (I) described in the present invention are present as mixtures of enantiomers and/or diastereoisomers in any proportion.

A first preferred group of compounds is that of formula (I) wherein:

R_1 and R_2 are both H or are combined to form an oxo group (=O);

R_3 is selected from H and (C₁-C₆) alkyl;

R_4 is H;

R_5 is selected from substituted or unsubstituted aryl and substituted or unsubstituted heteroaryl;

Z and Cy are as defined above.

A more preferred group of compounds is that of formula (I) wherein:

R₁ and R₂ are both H or are combined to form an oxo group (=O);

R₃ is selected from H, methyl, ethyl and propyl;

5 R₄ is H;

R₅ is selected from phenyl, 2-, 3- or 4-pyridinyl, 5-thiazolyl, 2-, 3-, 4- or 5-thienyl, 1H-pyrazol-4yl, 2-, 4-, 5- or 6- pyrimidinyl, all of which optionally substituted by one or more groups selected from (C₁-C₆) alkyl, (C₁-C₆) hydroxyalkyl, substituted or unsubstituted (C₁-C₆) aminoalkyl;;

10 Z and Cy are as defined above.

An even more preferred group of compounds is that of formula (I) wherein:

R₁ and R₂ are both H or combined to form an oxo group (=O);

R₃ is selected from H, methyl, ethyl, and propyl;

R₄ is H;

15 R₅ is selected from phenyl, 2-, 3-, 4- or 5-thienyl, all of which optionally substituted by one or more groups selected from piperazin-4-ylmethyl, (4-methylpiperazin-1-yl)methyl, piperidin-1-ylmethyl, hydroxymethyl, dimethylaminomethyl, and (3-(hydroxymethyl)azetidin-1-yl)methyl;

Z, and Cy are as defined above.

20 A second preferred group of compounds is that of formula (I) wherein:

R₁ and R₂ are both H or are combined to form an oxo group (=O);

R₃ is selected from H, methyl, ethyl and propyl;

R₄ is H;

25 R₅ is selected from substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl;

Z is absent (meaning Z is a bond) or a group NH;

Cy is an heteroaryl selected from the group of 9H-purin-6-yl, 1H-pyrazolo[3,4-d]pyrimidin-1-yl, 2-, 4-, 5- or 6-pyrimidinyl, which are all optionally substituted by

one or more groups selected from halogen, CN, NR₁₀R₁₁, optionally substituted aryl and optionally substituted heteroaryl selected from phenyl, 2-, 3-, 4-, 5-, 6-pyridinyl;

R₁₀, R₁₁ the same or different, are at each occurrence independently selected from the group consisting of H, (C₁-C₆) aminoalkyl, (C₁-C₆) hydroxyalkyl and (C₁-C₆) alkyl, or taken together with the nitrogen atom they are linked to, R₁₀ and R₁₁ may form a 5 to 6 membered heterocyclic radical;.

A second more preferred group of compounds is that of formula (I) wherein:

R₁ and R₂ are both H or combined to form an oxo group (=O);

R₃ is selected from H, methyl or ethyl;

10 R₄ is H;

R₅ is selected from an aryl which is phenyl, an heteroaryl selected from 2-, 3-, 4- or 5-thienyl, which are all optionally substituted by one or more groups selected from piperazinomethyl (4-methylpiperazin-1-yl)methyl, piperidin-1-ylmethyl, hydroxymethyl, dimethylaminomethyl and (3-(hydroxymethyl)azetidin-1-yl)methyl;

15 Z is absent or NH;

Cy is a heteroaryl selected from the group of 9H-purin-6-yl, 1H-pyrazolo[3,4-d]pyrimidin-1-yl, 2-, 4-, 5- or 6-pyrimidinyl; which are all optionally substituted by one or more groups selected from Cl, Br, F, I, CN; NH₂, aryl selected from 3-fluoro-5-hydroxyphenyl, 3-chloro-5-hydroxyphenyl and 3-cyano-5-hydroxyphenyl, heteroaryl selected from 6-, 5-, 4-hydroxypyridin-3-yl, (2,2,2-trifluoro-1-(pyridin-3-yl)ethanol)5yl.

A third more preferred group of compounds is that of formula (I) wherein

R₁ and R₂ are both H;

R₃ is selected from H, methyl or ethyl;

25 R₄ is H;

R₅ is selected from substituted or unsubstituted (C₃-C₆) heterocycloalkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl as above defined;

Z is absent;

Cy is 1H-pyrazolo[3,4-d]pyrimidin-1-yl, optionally and independently substituted by one or more groups selected from halogen, $\text{NR}_{10}\text{R}_{11}$, ($\text{C}_1\text{-C}_6$) alkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl as above defined;

5 or pharmaceutically acceptable salts or solvates thereof.

Even more preferred group of compounds is that of formula (I) wherein

R_1 and R_2 are both H;

R_3 is selected from H, methyl or ethyl;

R_4 is H;

10 R_5 is selected from the group of phenyl, 2-, 3-, 4- or 5-thienyl, which are all optionally substituted by one or more groups selected from substituted or unsubstituted ($\text{C}_1\text{-C}_6$) aminoalkyl,;

Z is absent;

15 Cy is 1H-pyrazolo[3,4-d]pyrimidin-1-yl, optionally substituted by one or more groups selected independently from halogen, $\text{NR}_{10}\text{R}_{11}$, phenyl and heteroaryl which is pyridinyl; said phenyl and heteroaryl in their turn further optionally and independently substituted by one or more groups selected from halogen, -OH, -CN; $\text{NR}_{10}\text{R}_{11}$ ($\text{C}_1\text{-C}_6$) -haloalkyl, ($\text{C}_1\text{-C}_6$) hydroxyalkyl;

R_{10} , R_{11} are as defined above;

20 or pharmaceutically acceptable salts or solvates thereof.

A fourth preferred group of compounds is that of formula (I) wherein:

R_1 and R_2 are both H or are combined to form an oxo group (=O);

R_3 is selected from H and $\text{C}_1\text{-C}_6$ alkyl;

R_4 is H;

25 R_5 is selected from substituted or unsubstituted aryl or substituted or unsubstituted heteroaryl;

Z is absent or NH;

Cy is substituted or unsubstituted heteroaryl.

A more preferred group of compounds is that of formula (I) wherein:

R₁ and R₂ are both H or are combined to form an oxo group (=O);

R₃ is selected from H and methyl;

R₄ is H;

5 R₅ is phenyl or thienyl; said phenyl or thienyl being optionally substituted by a group selected from substituted or unsubstituted (C₁-C₆) aminoalkyl, or (C₁-C₆) hydroxyalkyl;

Z is absent or NH;

Cy is an heteroaryl selected from the group consisting of 9H-purin-6-yl, 1H-pyrazolo[3,4-d]pyrimidin-1-yl and 2-, 4-, 5- or 6-pyrimidinyl, which are all optionally substituted by one, two or three groups selected from CN, NH₂, optionally substituted aryl and optionally substituted heteroaryl selected from 3-fluoro-5-hydroxyphenyl 3-chloro-5-hydroxyphenyl, 3-cyano-5-hydroxyphenyl, 3-hydroxy-5-pyridyl and (2,2,2-trifluoro-1-(pyridin-3-yl)ethanol)5yl;

15 According to specific embodiments, the present invention provides the compounds listed below:

3-((4-amino-3-(3-fluoro-5-hydroxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-1-yl)methyl)-4-phenyl-2H-chromen-2-one;

20 3-(1-(4-amino-3-(3-fluoro-5-hydroxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-4-phenyl-2H-chromen-2-one;

3-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol;

5-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-ol;

25 3-((9H-purin-6-ylamino)methyl)-4-phenyl-2H-chromen-2-one;

3-(1-(9H-purin-6-ylamino)ethyl)-4-phenyl-2H-chromen-2-one;

N-((4-phenyl-2H-chromen-3-yl)methyl)-9H-purin-6-amine;

4-amino-6-((4-phenyl-2H-chromen-3-yl)methylamino)pyrimidine-5-carbonitrile;

- 4-amino-6-(1-(4-phenyl-2H-chromen-3-yl)ethylamino)pyrimidine-5-carbonitrile;
1-(5-(4-amino-1-(1-(4-phenyl-2H-chromen-2-yl)ethyl)-1H-pyrazolo[3,4-
d]pyrimidin-3-yl)pyridin-3-yl)-2,2,2-trifluoroethan-1-ol;
3-(4-amino-1-(1-(4-phenyl-2H-chromen-2-yl)ethyl)-1H-pyrazolo[3,4-
5 d]pyrimidin-3-yl)-5-hydroxybenzonitrile;
3-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-
d]pyrimidin-3-yl)-5-chlorophenol;
3-(4-amino-1-(1-(4-(5-((4-methylpiperazin-1-yl)methyl)thiophen-2-yl)-2H-
chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol;
10 3-(4-amino-1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-
yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol;
3-(4-amino-1-(1-(4-(5-(hydroxymethyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-
1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol;
5-(4-amino-1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-
15 yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-ol
and pharmaceutical acceptable salts thereof.

The compounds of formula (I) including all the compounds here above listed can be generally prepared according to the procedure outlined in Schemes shown below using generally known methods.

- 20 In one embodiment of the present invention, according to SCHEME 1, compound (Va), wherein $R_1 = R_2 = R_3 = R_4 = H$, may be prepared from compound (II), such as for example commercially available chroman-4-one. Indeed, compound (II) may be converted into halogen derivative (IIIa), wherein $R_1 = R_2 = H$ (SCHEME 1, step 1), by halogenation-Vilsmeier reaction with an halogenating agents such as $POCl_3$
25 (Phosphorous oxychloride) in the presence of a suitable formamide such as DMF. Compound (IIIa) may be then converted into (IVa), wherein $R_1 = R_2 = H$, by cross-coupling reactions in the presence of a Palladium catalyst like Suzuki coupling with a suitable organoboron reagent (IXa) (SCHEME 1, step 2) and finally to compound (Va)

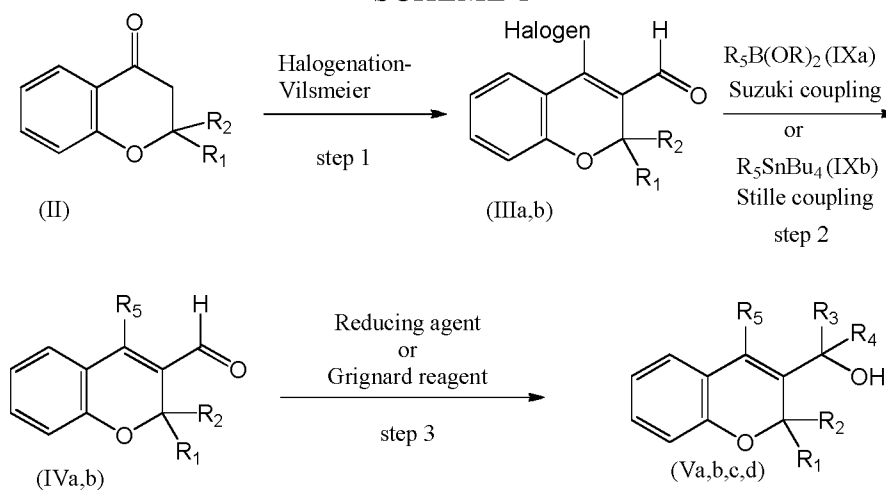
by reduction with an hydride reagent such as Sodium borohydride (SCHEME 1, step 3).

Similarly, compounds (Vb), wherein R_1 and R_2 are combined to form an oxo group ($=O$), $R_3 = R_4 = H$, can be prepared from compound (IIIb), wherein R_1 and R_2 are combined to form an oxo group ($=O$), such as for example commercially available 4-chloro-2-oxo-2H-chromene-3-carbaldehyde. Compound (IIIb) may be then converted into (IVb), wherein R_1 and R_2 are combined to form an oxo group ($=O$), by cross-coupling reactions in the presence of a Palladium catalyst like Stille coupling with an appropriate organostannane (IXb) (SCHEME 1, step 2) finally to compound (Vb) by reduction with an hydride reagent such as Sodium borohydride (SCHEME 1, step 3).

Compounds (Vc) wherein $R_1 = R_2 = R_3 = H$, $R_4 = Me$, can be prepared from compound (IVa), wherein $R_1 = R_2 = H$, by addition of a Grignard reagent like methylmagnesium bromide (SCHEME 1, step 3).

Similarly, compounds (Vd) wherein R_1 and R_2 are combined to form an oxo group ($=O$), $R_3 = H$, $R_4 = Me$ can be prepared from compound (IVb) wherein R_1 and R_2 are combined to form an oxo group ($=O$), by addition of a Grignard reagent such as methylmagnesium bromide (SCHEME 1, step 3).

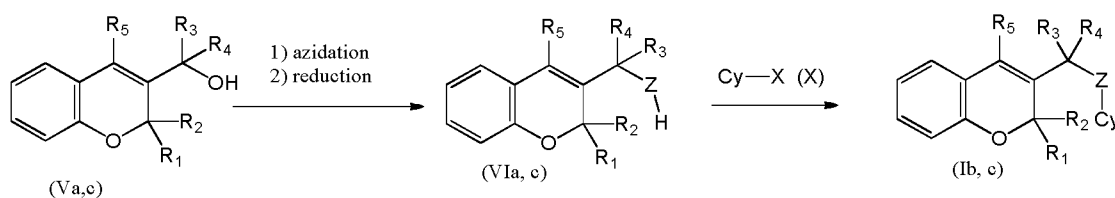
SCHEME 1



Compounds (Va), wherein $R_1 = R_2 = R_3 = R_4 = H$ and compounds (Vc), wherein

$R_1 = R_2 = R_3 = H$, $R_4 = Me$, may be then converted in (VIa), wherein $R_1 = R_2 = R_3 = R_4 = H$, $Z = NH$ and (VIc), wherein $R_1 = R_2 = R_3 = H$, $R_4 = Me$, $Z = NH$ by azidation reaction with DPPA (diphenylphosphorylazide) followed by reduction with a suitable reducing agent such as $LiAlH_4$ (SCHEME 2). Compounds (Ib), wherein $R_1 = R_2 = R_3 = R_4 = H$ and (Ic), wherein $R_1 = R_2 = R_3 = H$, $R_4 = Me$ were then prepared from compounds (VIa) and (VIc) by reaction with appropriate halogen-containing heterocycle (X) such 4-amino-6-chloropyrimidine-5-carbonitrile and 6-chloro-9H-purine in the presence of an appropriate base like DIEA (SCHEME 2). Following this synthetic route compounds 4-amino-6-((4-phenyl-2H-chromen-3-yl)methylamino)pyrimidine-5-carbonitrile (example 1), N-((4-phenyl-2H-chromen-3-yl)methyl)-9H-purin-6-amine (example 2), 4-amino-6-(1-(4-phenyl-2H-chromen-3-yl)ethylamino)pyrimidine-5-carbonitrile (example 3) were prepared.

SCHEME 2

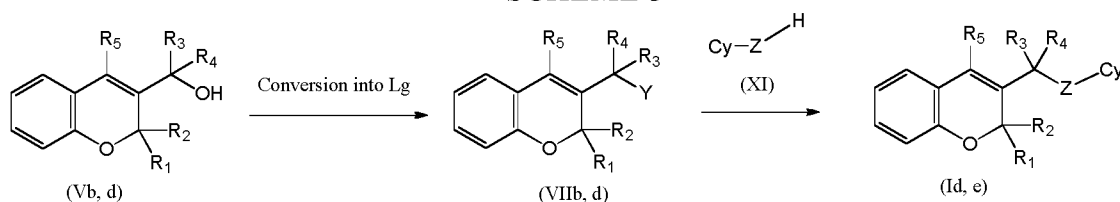


15

Compound (Id), wherein R_1 and R_2 are combined to form an oxo group ($=O$), $R_3 = R_4 = H$, $Z = NH$, and (Ie), wherein R_1 and R_2 are combined to form an oxo group ($=O$), $R_3 = H$, $R_4 = Me$, $Z = NH$, may be synthesized as outlined in Scheme 3 from compounds (Vb) and (Vd), that were converted into (VIIb) and (VIId), where the Y represents a leaving group (Lg) such as an halide atom, by reaction with a suitable halogenating agent such as PBr_3 , and finally reacted with a nitrogen based nucleophile (XI) in the presence of a base like NaH (sodium hydride) (SCHEME 3). Following this synthetic route compounds 3-((9H-purin-6-ylamino)methyl)-4-phenyl-2H-chromen-2-one (example 8) and 3-(1-(9H-purin-6-ylamino)ethyl)-4-phenyl-2H-chromen-2-one (example 9) were prepared.

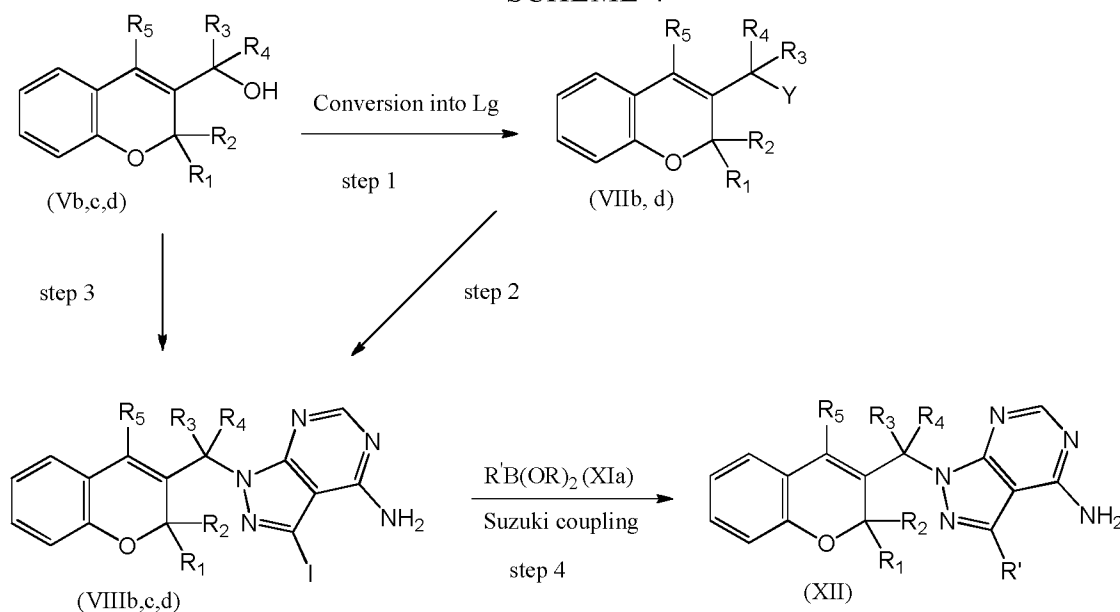
25

SCHEME 3



Compound VIIb, wherein R₁ and R₂ are combined to form an oxo group (=O) and R₃ = R₄ = H, Z is absent and compound VIIId, wherein R₁ and R₂ are combined to form an oxo group (=O), and R₃ = H, R₄ = Me, Z being absent can be synthesized as outlined in Scheme 4 from compounds (Vb) and (Vd), that were converted into (VIIb) and (VIIId), where the group Y represents a suitable leaving group such as a halide atom, by reaction with a suitable halogenating agent such as PBr₃ and then reacted with commercially available 3-iodo-1H-pyrazolo[3,4-d]pyrimidin-4-amine in the presence of a suitable base like K₂CO₃ (Scheme 4, step 1 and 2). Compound (VIIIc), wherein R₁ = R₂ = R₃ = H, R₄ = Me, Z being absent can be synthesized from compound (Vc), wherein R₁ = R₂ = R₃ = H, R₄ = Me, by Mitsunobu reaction with a dialkylazadicarboxylate like DIAD (diisopropylazodicarboxylate) in the presence of a phosphine such as PPh₃ (triphenylphosphine) and commercially available 3-iodo-1H-pyrazolo[3,4-d]pyrimidin-4-amine (SCHEME 4, step 3).

SCHEME 4



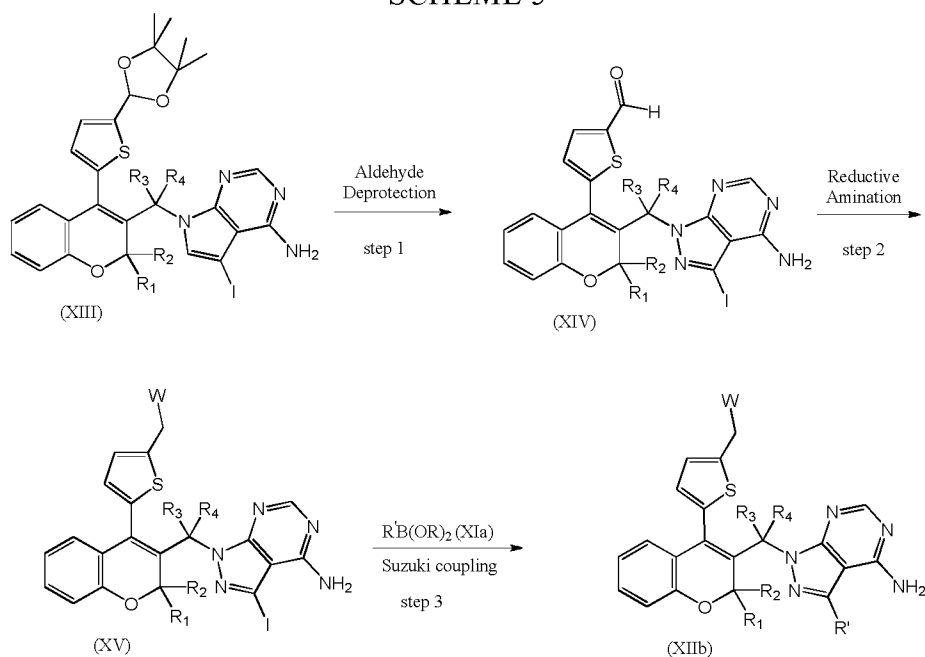
Compounds (VIIIb,c,d) can be further converted into compounds (XII) by

mean of a Suzuki coupling with a suitable organoboron reagent (XIa) (SCHEME 4, step 4).

Following this synthetic route compounds 3-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-chlorophenol (example 7c),
5 7c), 3-(4-amino-1-(1-(4-phenyl-2H-chromen-2-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-hydroxybenzonitrile (example 7b), 1-(5-(4-amino-1-(1-(4-phenyl-2H-chromen-2-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-yl)-2,2,2-trifluoroethan-1-ol (example 7a), 3-((4-amino-3-(3-fluoro-5-hydroxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-1-yl)methyl)-4-phenyl-2H-chromen-2-one (example 7), 3-(1-(4-
10 amino-3-(3-fluoro-5-hydroxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-4-phenyl-2H-chromen-2-one (example 6), 3-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol (example 4), 5-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-ol (example 5) were prepared.

15 In the particular case when R₅ is an heteroaromatic ring substituted with different moieties like for example the 4,4,5,5-tetramethyl-2-(thiophen-2-yl)-1,3-dioxolanyl moiety, compounds XIIb, wherein R₁ = R₂ = R₃ = H, R₄ = Me, Z being absent, can be prepared from compound XIII by a three step sequence (SCHEME 5). Compounds XIV can be prepared from compound XII by hydrolysis of the acetal
20 moiety by reaction with an aqueous solution of a mineral acid like HCl (SCHEME 5, step 1). Compounds XV wherein R₁ = R₂ = R₃ = H, R₄ = Me, Z being absent and W = NMe₂ or N-methylpiperazine or OH can be prepared from compound XIV by reductive amination in the presence of an amine like 1-methylpiperazine or dimethylamine and a suitable hydride donor like Sodium triacetoxyborohydride (SCHEME 5, step 2).
25 Compounds (XV) wherein R₁ = R₂ = R₃ = H, R₄ = Me, Z being absent and W = NMe₂ or N-methylpiperazine or OH can be further converted into compounds (XIIb) by mean of a Suzuki coupling with a suitable organoboron reagent (XIa) (SCHEME 5, step 3).

SCHEME 5



Following this synthetic route compounds 3-(4-amino-1-(1-(4-(5-((4-methylpiperazin-1-yl)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol (Example 10), 3-(4-amino-1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol (Example 11), 3-(4-amino-1-(1-(4-(5-(hydroxymethyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol (Example 12), 5-(4-amino-1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-ol (Example 13).

Some compounds may contain a protected hydroxyl or nitrogen group, such as for example silyl or benzyl ether, which were then removed under well-known procedure.

The compounds of the invention are inhibitors of kinase activity, in particular PI3-kinase activity. Generally speaking, compounds which are PI3K inhibitors may be useful the treatment of many disorders associated with PI3K enzymes mechanisms. Thus they may be used in the manufacture of a medicament for the treatment of said disorders.

In one embodiment, the disorders that can be treated by the compounds of the present invention include respiratory diseases selected from idiopathic chronic cough, cough-variant asthma, cough associated with thoracic tumour or lung cancer, viral or post-viral cough, upper airways cough syndrome (UACS), or post nasal drip cough, or cough associated with gastro- oesophageal reflux disease (both acid and non acid reflux), asthma, chronic bronchitis, chronic obstructive pulmonary disease (COPD), interstitial lung disease, (such as idiopathic pulmonary fibrosis (IPF)), congestive heart disease, sarcoidosis, infections (such as whooping cough), asthma, chronic obstructive pulmonary disease (COPD) and idiopathic pulmonary fibrosis (IPF); viral infections (including viral respiratory tract infections and viral exacerbation of respiratory diseases; non-viral respiratory infections including aspergillosis and leishmaniasis; allergic diseases including allergic rhinitis and atopic dermatitis; autoimmune diseases including rheumatoid arthritis and multiple sclerosis; inflammatory disorders including inflammatory bowel disease; cardiovascular diseases including thrombosis and atherosclerosis; hematologic malignancies; neurodegenerative diseases; pancreatitis; multiorgan failure; kidney diseases; platelet aggregation; cancer; sperm motility; transplantation rejection; graft rejection; lung injuries; and pain including pain associated with rheumatoid arthritis or osteoarthritis, back pain, general inflammatory pain, post hepatic neuralgia, diabetic neuropathy, inflammatory neuropathic pain (trauma), trigeminal neuralgia and central pain.

In another embodiment, the disorder that can be treated by the compound of the present invention is selected from the group consisting of idiopathic chronic cough, cough-variant asthma, cough associated with thoracic tumour or lung cancer, viral or post-viral cough, upper airways cough syndrome (UACS), post nasal drip cough, cough associated gastro- oesophageal reflux disease (both acid and non acid reflux), asthma, chronic bronchitis, chronic obstructive pulmonary disease (COPD) and interstitial lung disease (such as idiopathic pulmonary fibrosis (IPF)).

In a further embodiment, the disorder is selected from the group of asthma,

chronic obstructive pulmonary disease (COPD), idiopathic pulmonary fibrosis (IPF), cough and chronic cough.

The methods of treatment of the invention comprise administering a safe and effective amount of a compound of formula (I) or a pharmaceutically acceptable salt thereof to a patient in need thereof. As used herein, "safe and effective amount" in reference to a compound of formula (I) or a pharmaceutically acceptable salt thereof or other pharmaceutically-active agent means an amount of the compound sufficient to treat the patient's condition but low enough to avoid serious side effects and it can nevertheless be routinely determined by the skilled artisan. The compounds of formula (I) or pharmaceutically acceptable salts thereof may be administered once or according to a dosing regimen wherein a number of doses are administered at varying intervals of time for a given period of time. Typical daily dosages may vary depending upon the particular route of administration chosen.

The invention also provides pharmaceutical compositions of compounds of formula (I) in admixture with one or more pharmaceutically acceptable carrier or excipient, for example those described in Remington's Pharmaceutical Sciences Handbook, XVII Ed., Mack Pub., N.Y., U.S.A.

Administration of the compounds of the present invention and their pharmaceutical compositions may be accomplished according to patient needs, for example, orally, nasally, parenterally (subcutaneously, intravenously, intramuscularly, intrasternally and by infusion), by inhalation, rectally, vaginally, topically, locally, transdermally, and by ocular administration.

Various solid oral dosage forms can be used for administering compounds of the invention including such solid forms as tablets, gelcaps, capsules, caplets, granules, lozenges and bulk powders. The compounds of the present invention can be administered alone or combined with various pharmaceutically acceptable carriers, diluents (such as sucrose, mannitol, lactose, starches) and known excipients, including suspending agents, solubilizers, buffering agents, binders, disintegrants,

preservatives, colorants, flavorants, lubricants and the like. Time release capsules, tablets and gels are also advantageous in administering the compounds of the present invention.

Various liquid oral dosage forms can also be used for administering compounds
5 of the invention, including aqueous and non-aqueous solutions, emulsions, suspensions, syrups, and elixirs. Such dosage forms can also contain suitable known inert diluents such as water and suitable known excipients such as preservatives, wetting agents, sweeteners, flavorants, as well as agents for emulsifying and/or suspending the compounds of the invention. The compounds of the present invention
10 may be injected, for example, intravenously, in the form of an isotonic sterile solution. Other preparations are also possible.

Suppositories for rectal administration of the compounds of the invention can be prepared by mixing the compound with a suitable excipient such as cocoa butter, salicylates and polyethylene glycols.

15 Formulations for vaginal administration can be in the form of cream, gel, paste, foam, or spray formula containing, in addition to the active ingredient, such as suitable carriers, are also known.

For topical administration the pharmaceutical composition can be in the form of creams, ointments, liniments, lotions, emulsions, suspensions, gels, solutions,
20 pastes, powders, sprays, and drops suitable for administration to the skin, eye, ear or nose. Topical administration may also involve transdermal administration via means such as transdermal patches.

For the treatment of the diseases of the respiratory tract, the compounds according to the invention are preferably administered by inhalation.

25 Inhalable preparations include inhalable powders, propellant-containing metering aerosols or propellant-free inhalable formulations.

For administration as a dry powder, single- or multi-dose inhalers known from the prior art may be utilized. In that case the powder may be filled in gelatine, plastic

or other capsules, cartridges or blister packs or in a reservoir.

A diluent or carrier, generally non-toxic and chemically inert to the compounds of the invention, e.g. lactose or any other additive suitable for improving the respirable fraction may be added to the powdered compounds of the invention.

5 Inhalation aerosols containing propellant gas such as hydrofluoroalkanes may contain the compounds of the invention either in solution or in dispersed form. The propellant-driven formulations may also contain other ingredients such as co-solvents, stabilizers and optionally other excipients.

10 The propellant-free inhalable formulations comprising the compounds of the invention may be in form of solutions or suspensions in an aqueous, alcoholic or hydroalcoholic medium and they may be delivered by jet or ultrasonic nebulizers known from the prior art or by soft-mist nebulizers such as Respimat®.

The compounds of the invention can be administered as the sole active agent or in combination with other pharmaceutical active ingredients including those
15 currently used in the treatment of respiratory disorders, e.g. beta₂-agonists, antimuscarinic agents, corticosteroids mitogen-activated kinases (P38 MAP kinases) inhibitors, nuclear factor kappa-B kinase subunit beta inhibitors (IKK2), human neutrophil elastase (HNE) inhibitors, phosphodiesterase 4 (PDE4) inhibitors, leukotriene modulators, non-steroidal anti-inflammatory agents (NSAIDs) and mucus
20 regulators.

The invention therefore provides pharmaceutical compositions containing the compounds of the invention in combination with such pharmaceutically active ingredients, in admixture with one or more pharmaceutically acceptable carrier or excipient.

25 The dosages of the compounds of the invention depend upon a variety of factors including the particular disease to be treated, the severity of the symptoms, the route of administration, the frequency of the dosage interval, the particular compound utilized, the efficacy, toxicology profile, and pharmacokinetic profile of the

compound.

Advantageously, the compounds of formula (I) can be administered for example, at a dosage comprised between 0.001 and 1000 mg/day, preferably between 0.1 and 500 mg/day.

- 5 When the compounds of formula (I) are administered by inhalation route, they are preferably given at a dosage comprised between 0.001 and 500 mg/day, preferably between 0.1 and 200 mg/day.

The following examples illustrate the invention without limiting its scope.

General Experimental details

- 10 Flash chromatography is carried out using an Isolera MPLC system (manufactured by Biotage) using pre-packed silica gel or reverse-phase cartridges (supplied by Biotage).

Many of the compounds described in the following Examples have been prepared from stereochemically pure starting materials, for example 95% ee.

- 15 The stereochemistry of the compounds in the Examples, where indicated, has been assigned on the assumption that absolute configuration at resolved stereogenic centers of starting materials is maintained throughout any subsequent reaction conditions.

- 20 In the procedures that follow, after each starting material, reference to a compound number is sometimes provided. This is provided merely for assistance to the skilled chemist. The starting material may not necessarily have been prepared from the batch referred to.

- 25 When reference is made to the use of a “similar” or “analogous” procedure, as will be appreciated by those skilled in the art, such a procedure may involve minor variations, for example reaction temperature, reagent/solvent amount, reaction time, work-up conditions or chromatographic purification conditions.

Chemical Names of the compounds were generated with Structure To Name Enterprise 10.0 Cambridge Software.

Abbreviations:

Et₂O = diethyl ether; Et₃N = triethyl amine; DMF = dimethylformamide; EtOAc = Ethyl acetate; RT = room temperature; THF = tetrahydrofuran; DCM = dichloromethane; MeOH = methyl alcohol; EtOH = ethylic alcohol; TFA = Trifluoroacetic acid; LC-MS = Liquid Chromatography/Mass Spectrometry; MPLC = medium pressure liquid chromatography; dppf = 1,1'- Bis(diphenylphosphino) ferrocene; S-Phos-Pd-G2 = Chloro(2-dicyclohexylphosphino-2',6'-dimethoxy-1,1'-biphenyl)[2-(2'-amino-1,1'-biphenyl)]palladium(II); DIEA = N,N-Diisopropylethylamine; ACN = Acetonitrile; DMSO = Dimethylsulfoxide; UPLC = Ultra Performance Liquid Chromatography.

NMR characterization:

¹H-NMR spectra were performed on a Varian MR-400 spectrometer operating at 400 MHz (proton frequency), equipped with: a self-shielded z-gradient coil 5 mm 1H/nX broad band probehead for reverse detection, deuterium digital lock channel unit, quadrature digital detection unit with transmitter offset frequency shift. Chemical shift are reported as δ values in ppm relative to trimethyl silane (TMS) as an internal standard. Coupling constants (J values) are given in hertz (Hz) and multiplicities are reported using the following abbreviation (s= singlet, d=doublet, t=triplet, q=quartet, m=multiplet, br=broad, nd=not determined).

LC/UV/MS Analytical Methods**LC/UV/MS- Method 1**

LC instrument: Acquity Waters UPLC (or equivalent) interfaced with 2996 PDA detector

Column: Acquity UPLC BEH C18 1.7 um 50x2.1 mm

Column Temperature (°C) 30.0

Mobile phases: 95:5 H₂O:ACN+(0.1% HCOOH) (A); 5:95 H₂O:ACN+(0.1% HCOOH) (B)

Flow (ml/min) 0.6 (split in MS 1:6)

Stop Time (mins) 3.5

Gradient:

Time (min)	%A	%B
0.00	100	0
0.50	100	0
2.20	0.0	100.0
2.70	0.0	100.0
2.90	100	0

UV detection: BPI Detection (Start Wavelength nm 210, End Wavelength nm
5 400, Sampling Rate spectra/sec = 20)

Injection Volume (ul) - 1.00

Sample solvents: DMSO: MeOH: ACN ratio 1:3:3

LC/UV/MS- Method 2

LC instrument: Acquity Waters UPLC (or equivalent) interfaced with 2996

10 PDA detector

Column: Acquity UPLC BEH C18 1.7 um 50x2.1 mm

Column Temperature (°C) 30.0

Mobile phases: 95:5 H₂O:ACN+(0.1% HCOOH) (A); 5:95 H₂O:ACN+(0.1%
HCOOH) (B)

15 Flow (ml/min) 0.6 (split in MS 1:6)

Stop Time (mins) 12.0

Gradient:

Time (min)	%A	%B
0.00	100	0
0.50	100	0
10.0	0.0	100.0
11.0	0.0	100.0
12.0	100	0

UV detection: BPI Detection (Start Wavelength nm 210, End Wavelength nm

400, Sampling Rate spectra/sec = 20)

Injection Volume (ul) - 1.00

Sample solvents: DMSO: MeOH: ACN ratio 1:3:3

LC/UV/MS - Method 3 and 3a

5 **LC instrument: Acquity Waters UPLC (or equivalent)** interfaced with 2996
PDA detector

Column: Acquity UPLC CSH C18 1.7 um 130A 50X2.1 mm

Column Temperature (°C) 50.0

Mobile phases: HCOONH₄ 0.025M pH 3 (A); ACN + 0.1% HCOOH (B)

10 Flow (ml/min) 0.35 (split in MS 1:3 in method 3) (split 1:10 in method 3a)

Stop Time (mins) 10

Gradient:

Time (min)	%A	%B
0.00	80	20
5.50	20	80
7.5	20	80
8	80	20
10	80	20

UV detection: BPI Detection (Start Wavelength nm 210, End Wavelength nm

15 400, Sampling Rate spectra/sec = 20)

Injection Volume (ul) - 2.00

Sample solvents: H₂O/ACN 80/20

LC/UV/MS- Method 4

LC instrument: Acquity Waters UPLC (or equivalent) interfaced with 2996

20 PDA detector

Column: Acquity UPLC BEH C18 1.7 um 50x2.1 mm

Column Temperature (°C) 40.0

Mobile phases: 95:5 H₂O:ACN+(0.1% HCOOH) (A); 5:95 H₂O:ACN+(0.1%

HCOOH) (B)

Flow (ml/min) 1 ml/min

Stop Time (mins) 2

Gradient:

5

Time (min)	%A	%B
0.00	99	1
1.50	0.1	99.9
1.90	0.1	99.9
2.00	99	1

UV detection: BPI Detection (Start Wavelength nm 210, End Wavelength nm 400, Sampling Rate spectra/sec = 20)

Injection Volume (ul) - 1.00

LC/UV/MS- Method 5

10

UPLC instrument: Waters Acquity

Column: Kinetex 1.7u PFP 100A 100 x 2.1 mm (Phenomenex)

Column Temperature (°C): 55

Mobile phases: HCOONH₄ 0.025M pH 3 (A); ACN (B)

Flow (ml/min): 0.45 (split in MS 1:3)

15

Stop Time (mins): 10

Gradient:

Time (min) %A %B

Gradient:

Time (min)	%A	%B
0.00	85	15
5.00	55	45
5.50	20	80
6.50	20	80
7.00	85	15
10.00	85	15

UV detection: DAD

UV acquisition range (nm): 210-400

Injection Volume (μl): 2

Sample Solvent: Acetonitrile

5 LC/UV/MS- Method 6

LC instrument: Acquity Waters UPLC (or equivalent) interfaced with 2996

PDA detector

Column: Acquity UPLC CSH C18 1.7 μm 130A 50X2.1 mm

Column Temperature (°C) 40.0

10 Mobile phases: 95:5 H₂O:ACN+(0.1% HCOOH) (A); 5:95 H₂O:ACN+(0.1% HCOOH) (B)

Flow (ml/min) 1 ml/min

Stop Time (mins) 2

Gradient:

15

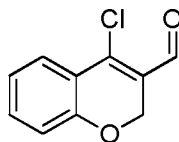
Time (min)	%A	%B
0.00	99	1
1.50	0.1	99.9
1.90	0.1	99.9
2.00	99	1

UV detection: BPI Detection (Start Wavelength nm 210, End Wavelength nm 400, Sampling Rate spectra/sec = 20)

Injection Volume (ul) - 1.00

PREPARATIONS OF INTERMEDIATES AND EXAMPLES

20 **Intermediate A1: 4-chloro-2H-chromene-3-carbaldehyde**

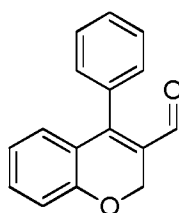


Chroman-4-one (2 g, 13.50 mmol) was dissolved in DCM (45 ml) and of DMF

(1.6 ml, 20.25 mmol), then POCl₃ (3.77 ml, 40.5 mmol) was added drop wise under nitrogen and the mixture heated at reflux for 6 h and RT overnight. The reaction was diluted with DCM, washed with water, with saturated NaCl_{aq}, dried over Na₂SO₄ and evaporated to dryness. The crude was chromatographed on silica gel with
5 Hexane\EtOAc mixtures to give the title compound (2.1 g, 80% yield) as a yellow solid.

UPLC-MS: 1.99 min, 194.8 [M+H]⁺, method 1.

Intermediate B1: 4-phenyl-2H-chromene-3-carbaldehyde



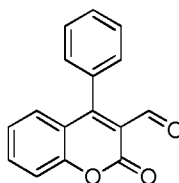
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4-Chloro-2H-chromene-3-carbaldehyde (Intermediate A1, 1g, 5.14 mmol), phenylboronic acid (0.75 g, 6.17 mmol), and Cs₂CO₃ (2.0 g, 6.17 mmol) were dissolved in DMF (19 ml) and deoxygenated under Argon for 5 min prior to the addition of Pd(PPh₃)₂Cl₂ (0.18 g, 0.257 mmol), then the mixture was heated under nitrogen
15 at 45 °C for 1 h and 4 h at 65 °C. The reaction mixture was allowed to cool to RT, partitioned between AcOEt and 1M HCl_{aq}, washed twice with water, once with saturated NaCl_{aq} then the organic layer was dried over Na₂SO₄ and evaporated to dryness. The crude was chromatographed on silica gel with Hexane\EtOAc mixtures to give the title compound (0.9 g, 74 % yield) as yellow solid.

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UPLC-MS: 2.14 min, 237.0 [M+H]⁺, method 1.

Intermediate B2: 2-oxo-4-phenyl-2H-chromene-3-carbaldehyde

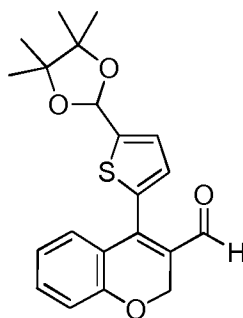


4-Chloro-2-oxo-2H-chromene-3-carbaldehyde (600 mg, 2.88 mmol), Pd-

bis(diphenylphosphine) chloride (202 mg, 0.288 mmol), tributyl(phenyl)stannane (1.47 g, 4.03 mmol), cesium fluoride (1.31 g, 8.63 mmol) were reacted in dioxane (5.9 ml) at 90 °C for 2 h. The reaction mixture was partitioned between $\text{NH}_4\text{Cl}_{\text{aq}}$ (100 ml) and AcOEt (30 ml), the organic layer was washed with Brine, dried over Na_2SO_4 and dried under reduced pressure to give and the crude was chromatographed on silica gel with Hexane\EtOAc mixtures to give the title compound (407 mg, yield 57%).

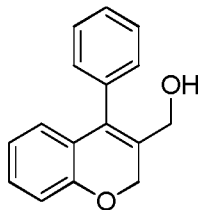
UPLC-MS: 4.55 min, 251 $[\text{M}+\text{H}]^+$, method 2.

Intermediate B3: 4-(5-(4,4,5,5-tetramethyl-1,3-dioxolan-2-yl)thiophen-2-yl)-2H-chromene-3-carbaldehyde



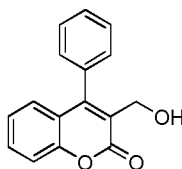
4-chloro-2H-chromene-3-carbaldehyde (Intermediate A1, 3.5 g, 17.98 mmol), 4,4,5,5-tetramethyl-2-(5-(4,4,5,5-tetramethyl-1,3-dioxolan-2-yl)thiophen-2-yl)-1,3,2-dioxaborolane (5.07 g, 14.99 mmol; prepared as described in WO 2015/091685, at pag. 138) and $\text{K}_3\text{PO}_4 \cdot \text{H}_2\text{O}$ (10.35 g, 45 mmol) were dissolved in THF (100 ml) and water (100 ml). Ar was bubbled for 15 min before the addition of XPhos Pd G2 (0.825 g, 1.049 mmol). Bubbling was continued for further 10 min the brown turbid mixture was stirred under Ar atm at RT overnight. The mixture was partitioned between ethyl acetate and water, the organic phase anhydried over sodium sulfate and the solvent evaporated to give the title compound (5.4 g, 97%) of red oil. The crude was used in the following synthetic step without further purification.

UPLC-MS: 2.64 min, 371.2 $[(\text{M}+\text{H})]^+$, 272.16 $[(\text{M}-100)]^+$, method 6 @

Intermediate C1: (4-phenyl-2H-chromen-3-yl)methanol

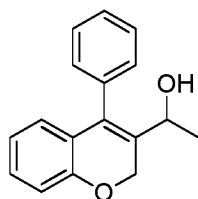
4-Phenyl-2H-chromene-3-carbaldehyde (Intermediate B1, 400 mg, 1.69 mmol) and NaBH₄ (256 mg, 6.77 mmol) were reacted in EtOH (8 ml) under nitrogen for 30 min at RT. The reaction was quenched by the addition of 1M HCl_{aq} (10 ml) and the mixture partitioned between AcOEt and 1M HCl_{aq}. The organic layer was washed with saturated NaCl_{aq}, dried over Na₂SO₄ and evaporated to dryness to give the title compound (382 mg, 95 % yield) as a colourless oil.

UPLC-MS: 1.94 min, 220.9 [(M+H)-H₂O]⁺, method 1.

Intermediate C2: 3-(hydroxymethyl)-4-phenyl-2H-chromen-2-one

2-Oxo-4-phenyl-2H-chromene-3-carbaldehyde (Intermediate B2, 191 mg, 0.763 mmol) and sodium tetrahydroborate (29 mg, 0.763 mmol) were reacted in methanol (7.5 ml) at RT. The reaction mixture was partitioned between AcOEt/NH₄Cl_{aq} 5% 1/1 (10 ml). The organic layer was dried over Na₂SO₄ and dried under reduced pressure to give the title compound (180 mg, 93%) that was used in the next step without any further purification.

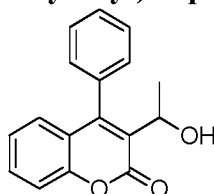
UPLC-MS: 1.76 min, 235 [(M+H)-H₂O]⁺, method 1.

Intermediate C3: 1-(4-phenyl-2H-chromen-3-yl)ethanol

4-Phenyl-2H-chromene-3-carbaldehyde (Intermediate B1, 520 mg, 2.20 mmol) was dissolved in anhydrous THF (8 ml) at 0 °C, then methylmagnesium bromide 3M in Et₂O (1.47 ml, 4.40 mmol) was added drop wise over 5 min. The mixture was stirred at 0 °C for 15 min, then quenched by the addition of saturated NH₄Cl_{aq} and
5 extracted with AcOEt. The organic layer was washed with saturated NaCl_{aq}, dried over Na₂SO₄ and evaporated to dryness to give the title compound (503 mg, 91 % yield) as a yellow oil.

UPLC-MS: 2.00 min, 234.8 [(M+H)-H₂O]⁺, method 1.

Intermediate C4: 3-(1-hydroxyethyl)-4-phenyl-2H-chromen-2-one



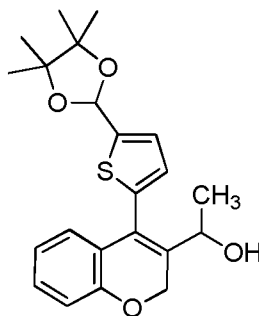
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2-Oxo-4-phenyl-2H-chromene-3-carbaldehyde (Intermediate B2, 585 mg, 2.34 mmol) and methylmagnesium bromide 3M in THF (0.86 ml, 2.57 mmol) were reacted in dry THF (7.5 ml) at -15 °C for 15 min. The reaction was partitioned between NH₄Cl_{aq} (1 ml) and AcOEt (2 ml). Phases were separated, the organic layer was dried
15 over sodium sulfate and evaporated under reduced pressure to afford a crude that was chromatographed on silica gel with Hexane\EtOAc mixtures to give the title compound (250 mg, 40 %).

UPLC-MS: 1.06 min, 249 [M+H]⁺, method 4.

Intermediate C5: 1-(4-(5-(4,4,5,5-tetramethyl-1,3-dioxolan-2-yl)thiophen-2-yl)-2H-chromen-3-yl)ethan-1-ol

20

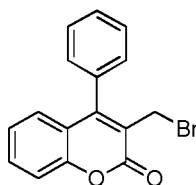


4-(5-(4,4,5,5-tetramethyl-1,3-dioxolan-2-yl)thiophen-2-yl)-2H-chromene-3-carbaldehyde (Intermediate B3, 5.55 g, 14.98 mmol) and methylmagnesium bromide 3M in THF (9.99 ml, 30.0 mmol) were reacted in dry THF (200 ml) at 0 °C for 2 h.

5 The reaction was partitioned between $\text{NH}_4\text{Cl}_{\text{aq}}$ (1 ml) and AcOEt (2 ml). Phases were separated, the organic layer was dried over sodium sulfate and evaporated under reduced pressure to afford a crude that was chromatographed on silica gel with Hexane\EtOAc mixtures to give the title compound (5.55 g, 96%).

UPLC-MS: 1.31min, 369.2 [(M+H)- H_2O]+, method 6

10 **Intermediate D1: 3-(bromomethyl)-4-phenyl-2H-chromen-2-one**

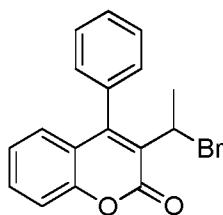


3-(Hydroxymethyl)-4-phenyl-2H-chromen-2-one (Intermediate C2, 160 mg, 0.634 mmol), tribromophosphine 1M in DCM (1.08 ml, 1.08 mmol), were reacted in DCM (1.6 ml) at RT. Solvents were evaporated to give the title compound (239 mg)

15 that was used for next step without any further purification.

UPLC-MS: 2.17 min, 234 [M-Br]+, method 1.

Intermediate D2: 3-(1-bromoethyl)-4-phenyl-2H-chromen-2-one



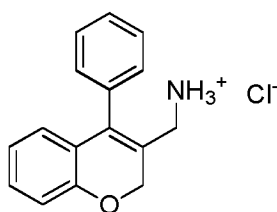
3-(1-Hydroxyethyl)-4-phenyl-2H-chromen-2-one (Intermediate C4, 250 mg, 0.94 mmol) and PBr_3 1M in DCM (1.57 mg, 1.57 mmol) were reacted in DCM (2.5 ml) at RT for 3 h. The solvent was evaporated under reduced pressure and the crude

20

was purified via reverse phase chromatography with a Biotage C18 30g SNAP column (Phase A, water 95%, ACN 5%, formic acid 0.1%; Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (203 mg, 66 %).

UPLC-MS: 2.24 min, 330.66, 328.66 [(M+H)]⁺, method 1

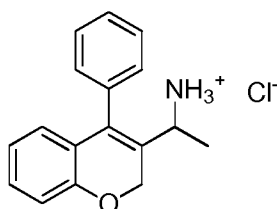
5 **Intermediate E1: (4-phenyl-2H-chromen-3-yl) methanamine hydrochloride**



(4-phenyl-2H-chromen-3-yl)methanol (Intermediate C1) DBU (0.48 ml, 3.19 mmol) and diphenylphorylazide (0.69 ml, 3.19 mmol) were reacted in THF (8 ml) at
10 RT for 3 h. The reaction mixture was partitioned between water and AcOEt, organic phase washed with 1M HCl_{aq}, with saturated NaCl_{aq}, dried over Na₂SO₄ and evaporated to dryness. The crude was dissolved in anhydrous THF (10 ml), then a solution 1M of LiAlH₄ in THF (3.19 ml, 3.19 mmol) was added drop wise under nitrogen. The reaction was stirred for 1h at RT and quenched by the addition of AcOEt
15 and 1M HCl_{aq}. The aqueous layer was neutralized with 1M NaOH_{aq} until pH ca 9-10 and extracted twice with AcOEt. The organic layer was dried over Na₂SO₄ and evaporated to dryness. The crude oil was dissolved in Et₂O with 2 ml of 4M HCl in dioxane and the mixture evaporated to dryness to give the title compound (290 mg, 66 % yield) as a yellow solid.

20 UPLC-MS: 1.45 min, 220.9 [(M+H)-NH₃]⁺, method 1

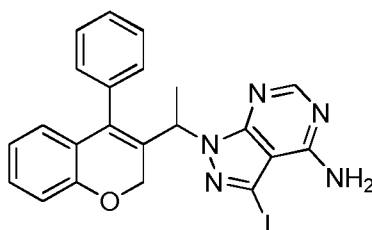
Intermediate E2: 1-(4-phenyl-2H-chromen-3-yl)ethanamine hydrochloride



The title compound was prepared analogously to compound of intermediate E1, from 1-(4-phenyl-2H-chromen-3-yl)ethanol (Intermediate C3, 350 mg, 1.39 mmol) to give the title compound (22 mg, 6 % yield).

UPLC-MS: 1.55 min, 235.0 [(M+H)-NH₃]⁺, method 1

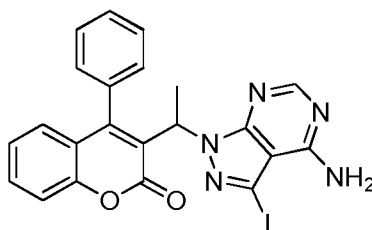
5 **Intermediate F1: 3-iodo-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine**



(4-Phenyl-2H-chromen-3-yl)ethanol (Intermediate C3 1.60 g, 6.34 mmol), 3-iodo-1H-pyrazolo[3,4-d]pyrimidin-4-amine (1.99 g, 7.61 mmol) and PPh₃ (2.0 g, 7.61 mmol) were stirred in THF (42 ml) for 5 min at RT prior to the drop wise addition of DIAD (1.22 ml, 6.28 mmol) at 0°C. The reaction was stirred at 0°C or 5 min and at RT for 1 h, then partitioned between AcOEt and 1M HCl_{aq}. The organic layer was washed three times with water, once with saturated NaCl_{aq}, dried over Na₂SO₄ and
15 evaporated to dryness. the crude was chromatographed on silica gel with Hexane\EtOAc mixtures to give the title compound (667 mg, 21 % yield) as yellowish solid.

UPLC-MS: 1.32 min, 496.0 [M+H]⁺, method 4

20 **Intermediate F2: 3-(1-(4-amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-4-phenyl-2H-chromen-2-one**

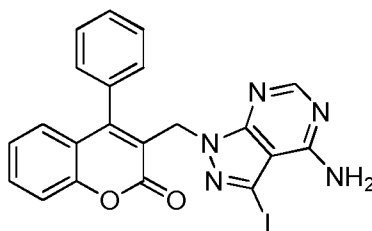


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3-(1-Bromoethyl)-4-phenyl-2H-chromen-2-one (Intermediate D2 101 mg, 0.307 mmol), 3-iodo-1H-pyrazolo[3,4-d]pyrimidin-4-amine (104 mg, 0.40 mmol) and K_2CO_3 (55 m, 0.399 mmol) were reacted in DMF (1 ml) at 60 °C for 18 h. The crude was purified via reverse phase chromatography with a C18 column (Phase A, water 95%, ACN 5%, formic acid 0.1%); Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (75 mg, 48 %).

UPLC-MS: 1.15 min, 510 [M+H]⁺, method 4

Intermediate F3: 3-((4-amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)methyl)-4-phenyl-2H-chromen-2-one



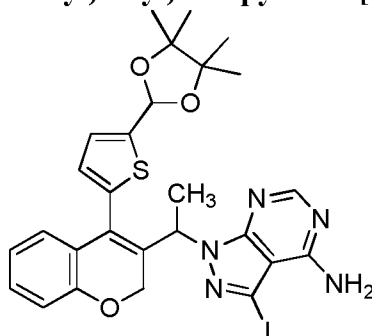
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3-(Bromomethyl)-4-phenyl-2H-chromen-2-one (Intermediate D1 102 mg, 0.324 mmol), K_2CO_3 (54 mg, 0.40 mmol) and 3-iodo-1H-pyrazolo[3,4-d]pyrimidin-4-amine (101 mg, 0.39 mmol) were reacted in DMF (1.2 ml, 15.50 mmol) at 80 °C for 3 h. The crude was purified via reverse phase chromatography with a C18 column (Phase A, water 95%, ACN 5%, formic acid 0.1%; Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (20 mg, 12.5%).

15

UPLC-MS: 1.84 min, 496 [M+H]⁺, method 4.

Intermediate F4: 3-iodo-1-(1-(4-(5-(4,4,5,5-tetramethyl-1,3-dioxolan-2-yl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine

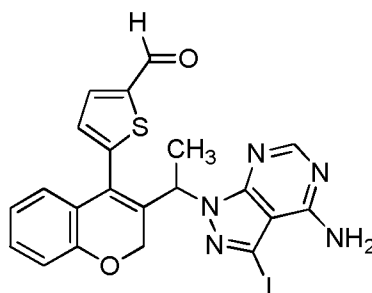


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1-(4-(5-(4,4,5,5-tetramethyl-1,3-dioxolan-2-yl)thiophen-2-yl)-2H-chromen-3-yl)ethanol (Intermediate C5, 2 g, 5.17 mmol), 3-iodo-1H-pyrazolo[3,4-d]pyrimidin-4-amine (1.621 g, 6.21 mmol) were stirred in THF (42 ml) for 5 min at RT prior to the addition of PPh₃ (1.629 g, 6.21 mmol) then DIAD (1.257 ml 5.17 mmol) at 0 °C. The reaction was stirred at 0 °C for 5 min and at RT overnight, then partitioned between AcOEt and saturated NH₄Cl_{aq}. The organic layer was washed with saturated NaCl_{aq}, dried over Na₂SO₄ and evaporated to dryness. The crude was purified via reverse phase chromatography with a C18 column (Phase A, water 95%, ACN 5%, formic acid 0.1%; Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (193 mg, 5%).

UPLC-MS: 1.46 min, 629,33 [M+H]⁺, 529.4 [(M+H)-100]⁺, method 6

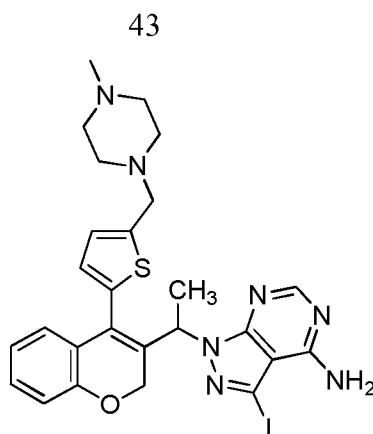
Intermediate G1: 5-(3-(1-(4-amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-2H-chromen-4-yl)thiophene-2-carbaldehyde



3-iodo-1-(1-(4-(5-(4,4,5,5-tetramethyl-1,3-dioxolan-2-yl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate F4, 193 mg, 0.307 mmol) was dissolved in ACN (12 mL) and then 1M HCl_{aq} was added till pH < 2 and the mixture stirred at RT overnight. ACN was evaporated to give the title product (150 mg, 92%) that was directly used in the next step without further purification.

UPLC-MS: 1.17 min, 529,73 [M+H]⁺, method 6

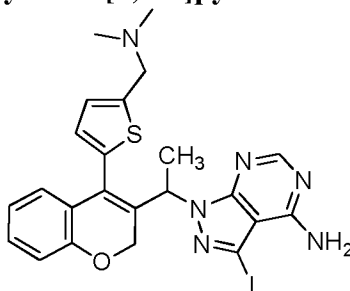
Intermediate H1: 3-iodo-1-(1-(4-(5-((4-methylpiperazin-1-yl)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine



Under a static Ar Atmosphere 5-(3-(1-(4-amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-2H-chromen-4-yl)thiophene-2-carbaldehyde (Intermediate G1, 162 mg, 0.306 mmol) was suspended in a mixture of DCM/DMF (15 ml \ 5 mL) then 1-methylpiperazine (0.175 ml, 1.530 mmol), acetic acid (0.088 ml, 1.530 mmol) were added and the mixture stirred at RT for 10 minutes. Sodium triacetoxyhydroborate (0.370 ml, 1.530 mmol) was then added and the mixture was stirred at RT for 4 h. After a further addition of 1-methylpiperazine (0.175 ml, 1.530 mmol), and sodium triacetoxyhydroborate (0.370 ml, 1.530 mmol), the reaction was stirred at RT overnight. Solvent was evaporated, the mixture partitioned between isopropylacetate and a 1M NaOH_{aq.}, then the organic phase was washed with water and saturated NaCl solution. The solvent was removed and the crude was purified via reverse phase chromatography with a C18 column (Phase A, water 95%, ACN 5%, formic acid 0.1%; Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (42 mg, 22.4 %).

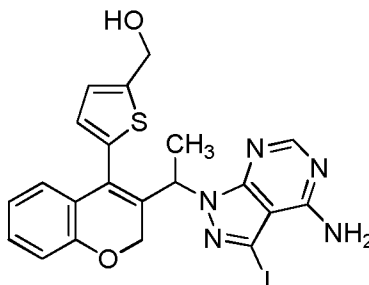
UPLC-MS: 0.71 min, 613.70 [M+H]⁺, method 6

Intermediate H2: 1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-4-amine



and

Intermediate H3: (5-(3-(1-(4-amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-2H-chromen-4-yl)thiophen-2-yl)methanol



5

Under a static Ar Atmosphere 5-(3-(1-(4-amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-2H-chromen-4-yl)thiophene-2-carbaldehyde (Intermediate G1, 177 mg, 0.334 mmol) was suspended in a mixture of DCM\Dioxane\Acetonitrile (15 ml/ 2.5 ml/ 2.5 ml) then dimethylamine 2.0 M in THF (0.018 ml, 0.334 mmol), acetic acid (0.096 ml, 1.672 mmol) were added and the mixture stirred at RT for 10 minutes. Then sodium triacetoxyhydroborate (0.404 ml, 1.672 mmol) was added and the mixture was stirred at RT for 4 h. A further addition of dimethylamine 2.0 M in THF (0.018 ml, 0.334 mmol) and sodium triacetoxyhydroborate (0.404 ml, 1.672 mmol) the reaction was stirred at RT overnight. HCl_{aq} 1M was added and the mixture was stirred for 10 min. Organic solvents were removed and the crude was purified via reverse phase chromatography with a C18 column (Phase A, water 95%, ACN 5%, formic acid 0.1%; Phase B ACN 95%, water 5%, formic acid 0.1%) to give

10
15

Intermediate H2: (58.5 mg, 31%) UPLC-MS: 0.68 min, 558,32 [M+H]⁺, method 6 and

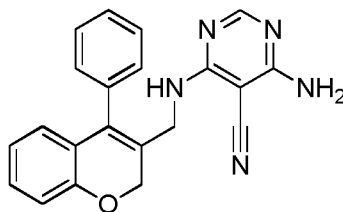
20

Intermediate H3: (53.5 mg, 30%), UPLC-MS: 1.06 min, 531,47 [M+H]⁺, method 6

PREPARATION OF COMPOUNDS:

Example 1

4-Amino-6-((4-phenyl-2H-chromen-3-yl)methylamino)pyrimidine-5-

carbonitrile

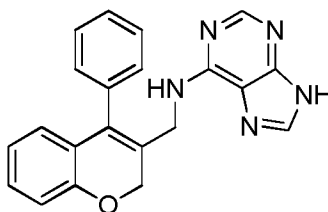
1-(4-Phenyl-2H-chromen-3-yl)methanamine hydrochloride (Intermediate E1
80 mg, 0.292 mmol), 4-amino-6-chloropyrimidine-5-carbonitrile (54 mg, 0.351
5 mmol) and DIEA (0.10 ml, 0.584 mmol) were reacted in dioxane (15 ml) at 80 °C for
3.5 h, then quenched by the addition of 1M HCl_{aq} (1 ml). The crude was purified via
reverse phase chromatography with a Biotage C18 60g SNAP column (Phase A, water
95%, ACN 5%, formic acid 0.1%); Phase B ACN 95%, water 5%, formic acid 0.1%)
to give the title compound (38 mg, 36 % yield).

10 ¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 7.85 (s, 1 H), 7.36 - 7.57 (m, 4 H), 7.05 -
7.33 (m, 5 H), 6.71 - 6.90 (m, 2 H), 6.41 - 6.58 (m, 1 H), 4.68 - 4.85 (m, 2 H), 3.72 - 4.04
(m, 2 H).

UPLC-MS: 5.26 min, 356.1 [M+H]⁺, method 5

Example 2

15 **N-((4-Phenyl-2H-chromen-3-yl)methyl)-9H-purin-6-amine**



The title compound was prepared analogously to compound of example 1, from
1-(4-phenyl-2H-chromen-3-yl)methanamine hydrochloride (Intermediate E1, 80 mg,
20 0.292 mmol) and 6-chloro-9H-purine (54 mg, 0.351 mmol) to give the title compound
(18 mg, 0.051 mmol, 18 % yield).

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 12.59 - 13.04 (bs, 1 H), 7.98 - 8.26 (m, 2
H), 7.73 - 7.91 (m, 1 H), 7.28 - 7.59 (m, 6 H), 7.11 (m, 1 H), 6.66 - 6.95 (m, 2 H), 6.53 (d,

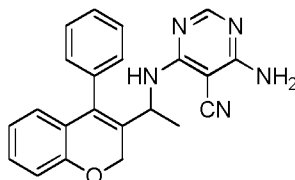
$J=7.06$ Hz, 1 H), 4.82 (s, 2 H), 3.99 - 4.28 (m, 2 H).

UPLC-MS: 4.82 min, 356.1 $[M+H]^+$, method 5

Example 3

4-Amino-6-(1-(4-phenyl-2H-chromen-3-yl)ethylamino)pyrimidine-5-

5 carbonitrile



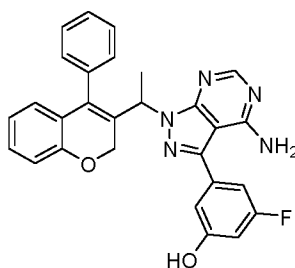
The title compound was prepared analogously to compound of example 1, from 1-(4-phenyl-2H-chromen-3-yl)ethanamine hydrochloride (Intermediate E2, 20 mg, 0.080 mmol) and 4-amino-6-chloropyrimidine-5-carbonitrile (32 mg, 0.207 mmol) to give the title compound (7 mg, 25 % yield) as a white solid.

^1H NMR (400 MHz, DMSO- d_6) δ ppm 7.95 (s, 1 H), 7.34 - 7.57 (m, 4 H), 7.01 - 7.31 (m, 5 H), 6.71 - 6.89 (m, 2 H), 6.34 - 6.48 (m, 1 H), 4.96 - 5.05 (m, 1 H), 4.70 - 4.82 (m, 1 H), 4.54 - 4.67 (m, 1 H), 1.27 (d, $J=7.06$ Hz, 3 H).

UPLC-MS: 5.64 min, 370.1 $[M+H]^+$, method 3a.

Example 4

3-(4-Amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol



3-Iodo-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate F1, 60 mg, 0.121 mmol), (3-fluoro-5-hydroxyphenyl)boronic acid (38 mg, 0.242 mmol), S-Phos Pd G2 (8.73 mg, 0.012 mmol) and $\text{K}_3\text{PO}_4 \cdot \text{H}_2\text{O}$ (118 mg, 0.363 mmol) were dispersed in THF (2 ml) and

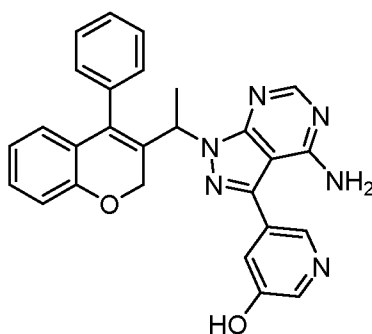
deoxygenated under argon for 5 min prior to the addition of water (0.5 ml) and the mixture heated by MW irradiation for 40 min at 85°C. The reaction mixture was diluted with AcOEt and washed twice with water, once with saturated NaCl_{aq}, the organic layer dried over Na₂SO₄ and dried under reduced pressure. The crude was chromatographed on silica gel with DCM/AcOEt mixtures to give the title compound (37 mg, 64% yield) as a yellowish solid.

¹H NMR (400 MHz, DMSO-d₆) δ ppm 10.19 (s, 1 H), 8.16 (s, 1 H), 7.43 - 7.57 (m, 3 H), 7.27 (d, J=7.06 Hz, 2 H), 7.06 - 7.20 (m, 1 H), 6.75 - 6.97 (m, 4 H), 6.67 (dt, J=11.03, 2.21 Hz, 1 H), 6.47 (dd, J=7.72, 1.54 Hz, 1 H), 5.55 - 5.73 (m, 1 H), 4.67 - 5.23 (m, 2 H), 1.66 (d, J=7.06 Hz, 3 H).

UPLC-MS: 5.39 min, 480.0 [M+H]⁺, method 3a.

Example 5

5-(4-Amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-ol



3-Iodo-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate F1 (60 mg, 0.121 mmol), 5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyridin-3-ol (53.6 mg, 0.242 mmol), S-Phos Pd G2 (8.73 mg, 0.012 mmol) and K₃PO₄ H₂O (118 mg, 0.363 mmol) were dispersed in THF (2 ml) and deoxygenated under Ar for 5 min prior to the addition of water (0.5 ml), then the reaction was heated under MW irradiation for 80 min at 85 °C. Reaction was quenched by the addition of 2M HCl_{aq} (5 ml) and the crude was purified via reverse phase chromatography with a Biotage C18 SNAP column (Phase A, water 95%, ACN 5%,

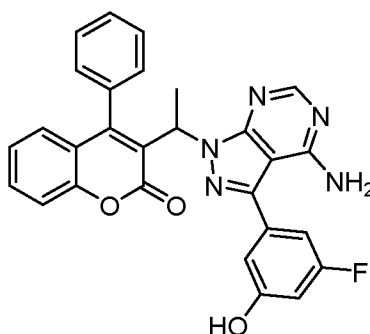
formic acid 0.1%); Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (48 mg, 86 % yield) as a yellowish solid.

^1H NMR (400 MHz, DMSO- d_6) δ ppm 9.98 - 10.46 (bs, 1 H), 8.33 (d, $J=1.32$ Hz, 1 H), 8.22 (d, $J=2.65$ Hz, 1 H), 8.17 (s, 1 H), 7.40 - 7.55 (m, 4 H), 7.27 (d, $J=6.62$ Hz, 2 H), 7.14 (m, 1 H), 6.74 - 6.88 (m, 2 H), 6.48 (dd, $J=7.94, 1.32$ Hz, 1 H), 5.63 (d, $J=7.06$ Hz, 1 H), 4.57 - 5.28 (m, 2 H), 1.67 (d, $J=7.06$ Hz, 3 H).

UPLC-MS: 4.27 min, 462.9 $[\text{M}+\text{H}]^+$, method 3a.

Example 6

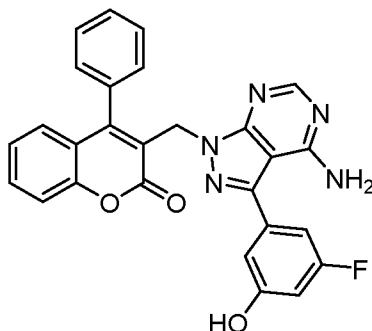
3-(1-(4-Amino-3-(3-fluoro-5-hydroxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-4-phenyl-2H-chromen-2-one.



3-(1-(4-Amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-4-phenyl-2H-chromen-2-one (Intermediate F2 (75 mg, 0.147 mmol), 3-fluoro-5-hydroxyphenylboronic acid (46 mg, 0.295 mmol), $\text{PdCl}_2(\text{dppf})$ (12.9 mg, 0.018 mmol) and potassium carbonate (41 mg, 0.295 mmol) were reacted in dioxane (730 μl) at 80°C for 1 h. The crude was purified via reverse phase chromatography with a Biotage C18 SNAP column (Phase A, water 95%, ACN 5%, formic acid 0.1%); Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (62 mg, 85%).

^1H NMR (400 MHz, DMSO- d_6) δ ppm 10.24 (s, 1 H), 8.05 (s, 1 H), 7.58 - 7.66 (m, 1 H), 7.33 - 7.53 (m, 5 H), 7.17 - 7.28 (m, 1 H), 6.91 - 6.96 (m, 1 H), 6.79 - 6.83 (m, 1 H), 6.69 - 6.79 (m, 2 H), 6.59 - 6.67 (m, 1 H), 5.52 - 5.73 (m, 1 H), 1.79 - 2.00 (m, 3 H).

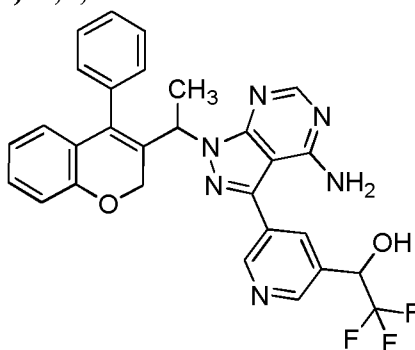
UPLC-MS: 4.45 min, 494 $[\text{M}+\text{H}]^+$, method 3

Example 7**3-((4-Amino-3-(3-fluoro-5-hydroxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-1-yl)methyl)-4-phenyl-2H-chromen-2-one**

5 3-((4-Amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)methyl)-4-phenyl-2H-chromen-2-one (Intermediate F3 (20 mg, 0.04 mmol)), 3-fluoro-5-hydroxyphenylboronic acid (12.6 mg, 0.08 mmol), cesium carbonate (26.3 mg, 0.08 mmol) and Pd(PPh₃)₄ (3.7 mg, 3.23 μmol) were reacted in DMF (200 μl) under microwave irradiation at 120 °C for 1 h. The crude was purified via reverse phase
10 chromatography with a Biotage C18 SNAP column (Phase A, water 95%, ACN 5%, formic acid 0.1%); Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (9 mg, 47 %).

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 8.14 (s, 1 H), 7.18 - 7.75 (m, 15 H), 5.36 (s, 2 H)

15 UPLC-MS: 4.00 min, 480 [M+H]⁺, method 3

Example 7a**1-(5-(4-amino-1-(1-(4-phenyl-2H-chromen-2-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-yl)-2,2,2-trifluoroethan-1-ol.**

3-iodo-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate F1 (50 mg, 0.101 mmol)), 2,2,2-trifluoro-1-(5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyridin-3-yl)ethanol (92 mg, 0.303 mmol) and $K_3PO_4 \cdot H_2O$ (70 mg, 0.303 mmol) were dispersed in THF (3.75 ml) and deoxygenated
5 under Ar for 5 min prior to the addition of water (1.25 ml). Reaction was heated at 70 °C and then S-Phos Pd G2 (7.27 mg, 10.09 μ mol) was added. The reaction was stirred for 30 min.

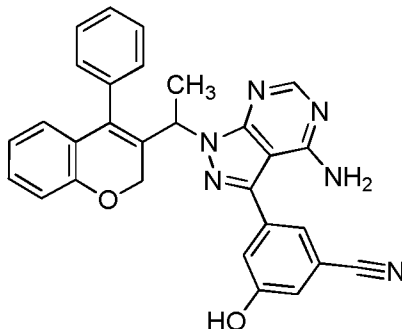
The mixture was then quenched with 1M HCl_{aq}, the solvent evaporated and the residue submitted to reverse phase chromatography crude was purified via reverse phase
10 chromatography with a Biotage C18 SNAP column (Phase A, water 95%, ACN 5%, formic acid 0.1%); Phase B ACN 95%, water 5%, formic acid 0.1%) to yield the title compound (0.042 g, 0.072 mmol, 71.6 % yield) as a yellow solid.

1H NMR (400 MHz, DMSO- d_6) δ ppm 8.83 - 8.94 (m, 1 H), 8.67 - 8.81 (m, 1 H), 8.14 - 8.27 (m, 2 H), 7.42 - 7.62 (m, 3 H), 7.23 - 7.35 (bs, 2 H), 7.09 - 7.21 (m, 2 H), 6.69
15 - 6.92 (m, 2 H), 6.42 - 6.58 (m, 1 H), 5.56 - 5.74 (m, 1 H), 5.33 - 5.54 (m, 1 H), 5.00 - 5.23 (m, 1 H), 4.67 - 4.87 (m, 1 H), 1.58 - 1.86 (m, 3 H)

UPLC-MS: 1.19 min, 545 [M+H]⁺, method 6.

Example 7b

**3-(4-amino-1-(1-(4-phenyl-2H-chromen-2-yl)ethyl)-1H-pyrazolo[3,4-
20 d]pyrimidin-3-yl)-5-hydroxybenzonitrile**



The title compound was prepared analogously to compound of Example 7, from 3-iodo-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate F1 (30 mg, 0.061 mmol)), 3-hydroxy-5-(4,4,5,5-tetramethyl-

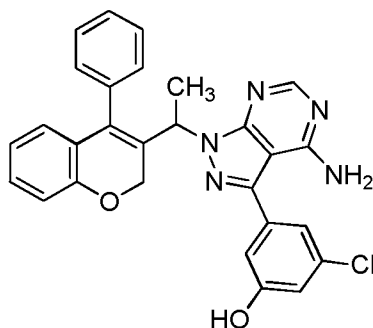
1,3,2-dioxaborolan-2-yl)benzonitrile (45 mg, 0.182 mmol), K₃PO₄ H₂O (42 mg, 0.182 mmol) and SPhos Pd G2 (4.36 mg, 6.06 μmol) to give the title compound (7.8 mg, 0.016 mmol, 26.5 % yield) as a yellow solid.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 10.30 - 10.61 (bs, 1 H), 8.05 - 8.23 (m, 1 H), 7.42 - 7.59 (m, 4 H), 7.33 - 7.42 (m, 1 H), 7.19 - 7.33 (m, 3 H), 7.07 - 7.19 (m, 1 H), 6.71 - 6.87 (m, 2 H), 6.38 - 6.53 (m, 1 H), 5.57 - 5.71 (m, 1 H), 4.67 - 5.22 (m, 2 H), 1.61 - 1.72 (m, 3 H)

UPLC-MS: 1.26 min, 487.2 [M+H]⁺, method 6.

Example 7c

10 **3-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-chlorophenol**



The title compound was prepared analogously to compound of Example 7, from 3-iodo-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate F1 (30 mg, 0.061 mmol), 3-chloro-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenol (15 mg, 0.061 mmol), K₃PO₄ H₂O (42 mg, 0.182 mmol) and SPhos Pd G2 (4.36 mg, 6.06 μmol) to give the title compound (10.7 mg, 0.022 mmol, 35.6 % yield) as a yellow solid.

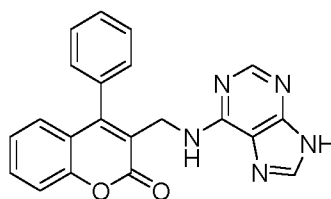
¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 10.09 (s, 1 H), 8.15 (s, 1 H), 7.36 - 7.60 (m, 3 H), 7.22 - 7.34 (m, 2 H), 7.08 - 7.17 (m, 2 H), 6.99 - 7.08 (m, 1 H), 6.72 - 6.94 (m, 3 H), 6.40 - 6.53 (m, 1 H), 5.44 - 5.71 (m, 2 H), 1.56 - 1.76 (m, 3 H) UPLC-MS:

1.37 min, 496.1 [M+H]⁺, method 6.

Example 8

3-((9H-Purin-6-ylamino)methyl)-4-phenyl-2H-chromen-2-one.

52



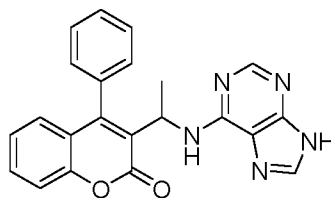
Tert-butyl 9-trityl-9H-purin-6-ylcarbamate (70 mg, 0.222 mmol) and 50% dispersion in mineral oil NaH (9.7 mg, 0.244 mmol) were dissolved in DMF (0.5 ml) at 0°C. A solution of 3-(bromomethyl)-4-phenyl-2H-chromen-2-one (Intermediate D1
5 (73 mg, 0.143 mmol) in DMF (0.5 ml) was then added. The reaction mixture was stirred at 0°C for 5 min and at 80°C for 1 h. The reaction mixture was then diluted with EtOAc (20 ml) and washed with 0.2 M HCl, sat NaCl, dried over Na₂SO₄ and concentrated under reduced pressure. TFA (1.5 ml) in DCM (2 ml) was added and the mixture stirred for 1 h then dried under reduced pressure to give a crude that was
10 purified via reverse phase chromatography with a Biotage C18 30g SNAP column (Phase A, water 95%, ACN 5%, formic acid 0.1%); Phase B ACN 95%, water 5%, formic acid 0.1%) to give the title compound (4 mg, 5%).

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 12.73 - 12.98 (bs, 1 H), 7.98 - 8.16 (m, 2 H), 7.36 - 7.70 (m, 8 H), 7.18 - 7.35 (m, 1 H), 6.89 - 7.05 (m, 1 H), 4.00 - 4.59 (m, 2 H)

15 UPLC-MS: 1.69 min, 370 [M+H]⁺, method 1

Example 9

3-(1-(9H-Purin-6-ylamino)ethyl)-4-phenyl-2H-chromen-2-one.



20 The title compound was prepared analogously to compound of Example 8, from 3-(1-bromoethyl)-4-phenyl-2H-chromen-2-one (Intermediate D2 (63 mg, 0.191 mmol) and tert-butyl 9-trityl-9H-purin-6-ylcarbamate (101 mg, 0.21 mmol) to give the title compound (18 mg, 25%).

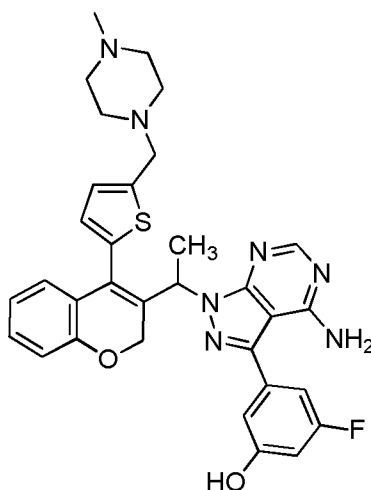
¹H NMR (400 MHz, DMSO) d ppm 13.64 - 13.85 (bs, 1 H), 8.74 - 9.07 (m, 2

H), 8.33 - 8.56 (m, 4 H), 8.11 - 8.32 (m, 3 H), 8.01 - 8.11 (m, 1 H), 7.77 - 7.90 (m, 1 H), 7.65 - 7.73 (m, 1 H), 5.75 - 6.17 (m, 1 H), 2.20 - 2.52 (m, 3 H).

UPLC-MS: 3.47 min, 384 [M+H]⁺, method 3

Example 10

3-(4-amino-1-(1-(4-(5-((4-methylpiperazin-1-yl)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol



3-fluoro-5-hydroxyphenylboronic acid (10.67 mg, 0.068 mmol), 3-iodo-1-(1-(4-(5-((4-methylpiperazin-1-yl)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate H1, 42 mg, 0.068 mmol) and potassium phosphate hydrate (47.3 mg, 0.205 mmol) were dispersed in THF (3.75 ml) and deoxygenated under Ar for 5 min prior to the addition of water (1.25 ml). Reaction was heated at 70 °C and then S-Phos Pd G2 (7.27 mg, 10.09 μmol) was added. The reaction was stirred for 3 h, before the addition of further equivalents of catalyst and base. The reaction was stirred for other 3 h at 70 °C.

The mixture was then quenched with 1M HCl_{aq}, the solvent evaporated and the residue submitted to reverse phase chromatography crude was purified via reverse phase chromatography with a Biotage C18 SNAP column (Phase A, water 95%, ACN 5%, formic acid 0.1%); Phase B ACN 95%, water 5%, formic acid 0.1%) to yield the title compound (12.8 mg, 31.3 % yield) as a white solid.

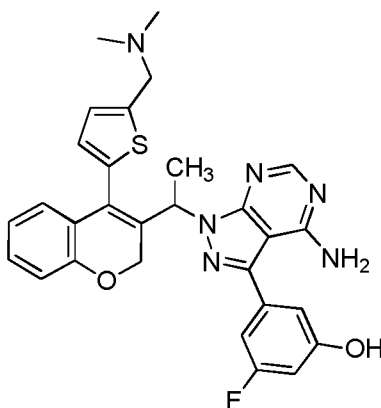
¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 10.04 - 10.33 (m, 1 H), 8.15 (d, *J*=7.9 Hz, 2 H), 6.55 - 7.26 (m, 10 H), 5.84 - 6.00 (m, 1 H), 4.63 - 5.15 (m, 2 H), 3.55 - 3.85 (m, 2 H), 2.33 (m, 8 H), 2.16 (s, 3 H), 1.68 (d, *J*=7.0 Hz, 3 H).

UPLC-MS: 0.75 min, 598.16 [M+H]⁺, method 6.

5

Example 11

3-(4-amino-1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol



10

The title compound was prepared analogously to compound of Example 7, from 1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate H2, 60 mg, 0.107 mmol), 3-fluoro-5-hydroxyphenylboronic acid (16.75 mg, 0.107 mmol), potassium phosphate hydrate (74.2 mg, 0.322 mmol) and SPhos Pd G2 (7.74 mg, 10.74 μmol) to give the title compound (3.7 mg, 6.3 % yield) as a yellow solid.

15

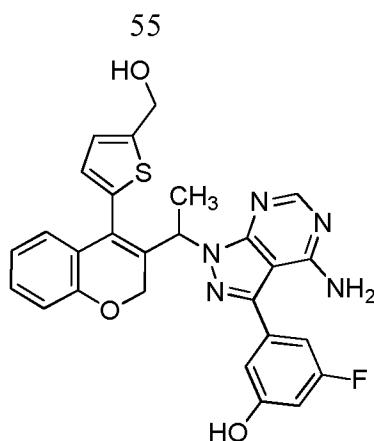
¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 10.17 (s, 1 H) 7.12 - 7.19 (m, 1 H) 6.92 (s, 1 H) 6.80 - 6.90 (m, 4 H) 6.77 (br d, *J*=7.89 Hz, 2 H) 6.65 (br d, *J*=10.09 Hz, 1 H) 6.48 (s, 1 H) 5.88 (br d, *J*=7.45 Hz, 1 H) 5.10 (d, *J*=14.47 Hz, 1 H) 4.81 (br d, *J*=14.47 Hz, 1 H) 3.63 (s, 2 H) 1.67 (d, *J*=7.45 Hz, 3 H)

20

UPLC-MS: 0.70 min, 542.78 [M+H]⁺, method 6.

Example 12

3-(4-amino-1-(1-(4-(5-(hydroxymethyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol

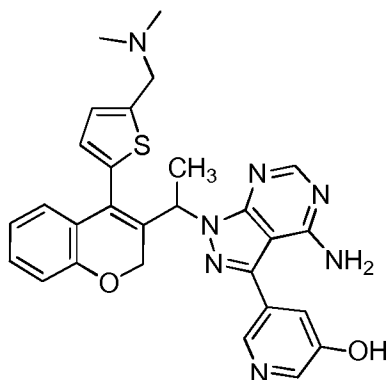


The title compound was prepared analogously to compound of Example 7, from
 (5-(3-(1-(4-amino-3-iodo-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-2H-
 chromen-4-yl)thiophen-2-yl)methanol (Intermediate H3, 53.5 mg, 0.101 mmol), 3-
 5 fluoro-5-hydroxyphenylboronic acid (47.1 mg, 0.302 mmol) potassium phosphate
 hydrate (69.6 mg, 0.302 mmol) and SPhos Pd G2 (7.26 mg, 10.07 μ mol) to give the
 title compound (10.0 mg, 19.6 % yield).

^1H NMR (400 MHz, DMSO- d_6) δ ppm 10.05 - 10.36 (bs, 1 H), 8.20 (s, 1 H), 6.47 -
 7.25 (m, 11 H), 5.89 (d, $J=7.0$ Hz, 1 H), 5.55 (br. s., 1 H), 5.13 (d, $J=14.9$ Hz, 1 H), 4.19 -
 10 4.82 (m, 3 H), 1.71 (d, $J=7.5$ Hz, 3 H)

UPLC-MS: 1.03 min, 515.93 $[\text{M}+\text{H}]^+$, method 6.

Example 13



**5-(4-amino-1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-
 15 yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-ol**

The title compound was prepared analogously to compound of Example 7, from
 1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-3-iodo-
 1H-pyrazolo[3,4-d]pyrimidin-4-amine (Intermediate H2, 30 mg, 0.054 mmol), 5-

(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyridin-3-ol (35.6 mg, 0.161 mmol), potassium phosphate hydrate (37.1 mg, 0.161 mmol) and SPhos Pd G2 (3.87 mg, 5.37 μ mol) to give the title compound (28.2 mg, 11.7 % yield) as a solid.

PHARMACOLOGICAL ACTIVITY OF THE COMPOUNDS OF THE

5 INVENTION

In vitro determination of the PI3K enzyme inhibitory activity in the cell free assay

Human recombinant proteins PI3K α , PI3K β , PI3K γ and PI3K δ were purchased from Millipore Ltd (Billerica, MA). Compounds were dissolved at 0.5mM in DMSO and were tested at different concentrations for their activity against PI3Ks using the ADP-GloTM Kinase Assay (Promega, Madison WI) according to the manufacturer's instructions.

Briefly, the kinase reactions were performed in 384-well white plates (Greiner Bio-One GmbH, Frickenhausen). Each well was loaded with 0.1 μ l of test compounds and 2.5 μ l of 2x reaction buffer (40 mM Tris pH7.5, 0.5 mM EGTA, 0.5 mM Na₃VO₄, 5 mM β -glycerophosphate, 0.1 mg/ml BSA, 1 mM DTT), containing 50 μ M PI and PS substrates (L- α -phosphatidylinositol sodium salt and L- α -phosphatidyl-L-serine, Sigma-Aldrich, St. Louis MO) and the PI3K recombinant proteins (PI3K γ 0.25 ng/ μ l, PI3K δ 1 ng/ μ l, PI3K α 0.125 ng/ μ l, PI3K β 1 ng/ μ l).

The reactions were started by adding 2.5 μ l of 2x ATP solution to each well (final concentrations: PI3K γ ATP 30 μ M; PI3K δ ATP 80 μ M; PI3K α ATP 50 μ M; PI3K β ATP 100 μ M) and incubated for 60 min at room temperature. Subsequently, each kinase reaction was incubated for 40 min with 5 μ l ADP-GloTM Reagent, allowing depletion of unconsumed ATP. Then, the Kinase Detection Reagent (10 μ l) was added in each well to convert ADP to ATP and to allow the newly synthesized ATP to be measured using a luciferase/luciferin reaction. Following 60 min incubation, the luminescence signal was measured using a Wallac EnVision® multilabel reader (PerkinElmer, Waltham MA).

Curve fitting and IC₅₀ calculation were carried out using a four-parameter logistic model in XLfit (IDBS, Guilford, UK) for Microsoft Excel (Microsoft, Redmont, WA).

Compounds of the invention showed an IC₅₀ lower than 1 μ M with respect to
5 the PI3K-delta subunit, preferably lower than 100 nM.

In vitro determination of the PI3K enzyme inhibitory activity in the PBMCs assay

Human peripheral blood mononuclear cells (PBMCs) were purchased from Lonza (Basel, CH), washed and resuspended in RPMI 1640 medium (w/o Phenol Red)
10 supplemented with 10% FBS, 2 mM glutamine, 100 U/ml penicillin and 100 μ g/mL streptomycin (Life Technologies, Carlsbad CA). PBMCs were plated at a density of 10⁵ cells/well in 96-well plates coated with 6 μ g/ml anti-human CD3 antibody (Biolegend, San Diego CA).

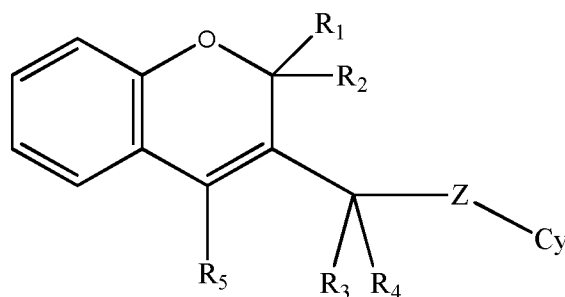
Cells were treated in RPMI (w/o Phenol Red) supplemented with 10% FBS
15 with different concentrations of PI3K inhibitors (10⁻¹²M-10⁻⁵M, final DMSO concentration 0.2%), co-stimulated with 3 μ g/ml anti-human CD28 antibody (BD Biosciences, San Jose CA) and incubated for 72 h in an atmosphere of 95% air and 5% CO₂ at 37°C. Human IL-6 and IL-17 were measured in the supernatants using paired antibody quantitative ELISA kits (from Life Technologies, Carlsbad CA and
20 R&D Systems, Minneapolis MN respectively) according to the manufacturer's instructions.

IC₅₀ values were determined from concentration-response curves by nonlinear regression analysis using the Graph Pad Prism v.6 (GraphPad Software, La Jolla CA).

Compounds of the invention showed an IC₅₀ lower than 1 μ M with respect to
25 the PI3K-delta subunit.

CLAIMS

1. A compound of formula (I):



(I)

wherein:

R₁ and R₂ are both H or are combined to form an oxo group (=O);

R₃ and R₄, the same or different, in each occurrence are independently selected from the group consisting of: H, (C₁-C₆) alkyl and (C₁-C₆) haloalkyl;

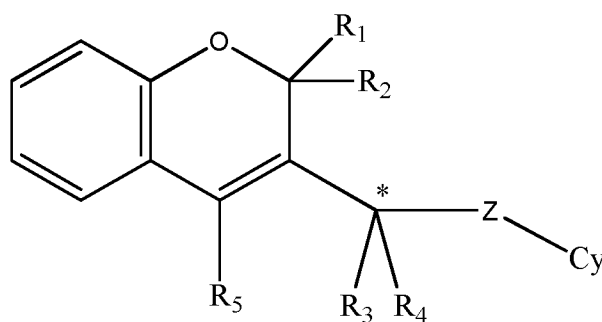
- 10 R₅ is selected from the group consisting of substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl;

Z, is absent or NH₂;

Cy is a substituted or unsubstituted heteroaryl;

or pharmaceutically acceptable salts thereof.

- 15 2. A compound of formula (IA)



(IA)

or pharmaceutically acceptable salt thereof;

- 20 wherein R₃ has the same meaning as in claim 1 except H, R₄ is H and the absolute

configuration of the chiral carbon (*) is (R) or (S) and all the other variable are as defined in claim 1.

3. A compound according to Claim 1 wherein:

R₁ and R₂ are both H or are combined to form an oxo group (=O);

5 R₃ is selected from H and (C₁-C₆) alkyl;

R₄ is H;

R₅ is selected from substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl;

Z, is absent or NH,;

10 Cy is a substituted or unsubstituted heteroaryl;

or pharmaceutically acceptable salts thereof.

4. A compound according to Claim 1 wherein:

R₁ and R₂ are both H or are combined to form an oxo group (=O);

R₃ is selected from H, methyl, ethyl and propyl;

15 R₄ is H;

R₅ is selected from phenyl, 2-, 3- or 4-pyridinyl, 5-thiazolyl, 2-, 3-, 4- or 5-thienyl, 1H-pyrazol-4-yl, 2-, 4-, 5- or 6- pyrimidinyl; all of which optionally substituted by one or more groups selected from (C₁-C₆) alkyl, (C₁-C₆) hydroxyalkyl, substituted or unsubstituted (C₁-C₆) aminoalkyl;

20 Z and Cy are as defined in Claim 1;

or pharmaceutically acceptable salts thereof.

5. A compound according to Claim 1 wherein:

R₁ and R₂ are both H or combined to form an oxo group (=O);

R₃ is selected from H, methyl, ethyl and propyl;

25 R₄ is H;

R₅ is selected from phenyl, 2-, 3-, 4- or 5-thienyl; all of which optionally substituted by one or more groups selected from 4-piperazinomethyl, (4-methylpiperazin-1-yl)methyl, piperidin-1-ylmethyl, hydroxymethyl,

dimethylaminomethyl and (3-(hydroxymethyl)azetidin-1-yl)methyl;

Z, and Cy are as defined in Claim 1;

or pharmaceutically acceptable salts thereof.

6. A compound according to Claim 1 wherein:

5 R₁ and R₂ are both H or are combined to form an oxo group (=O);

R₃ is selected from H, methyl, ethyl and propyl;

R₄ is H;

R₅ is selected from substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl;

10 Z is absent or NH;

Cy is an heteroaryl selected from the group of 9H purin-6-yl, 1H-pyrazolo[3,4-d]pyrimidin-1-yl, and 6-pyrimidinyl; which are all optionally substituted by one or more groups selected from halogen, CN, NR₁₀R₁₁, optionally substituted aryl and optionally substituted heteroaryl, selected from phenyl, 2-, 3-, 4-, 5-, 6-pyridinyl;

15 R₁₀, R₁₁, the same or different, are at each occurrence independently selected from the group consisting of H, (C₁-C₆) aminoalkyl, (C₁-C₆) hydroxyalkyl and (C₁-C₆) alkyl, or taken together with the nitrogen atom they are linked to, R₁₀ and R₁₁ may form, a 5 to 6 membered heterocyclic radical;

or pharmaceutically acceptable salts thereof.

20 7. A compound according to Claim 1 wherein:

R₁ and R₂ are both H or combined to form an oxo group (=O);

R₃ is selected from H, methyl or ethyl;

R₄ is H;

25 R₅ is selected from an aryl which is phenyl, an heteroaryl selected from 2-, 3-, 4- or 5-thienyl, which are all optionally substituted by one or more groups selected from 4-piperazinomethyl, (4-methylpiperazin-1-yl)methyl, piperidin-1-ylmethyl, hydroxymethyl, dimethylaminomethyl and (3-(hydroxymethyl)azetidin-1-yl)methyl;

Z is absent or NH;

Cy is a heteroaryl selected from the group of 9H-purin-6-yl; 1H-pyrazolo[3,4-d]pyrimidin-1-yl; and 2-, 4-, 5- or 6-pyrimidinyl; which are all optionally substituted by one or more groups selected from Cl, Br, F, I, -CN, NH₂, optionally substituted aryl selected from 3-fluoro-5-hydroxyphenyl, 3-chloro-5-hydroxyphenyl and 3-cyano-5-hydroxyphenyl; optionally substituted heteroaryl selected from hydroxy-pyridyl and (2,2,2-trifluoro-1-(pyridin-3-yl)ethanol)5yl;

or pharmaceutically acceptable salts thereof.

8. A compound according to Claim 1 wherein:

R₁ and R₂ are both H;

10 R₃ is selected from H, methyl or ethyl;

R₄ is H;

R₅ is selected from substituted or unsubstituted (C₃-C₆) heterocycloalkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl;

Z is absent;

15 Cy is 1H-pyrazolo[3,4-d]pyrimidin-1-yl, optionally and independently substituted by one or more groups selected from halogen, NR₁₀R₁₁, (C₁-C₆) alkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl;

or pharmaceutically acceptable salts or solvates thereof.

9. A compound according to Claim 1 wherein:

20 R₁ and R₂ are both H;

R₃ is selected from H, methyl or ethyl;

R₄ is H;

25 R₅ is selected from the group of phenyl, 2-, 3-, 4- or 5-thienyl, which are all optionally substituted by one or more groups selected from substituted or unsubstituted (C₁-C₆) aminoalkyl;

Z is absent;

Cy is 1H-pyrazolo[3,4-d]pyrimidin-1-yl, optionally substituted by one or more groups selected independently from halogen, NR₁₀R₁₁, phenyl and heteroaryl which

is pyridinyl; said phenyl and heteroaryl in their turn further optionally and independently substituted by one or more groups selected from halogen, -OH, -CN; NR₁₀R₁₁ (C₁-C₆) -haloalkyl, (C₁-C₆) hydroxyalkyl;

R₁₀, R₁₁, the same or different, are at each occurrence independently selected
5 from the group consisting of H, (C₁-C₆) aminoalkyl, (C₁-C₆) hydroxyalkyl and (C₁-C₆) alkyl, or taken together with the nitrogen atom they are linked to, R₁₀ and R₁₁ may form, a 5 to 6 membered heterocyclic radical;

or pharmaceutically acceptable salts or solvates thereof.

10. A compound according to Claim 1 wherein:

10 R₁ and R₂ are both H or are combined to form an oxo group (=O);

R₃ is selected from H and methyl;

R₄ is H;

R₅ is phenyl or thienyl; said phenyl or thienyl being optionally substituted by a group selected from substituted or unsubstituted (C₁-C₆) aminoalkyl, or (C₁-C₆)
15 hydroxyalkyl;

Z is absent or NH;

Cy is a heteroaryl selected from the group of 9H-purin-6-yl; 1H-pyrazolo[3,4-d]pyrimidin-1-yl; and 2-, 4-, 5- or 6-pyrimidinyl; which are all optionally substituted by one or more groups selected from CN, NH₂, aryl selected from 3-fluoro-5-hydroxyphenyl, 3-chloro-5-hydroxyphenyl and 3-cyano-5-hydroxyphenyl; heteroaryl
20 selected from 3-hydroxy-5-pyridyl, (2,2,2-trifluoro-1-(pyridin-3-yl)ethanol)5yl;

or pharmaceutically acceptable salt thereof.

11. A compound according to claim 1 selected from:

3-((4-amino-3-(3-fluoro-5-hydroxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-1-yl)methyl)-4-phenyl-2H-chromen-2-one;

3-(1-(4-amino-3-(3-fluoro-5-hydroxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-1-yl)ethyl)-4-phenyl-2H-chromen-2-one;

3-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol;

5-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-ol;

5 3-((9H-purin-6-ylamino)methyl)-4-phenyl-2H-chromen-2-one;

3-(1-(9H-purin-6-ylamino)ethyl)-4-phenyl-2H-chromen-2-one;

N-((4-phenyl-2H-chromen-3-yl)methyl)-9H-purin-6-amine;

4-amino-6-((4-phenyl-2H-chromen-3-yl)methylamino)pyrimidine-5-carbonitrile;

10 4-amino-6-(1-(4-phenyl-2H-chromen-3-yl)ethylamino)pyrimidine-5-carbonitrile;

1-(5-(4-amino-1-(1-(4-phenyl-2H-chromen-2-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-yl)-2,2,2-trifluoroethan-1-ol;

15 3-(4-amino-1-(1-(4-phenyl-2H-chromen-2-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-hydroxybenzonitrile;

3-(4-amino-1-(1-(4-phenyl-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-chlorophenol;

3-(4-amino-1-(1-(4-(5-((4-methylpiperazin-1-yl)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol;

20 3-(4-amino-1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol;

3-(4-amino-1-(1-(4-(5-(hydroxymethyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)-5-fluorophenol;

25 5-(4-amino-1-(1-(4-(5-((dimethylamino)methyl)thiophen-2-yl)-2H-chromen-3-yl)ethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl)pyridin-3-ol

or pharmaceutically acceptable salt thereof.

12. A pharmaceutical composition comprising a compound as defined in anyone from claim 1 to 11, or a pharmaceutically acceptable salt thereof, in admixture with

one or more pharmaceutically acceptable carrier or excipient.

13. A pharmaceutical composition comprising a compound as defined in anyone from claim 1 to 11 or a pharmaceutically acceptable salt thereof in combination with one or more active ingredient selected from beta₂-agonists, antimuscarinic agents, corticosteroids mitogen-activated kinases (P38 MAP kinases) inhibitors, nuclear factor kappa-B kinase subunit beta inhibitors (IKK2), human neutrophil elastase (HNE) inhibitors, phosphodiesterase 4 (PDE4) inhibitors, leukotriene modulators, non-steroidal anti-inflammatory agents (NSAIDs) and mucus regulators; in admixture with one or more pharmaceutically acceptable carrier or excipient.

14. A compound according to any one of claims 1 to 11, for use as a medicament.

15. A compound as defined in any one of claims 1 to 11, or a pharmaceutically acceptable salt thereof, for use as a medicament for the treatment of a disorder associated by PI3K enzymes mechanisms.

16. A compound according to claim 15 wherein the disorder associated by PI3K enzymes mechanisms is selected from the group consisting of respiratory diseases including idiopathic chronic cough, cough variant asthma, cough associated with thoracic tumour or lung cancer, viral or post-viral cough, upper airways cough syndrome (UACS) or post nasal drip cough, or cough associated gastro oesophageal reflux disease (both acid and non acid reflux), chronic bronchitis, chronic obstructive pulmonary disease (COPD), interstitial lung disease (such as idiopathic pulmonary fibrosis (IPF)), congestive heart disease, sarcoidosis or infection (such as whooping cough), asthma, chronic obstructive pulmonary disease (COPD) and idiopathic pulmonary fibrosis (IPF)); viral infections (including viral respiratory tract infections and viral exacerbation of respiratory diseases such as asthma and COPD); non-viral respiratory infections (including aspergillosis and leishmaniasis); allergic diseases (including allergic rhinitis and atopic dermatitis); autoimmune diseases (including rheumatoid arthritis and multiple sclerosis); inflammatory disorders (including inflammatory bowel disease); cardiovascular diseases (including thrombosis and

atherosclerosis); hematologic malignancies; neurodegenerative diseases; pancreatitis; multiorgan failure; kidney diseases; platelet aggregation; cancer; sperm motility; transplantation rejection; graft rejection; lung injuries; and pain (including pain associated with rheumatoid arthritis or osteoarthritis, back pain, general inflammatory pain, post hepatic neuralgia, diabetic neuropathy, inflammatory neuropathic pain (trauma), trigeminal neuralgia and Central pain).

17 A compound according to claim 16 wherein the disorder associated by PI3K enzymes mechanisms is asthma, chronic obstructive pulmonary disease COPD idiopathic pulmonary fibrosis (IPF).

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/058261

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	C07D403/12	C07D473/34
	A61P11/00	A61P29/00
		A61P35/00
ADD.		
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)		
C07D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EPO-Internal, WPI Data, CHEM ABS Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2014/164942 A1 (UNIV MICHIGAN [US]; REHEMTULLA ALNAWAZ [US]; GALBAN STEPHANIE [US]) 9 October 2014 (2014-10-09) cited in the application claim 1 page 1, paragraph [0002] -----	1-17
A	US 2011/118257 A1 (MUTHUPPALANIAPPAN MEYYAPPAN [IN] ET AL) 19 May 2011 (2011-05-19) claim 1 page 1, paragraph [0002] -----	1-17
A	CN 102 746 281 A (UNIV SICHUAN) 24 October 2012 (2012-10-24) claim 1 page 7, paragraph [0002] -----	1-17
	-/-	
☒ Further documents are listed in the continuation of Box C. ☒ See patent family 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 application or patent 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 "T" 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 "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
21 June 2016		06/07/2016
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Beligny, Samuel

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/058261

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/005247 A1 (ALARCON SANCHEZ BALBINO JOSE [ES] ET AL) 2 January 2014 (2014-01-02) cited in the application claims 1, 18, 19 -----	1-17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/058261

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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