Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2901869 A1 2014/09/04

(21) 2 901 869

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2014/02/27
(87) Date publication PCT/PCT Publication Date: 2014/09/04
(85) Entrée phase nationale/National Entry: 2015/08/19
(86) N° demande PCT/PCT Application No.: EP 2014/053874
(87) N° publication PCT/PCT Publication No.: 2014/131852
(30) Priorités/Priorities: 2013/02/27 (EP13382060.5); 2013/03/22 (US61/804,558); 2013/07/16 (EP13382290.8)

(51) Cl.Int./Int.Cl. *A61K 31/4709* (2006.01), *A61K 31/56* (2006.01), *A61K 31/58* (2006.01), *A61P 11/00* (2006.01)

(71) Demandeur/Applicant:
ALMIRALL, S.A., ES

(72) Inventeurs/Inventors:
APARICI VIRGILI, MONICA, ES;
CALBET MURTRO, MARTA, ES;
MIRALPEIX GUELL, MONTSERRAT, ES;
GAVALDA MONEDERO, AMADEU, ES;
PUIG DURAN, CARLOS, ES

(74) Agent: BLAKE, CASSELS & GRAYDON LLP

(54) Titre : COMBINAISONS COMPRENANT DES COMPOSES MABA ET DES CORTICOSTEROIDES
(54) Title: COMBINATIONS COMPRISING MABA COMPOUNDS AND CORTICOSTEROIDS

(57) Abrégé/Abstract:
A combination which comprises (a) corticosteroid and (b) a dual muscarinic antagonist - β2 adrenergic agonist compound, or any pharmaceutically acceptable salt or solvate thereof.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 September 2014 (04.09.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/131852 A1

(51) International Patent Classification:
A61K 31/4709 (2006.01) *A61K 31/58* (2006.01)
A61K 31/56 (2006.01) *A61P 11/00* (2006.01)

(21) International Application Number:
PCT/EP2014/053874

(22) International Filing Date:
27 February 2014 (27.02.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

13382060.5	27 February 2013 (27.02.2013)	EP
61/804,558	22 March 2013 (22.03.2013)	US
13382290.8	16 July 2013 (16.07.2013)	EP

(71) Applicant: **ALMIRALL, S.A.** [ES/ES]; Ronda del General Mitre 151, E-08022 Barcelona (ES).

(72) Inventors: **APARICI VIRGILI, Monica**; C/ Laureà Miró 408-410, Sant Feliu de Llobregat, E-08980 Barcelona (ES). **CALBET MURTRO, Marta**; C/ Laureà Miró 408-410, Sant Feliu de Llobregat, E-08980 Barcelona (ES). **MIRALPEIX GUELL, Montserrat**; C/ Laureà Miró 408-410, Sant Feliu de Llobregat, E-08980 Barcelona (ES). **GAVALDA MONEDERO, Amadeu**; C/ Laureà Miró 408-410, Sant Feliu de Llobregat, E-08980 Barcelona (ES). **PUIG DURAN, Carlos**; C/ Laureà Miró 408-410, Sant Feliu de Llobregat, E-08980 Barcelona (ES).

(74) Agent: **SRINIVASAN, Ravi Chandran**; 14 South Square, Gray's Inn, London Greater London WC1R 5JJ (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2014/131852 A1

(54) Title: COMBINATIONS COMPRISING MABA COMPOUNDS AND CORTICOSTEROIDS

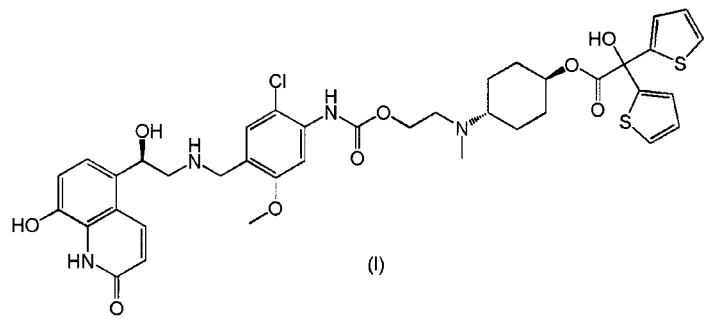
(57) Abstract: A combination which comprises (a) corticosteroid and (b) a dual muscarinic antagonist - β2 adrenergic agonist compound, or any pharmaceutically acceptable salt or solvate thereof.

COMBINATIONS COMPRISING MABA COMPOUNDS AND CORTICOSTEROIDS

The present invention relates to a combination of two or more pharmaceutically active substances for use in the treatment of respiratory diseases. In particular, the present invention relates to a combination of a corticosteroid with a compound having a dual muscarinic antagonist and a β2 adrenergic agonist activity (MABA).

BACKGROUND OF THE INVENTION

Trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}(methyl)amino]-cyclohexyl hydroxy(di-2-thienyl)acetate is described in WO 2011/141180. It has the structure shown below.



(I)

The compound of formula (I) is a potent dual-acting muscarinic antagonist-β2 agonist (MABA) intended for administration by inhalation for treatment of respiratory diseases, especially asthma and chronic obstructive pulmonary disease (COPD), currently in clinical trials.

DESCRIPTION OF THE INVENTION

Surprisingly, an unexpectedly beneficial therapeutic effect can be observed in the treatment of inflammatory or obstructive diseases of the respiratory tract if a dual muscarinic antagonist - β2 adrenergic agonist compound of the present invention is used with one or more corticosteroids.

In particular, the combination of a dual muscarinic antagonist - β2 adrenergic agonist compound of the present invention with a corticosteroid produces significantly greater inhibition of Interleukin-8 (IL-8) secretion, which is associated with inflammatory and obstructive diseases of the respiratory tract, as compared to that obtained with the corticosteroid alone.

Thus, the present invention provides a combination which comprises (a) a corticosteroid and (b) a dual muscarinic antagonist - β2 adrenergic agonist compound which is trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate, or any pharmaceutically acceptable salt or solvate thereof.

The invention also provides a pharmaceutical composition comprising the combination of the present invention and a pharmaceutically-acceptable carrier.

The invention also provides a method of treating a disease or condition associated with dual muscarinic receptor and β2 adrenergic receptor activities (e.g. a pulmonary disease, such as asthma or chronic obstructive pulmonary disease, pre-term labor, glaucoma, a neurological disorder, a cardiac disorder, inflammation, urological disorders such as urinary incontinence and gastrointestinal disorders such as irritable bowel syndrome or spastic colitis) in a mammal, comprising administering to the mammal, a therapeutically effective amount of a compound of formula (I) with a corticosteroid.

Also is provided a product, a kit of parts or a package comprising (a) a corticosteroid and (b) a dual muscarinic antagonist - β2 adrenergic agonist compound of formula (I), as a combined preparation for simultaneous, concurrent, separate or sequential use in the treatment of a patient suffering from or susceptible to a disease as defined above.

DETAILED DESCRIPTION OF THE INVENTION.

The term "therapeutically effective amount" refers to an amount sufficient to effect treatment when administered to a patient in need of treatment.

The term "treatment" as used herein refers to the treatment of a disease or medical condition in a human patient which includes:

(a) preventing the disease or medical condition from occurring, i.e., prophylactic treatment of a patient;

(b) ameliorating the disease or medical condition, i.e., causing regression of the disease or medical condition in a patient;

(c) suppressing the disease or medical condition, i.e., slowing the development of the disease or medical condition in a patient; or

(d) alleviating the symptoms of the disease or medical condition in a patient.

The phrase "disease or condition associated with muscarinic receptor and β2 adrenergic receptor activities" includes all disease states and/or conditions that are acknowledged now, or that are found in the future, to be associated with both muscarinic receptor and β2 adrenergic receptor activity. Such disease states include, but are not limited to, pulmonary diseases, such as asthma and chronic obstructive pulmonary disease (including chronic bronchitis and emphysema), as well as neurological disorders and cardiac disorders. β2 adrenergic receptor activity is also known to be associated with pre-term labor (see International Patent Application Publication Number WO 98/09632), glaucoma and some types of inflammation (see International Patent Application Publication Number WO 99/30703 and Patent Application Publication Number EP 1 078 629).

On the other hand M3 receptor activity is associated with gastrointestinal-tract disorders such as Irritable bowel syndrome (IBS) (see, for ex., US5397800), gastrointestinal (GI) ulcers , spastic colitis (see, for ex., US 4556653); urinary-tract disorders such as urinary incontinence (see, for ex., J.Med.Chem., 2005, 48, 6597-6606), pollakiuria; motion sickness and vagally induced sinus bradycardia.

The term "solvate" refers to a complex or aggregate formed by one or more molecules of a solute, i.e. a compound of the invention or a pharmaceutically-acceptable salt thereof, and one or more molecules of a solvent. Such solvates are typically crystalline solids having a substantially fixed molar ratio of solute and solvent. Representative solvents include by way of example, water, methanol, ethanol, isopropanol, acetic acid, and the like. When the solvent is water, the solvate formed is a hydrate.

It will be appreciated that the term "or a pharmaceutically acceptable salt or solvate thereof" is intended to include all permutations of salts and solvates, such as a solvate of a pharmaceutically-acceptable salt of a compound of the invention.

The respiratory disease or condition to be treated with the formulations and methods of the present invention is typically asthma, acute or chronic bronchitis, emphysema, chronic obstructive pulmonary disease (COPD), bronchial hyperreactivity or rhinitis, in particular asthma or chronic obstructive pulmonary disease (COPD).

The term "pharmaceutically-acceptable salt" refers to a salt prepared from a base or acid which is acceptable for administration to a patient, such as a mammal. Such salts can be derived from pharmaceutically-acceptable inorganic or organic bases and from pharmaceutically-acceptable inorganic or organic acids.

Salts derived from pharmaceutically-acceptable acids include acetic, benzenesulfonic, benzoic, camphosulfonic, citric, ethanesulfonic, formic, fumaric, gluconic, glutamic, hydrobromic, hydrochloric, hydrofluoric, lactic, maleic, malic, mandelic, methanesulfonic, mucic, nitric, pantothenic, phosphoric, succinic, sulfuric, tartaric, p-toluenesulfonic, xinafoic (1-hydroxy-2-naphthoic acid), napadisilic (1,5-naphthalenedisulfonic acid), triphenyl acetic and the like.

Salts derived from pharmaceutically-acceptable inorganic bases include aluminum, ammonium, calcium, copper, ferric, ferrous, lithium, magnesium, manganic, manganous, potassium, sodium, zinc and the like.

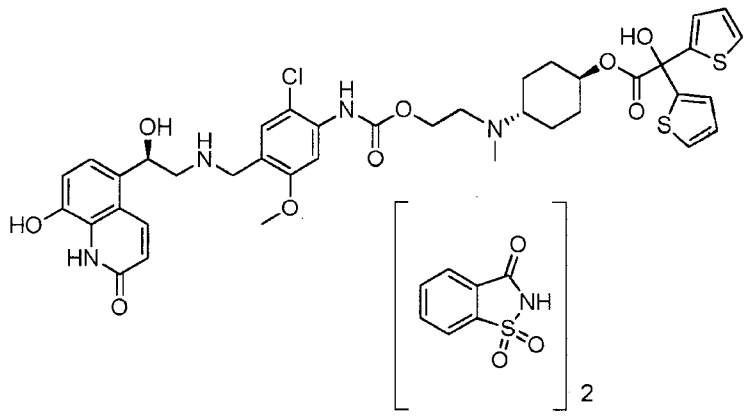
Salts derived from pharmaceutically-acceptable organic bases includes sulfimide derivatives, such as, benzoic sulfimide (also known as saccharin), thieno[2,3-d]isothiazol-3(2H)-one 1,1-dioxide and isothiazol-3(2H)-one 1,1-dioxide, salts of primary, secondary and tertiary amines, including substituted amines, cyclic amines, naturally-occurring amines and the like, such as arginine, betaine, caffeine, choline, N,N'-dibenzylethylenediamine, diethylamine, 2-diethylaminoethanol, 2-dimethylaminoethanol, ethanolamine, ethylenediamine, N-ethylmorpholine, N-ethylpiperidine, glucamine, glucosamine, histidine, hydrabamine, isopropylamine, lysine, methylglucamine, morpholine, piperazine, piperidine, polyamine resins, procaine, purines, theobromine, triethylamine, trimethylamine, tripropylamine, tromethamine and the like.

Typically, the compound of formula (I), in the combination product of the present invention, is administered in the form a salt derived from pharmaceutically-acceptable sulfimide derivative, such as, benzoic sulfimide (also known as saccharin), thieno[2,3-d]isothiazol-3(2H)-one 1,1-dioxide and isothiazol-3(2H)-one 1,1-dioxide or from pharmaceutically acceptable acids including citric, lactic, mucic, L-tartaric acid,

pantothenic, glucuronic, lactobionic, gluconic, 1-hydroxy-2-naphthoic, mandelic, malic, methanesulfonic, ethanedisulfonic, benzenesulphonic, p-toluenesulfonic, naphthalene-1,5-disulfonic, napthalene-2-sulfonic, (1S)-camphor-10-sulfonic. Particularly preferred are salts derived from ethanesulphonic acid, L-tartaric acid and benzoic sulfimide (saccharin), being most preferred L-tartaric acid and benzoic sulfimide (saccharin).

Thus in one embodiment, the salt of the dual muscarinic antagonist - β2 adrenergic agonist compound used in the present invention is derived from L-tartaric acid. Thus, the dual muscarinic antagonist - β2 adrenergic agonist compound is preferably the L-tartrate salt of trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate.

Salts derived from saccharin (benzoic sulfimide) are typically saccharinate or disaccharinate and pharmaceutically acceptable solvates thereof. The MABA compound trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]-ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate is preferably administered in the form of a disaccharinate salt (ie. trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate, disaccharinate) having the following chemical structure:



Typically the combination contains the active ingredients (a) and (b) forming part of a single pharmaceutical composition.

Also provided is a product comprising (a) a corticosteroid and (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention as a combined preparation for

simultaneous, separate or sequential use in the treatment of a human or animal patient.

Typically the product is for simultaneous, separate or sequential use in the treatment of a respiratory disease which is asthma, acute or chronic bronchitis, emphysema, chronic obstructive pulmonary disease (COPD), bronchial hyperreactivity or rhinitis in a human or animal patient.

The present invention further provides the use of (a) a corticosteroid and (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention for the preparation of a medicament for simultaneous, concurrent, separate or sequential use in the treatment of a said respiratory disease in a human or animal patient.

Also provided is the use of (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention for the preparation of a medicament, for simultaneous, concurrent, separate or sequential use in combination with (a) a corticosteroid for the treatment of a said respiratory disease in a human or animal patient.

Also provided is the use of (a) a corticosteroid for the preparation of a medicament for use in the treatment of a said respiratory disease in a human or animal patient by simultaneous, concurrent, separate or sequential co-administration in combination with (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention.
The invention further provides a dual muscarinic antagonist - β2 adrenergic agonist compound of the invention for simultaneous, concurrent, separate or sequential use in combination with a corticosteroid for the treatment of a said respiratory disease.

The invention further provides (a) a corticosteroid as for simultaneous, concurrent, separate or sequential use in combination with (b) a dual muscarinic antagonist - β2 adrenergic agonist compound of the invention for the treatment of a said respiratory disease.

The invention further provides a combination of the invention for simultaneous, concurrent, separate or sequential use in the treatment of a said respiratory disease.

Typically said respiratory disease is selected from asthma, acute or chronic bronchitis, emphysema, chronic obstructive pulmonary disease (COPD), bronchial hyperreactivity

and rhinitis, preferably selected from asthma and chronic obstructive pulmonary disease (COPD).

Preferably said patient is human.

Also provided is a pharmaceutical composition comprising (a) a corticosteroid and (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention in association with (c) a pharmaceutically acceptable carrier or diluent.

The invention also provides a kit of parts comprising (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention together with instructions for simultaneous, concurrent, separate or sequential use in combination with (a) a corticosteroid, for the treatment of a human or animal patient suffering from or susceptible to a said respiratory disease.

Further provided is a package comprising (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention and (a) a corticosteroid for the simultaneous, concurrent, separate or sequential use in the treatment of a said respiratory disease.

Further provided is a combination, product, kit of parts or package as hereinabove described wherein such combination, product, kit of parts or package further comprises (c) another active compound selected from: (i) PDE IV inhibitors, (ii) leukotriene D4 antagonists, (iii) inhibitors of egfr-kinase, (iv) p38 kinase inhibitors , (iv) JAK inhibitors and (v) NK1 receptor agonists for simultaneous, separate or sequential use.

It is an embodiment of the present invention that the combination, product, kit of parts or package comprise (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention and (a) a corticosteroid, as the sole active compounds.

It is also an embodiment of the present invention the use of (b) a dual muscarinic antagonist - β2 adrenergic agonist of the invention and (a) a corticosteroid without any other active compound for the preparation of a medicament for simultaneous, concurrent, separate or sequential use in the treatment of a respiratory disease as defined above.

Examples of suitable corticosteroids to be used in the combinations of the invention are prednisolone, methylprednisolone, dexamethasone, dexamethasone acetate,

dexamethasone cipecilate, naflocort, deflazacort, halopredone acetate, budesonide, beclomethasone dipropionate, hydrocortisone, triamcinolone acetonide, fluocinolone acetonide, fluocinonide, clocortolone pivalate, methylprednisolone aceponate, dexamethasone palmitoate, tipredane, hydrocortisone aceponate, prednicarbate, alclometasone dipropionate, halometasone, methylprednisolone suleptanate, mometasone, mometasone furoate, rimexolone, prednisolone farnesylate, ciclesonide, butixocort propionate, (6alpha,11beta,16beta,17alpha)-6,9-Difluoro-11-hydroxy-16-methyl-3-oxo-17-(1-oxopropoxy)androsta-1,4-diene-17-carbothioic acid S-methyl ester (RS-85095), 9alpha-Chloro-6alpha-fluoro-11beta-hydroxy-16alpha-methyl-3-oxo-17alpha-propanoyloxy-androsta-1,4-diene-17beta-carboxylic acid methyl ester (CGP-13774), 16alpha,17alpha-[(R)-Butylidenedioxy]-6alpha,9alpha-difluoro-11beta-hydroxy-3-oxo-4-androstene-17beta-carbothioic acid S-(2-oxotetrahydrofuran-3-y) ester (GW-250495), deltacortisone, NO-Prednisolone, NO-Budesonide, etiprednol dicloacetate, QAE-397, (3beta,5alpha,7beta)-3,7-Dihydroxyandrostan-17-one (7beta-OH-EPIA), 16alpha,17alpha-[(R)-Butylidenedioxy]-6alpha,9alpha-difluoro-11beta-hydroxy-17beta-(methylsulfanyl)androst-4-en-3-one (RPR-106541), deprodone propionate, fluticasone, fluticasone propionate, fluticasone furoate, halobetasol propionate, loteprednol etabonate, betamethasone butyrate propionate, flunisolide, prednisone, dexamethasone sodium phosphate, triamcinolone, betamethasone 17-valerate, betamethasone, betamethasone dipropionate, 21-Chloro-11beta-hydroxy-17alpha-[2-(methylsulfanyl)acetoxy]-4-pregnene-3,20-dione, desisobutyrylciclesonide, hydrocortisone acetate, hydrocortisone sodium succinate, prednisolone sodium phosphate and hydrocortisone probutate, prednisolone sodium metasulfobenzoate and clobetasol propionate.

The preferred corticosteroids to be used in the combinations of the invention are prednisolone, methylprednisolone, dexamethasone, naflocort, deflazacort, halopredone acetate, budesonide, beclomethasone dipropionate, hydrocortisone, triamcinolone acetonide, fluocinolone acetonide, fluocinonide, clocortolone pivalate, methylprednisolone aceponate, dexamethasone palmitoate, tipredane, hydrocortisone aceponate, prednicarbate, alclometasone dipropionate, halometasone, methylprednisolone suleptanate, mometasone furoate, rimexolone, prednisolone famesylate, ciclesonide, deprodone propionate, fluticasone, fluticasone propionate, fluticasone furoate, halobetasol propionate, loteprednol etabonate, betamethasone butyrate propionate, flunisolide, prednisone, dexamethasone sodium phosphate, triamcinolone, betamethasone 17- valerate, betamethasone, hydrocortisone acetate,

hydrocortisone sodium succinate, prednisolone sodium phosphate and hydrocortisone probutate.

Particularly preferred corticosteroids under the present invention are: budesonide, beclomethasone dipropionate, mometasone furoate, ciclesonide, triamcinolone, triamcinolone acetonide, triamcinolone hexaacetonide, fluticasone, fluticasone propionate and fluticasone furoate optionally in the form of their racemates, their enantiomers, their diastereomers and mixtures thereof, and optionally their pharmacologically-compatible acid addition salts. More preferred are budesonide, mometasone furoate, fluticasone, fluticasone propionate and fluticasone furoate, being the most preferred corticosteroids are mometasone, fluticasone propionate and fluticasone furoate.

Any reference to corticosteroids within the scope of the present invention includes a reference to salts or derivatives thereof which may be formed from the corticosteroids. Examples of possible salts or derivatives include: sodium salts, sulphobenzoates, phosphates, isonicotinates, acetates, propionates, dihydrogen phosphates, palmitates, pivaiates, farnesylates, aceponates, suleptanates, prednicarbates, furoates or acetonides. In some cases the corticosteroids may also occur in the form of their hydrates.

A preferred embodiment of the present invention is a combination of L-tartrate salt of a trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]-ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate with a corticosteroid. Preferred corticosteroids are selected from budesonide, beclomethasone dipropionate, mometasone furoate, ciclesonide, fluticasone, fluticasone propionate and fluticasone furoate, more preferably, mometasone furoate, fluticasone propionate and fluticasone furoate.

A particularly preferred embodiment of the present invention is a combination of a trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]-ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate disaccharinate with a corticosteroid. Preferred corticosteroids are selected from budesonide, beclomethasone dipropionate, mometasone furoate, ciclesonide, fluticasone,

fluticasone propionate and fluticasone furoate, more preferably, mometasone furoate, fluticasone propionate and fluticasone furoate.

According to another embodiment of the invention the corticosteroid is budesonide.

According to another embodiment of the invention the corticosteroid is mometasone furoate.

According to another embodiment of the invention the corticosteroid is fluticasone.

According to another embodiment of the invention the corticosteroid is fluticasone propionate.

According to another embodiment of the invention the corticosteroid is fluticasone furoate

In an alternative execution the invention consist in a kit of parts comprising a dual muscarinic antagonist - β2 adrenergic agonist of the invention together with instructions for simultaneous, concurrent, separate or sequential use in combination with a corticosteroid for the treatment of a respiratory disease, in particular for the treatment of asthma or COPD.

The present invention may also be executed in the form of a package comprising a dual muscarinic antagonist - β2 adrenergic agonist of the invention and a corticosteroid for the simultaneous, concurrent, separate or sequential use in the treatment of a respiratory disease, in particular for the treatment of asthma or COPD.

It is also an object of the present invention a dual muscarinic antagonist - β2 adrenergic agonist of the invention for simultaneous, concurrent, separate or sequential use in combination with a corticosteroid for the treatment of a respiratory disease, in particular for the treatment of asthma or COPD.

It is also an object of the present invention the use of a dual muscarinic antagonist - β2 adrenergic agonist of the invention for the preparation of a medicament, for simultaneous, concurrent, separate or sequential use in combination with a corticosteroid for the treatment of a respiratory disease, in particular for the treatment of asthma or COPD.

The invention is also directed to a method of treating a patient suffering a disease or condition for use in the treatment of a pathological condition or disease associated with both muscarinic receptor antagonist and β2 adrenergic receptor agonist activities, in particular for the treatment of respiratory diseases (such as, asthma, acute or chronic bronchitis, emphysema, chronic obstructive pulmonary disease (COPD), bronchial hyperreactivity or rhinitis), pre-labor, glaucoma, neurological disorders, cardiac disorders, inflammation and gastrointestinal disorders, more preferably respiratory disease, such as asthma or COPD, comprising administering to the patient an effective amount of a dual muscarinic antagonist - β2 adrenergic agonist of the invention and a corticosteroid.

Any reference to corticosteroids within the scope of the present invention includes a reference to salts or derivatives thereof which may be formed from the corticosteroids. Examples of possible salts or derivatives include: sodium salts, sulphobenzoates, phosphates, isonicotinates, acetates, propionates, dihydrogen phosphates, palmitates, pivaiates, farnesylates, aceponates, suleptanates, prednicarbates, furoates or acetonides. In some cases the corticosteroids may also occur in the form of their hydrates.

A particularly preferred embodiment of the present invention is a combination of trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate, or any pharmaceutically acceptable salt or solvate thereof with a corticosteroid selected from budesonide, beclomethasone, ciclesonide and fluticasone and esters thereof.

Even more preferred is the combination of trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate, or any pharmaceutically acceptable salt or solvate thereof with fluticasone and the combination of trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}-carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate, or any pharmaceutically acceptable salt or solvate thereof with budesonide.

It is a most preferred execution of the present invention that, in the combination, kit of parts, package, use or method of treatment described above, the compound of formula (I) is trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate disaccharinate.

More preferably the corticosteroid may be selected from the group comprising budesonide, beclomethasone, mometasone, ciclesonide and fluticasone optionally in the form of their racemates, their enantiomers, their diastereomers and mixtures thereof, and optionally their pharmacologically-compatible acid addition salts and most preferably it is selected from mometasone and fluticasone.

The combinations of the invention can optionally comprise one or more additional active substances which are known to be useful in the treatment of respiratory disorders, such as PDE4 inhibitors, leukotriene D4 inhibitors, inhibitors of egfr-kinase, p38 kinase inhibitors, JAK inhibitors and/or NK1-receptor antagonists.

The invention thus provides a method of treating a disease or condition associated with dual muscarinic receptor and β2 adrenergic receptor activities (e.g. a respiratory disease, such as asthma or chronic obstructive pulmonary disease, pre-term labor, glaucoma, a neurological disorder, a cardiac disorder, inflammation, urological disorders such as urinary incontinence and gastrointestinal disorders such as irritable bowel syndrome or spastic colitis) in a mammal, comprising administering to the mammal, a therapeutically effective amount of a compound of formula(I) with one or more other therapeutic agents.

Examples of suitable PDE4 inhibitors to be used in the combinations of the invention are benafentrine dimaleate, etazolate, denbufylline, rolipram, cipamfylline, zardaverine, arofylline, filaminast, tipelukast, tofimilast, piclamilast, tolafentrine, mesopram, drotaverine hydrochloride, lirimilast, roflumilast, cilomilast, oglemilast, apremilast, tetomilast, filaminast, (R)-(+)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine (CDP-840), N-(3,5-Dichloro-4-pyridinyl)-2-[1-(4-fluorobenzyl)-5-hydroxy-1H-indol-3-yl]-2-oxoacetamide (GSK-842470), 9-(2-Fluorobenzyl)-N6-methyl-2-(trifluoromethyl)adenine (NCS-613), N-(3,5-Dichloro-4-pyridinyl)-8-methoxyquinoline-5-carboxamide (D-4418), 3-[3-(Cyclopentyloxy)-4-methoxybenzyl]-6-(ethylamino)-8-isopropyl-3H-purine hydrochloride (V-11294A), 6-[3-(N,N-

Dimethylcarbamoyl)phenylsulfonyl]-4-(3-methoxyphenylamino)-8-methylquinoline-3-carboxamide hydrochloride (GSK-256066), 4-[6,7-Diethoxy-2,3-bis(hydroxymethyl)naphthalen-1-yl]-1-(2-methoxyethyl)pyridin-2(1H)-one (T-440), (-)-trans-2-[3'-[3-(N-Cyclopropylcarbamoyl)-4-oxo-1,4-dihydro-1,8-naphthyridin-1-yl]-3-fluorobiphenyl-4-yl]cyclopropanecarboxylic acid (MK-0873), CDC-801, UK-500001, BLX-914, 2-carbomethoxy-4-cyano-4-(3-cyclopropylmethoxy-4-difluroromethoxyphenyl)cyclohexan1-one, *cis* [4-cyano-4-(3-cyclopropylmethoxy-4-difluoromethoxyphenyl)cyclohexan-1-ol, CDC-801 and 5(S)-[3-(Cyclopentyloxy)-4-methoxyphenyl]-3(S)-(3-methylbenzyl)piperidin-2-one (IPL-455903).

Examples of suitable LTD4 antagonists to be used in the combinations of the invention are tomelukast, ibudilast, pobilukast, pranlukast hydrate, zafirlukast, ritolukast, verlukast, sulukast, cinalukast, iralukast sodium, montelukast sodium, 4-[4-[3-(4-Acetyl-3-hydroxy-2-propylphenoxy)propylsulfonyl]phenyl]-4-oxobutyric acid, [[5-[[3-(4-Acetyl-3-hydroxy-2-propylphenoxy)propyl]thio]-1,3,4-thiadiazol-2-yl]thio]acetic acid, 9-[(4-Acetyl-3-hydroxy-2-n-propylphenoxy)methyl]-3-(1H-tetrazol-5-yl)-4H-pyrido[1,2-a]pyrimidin-4-one, 5-[3-[2-(7-Chloroquinolin-2-yl)vinyl]phenyl]-8-(N,N-dimethylcarbamoyl)-4,6-dithiaoctanoic acid sodium salt; 3-[1-[3-[2-(7-Chloroquinolin-2-yl)vinyl]phenyl]-1-[3-(dimethylamino)-3-oxopropylsulfanyl]methylsulfanyl]propionic acid sodium salt, 6-(2-Cyclohexylethyl)-[1,3,4]thiadiazolo[3,2-a]-1,2,3-triazolo[4,5-d]pyrimidin-9(1H)-one, 4-[6-Acetyl-3-[3-(4-acetyl-3-hydroxy-2-propylphenylthio)propoxy]-2-propylphenoxy]butyric acid, (R)-3-Methoxy-4-[1-methyl-5-[N-(2-methyl-4,4,4-trifluorobutyl)carbamoyl]indol-3-ylmethyl]-N-(2-methylphenylsulfonyl)benzamide, (R)-3-[2-Methoxy-4-[N-(2-methylphenylsulfonyl)carbamoyl]benzyl]-1-methyl-N-(4,4,4-trifluoro-2-methylbutyl)indole-5-carboxamide and (+)-4(S)-(4-Carboxyphenylthio)-7-[4-(4-phenoxybutoxy)phenyl]-5(Z)-heptenoic acid.

Examples of suitable inhibitors of egfr-kinase to be used in the combinations of the invention are palifermin, cetuximab, gefitinib, repifermin, erlotinib hydrochloride, canertinib dihydrochloride, lapatinib, and N-[4-(3-Chloro-4-fluorophenylamino)-3-cyano-7-ethoxyquinolin-6-yl]-4-(dimethylamino)-2(E)-butenamide.

Examples of suitable p38 kinase inhibitors to be used in the combinations of the invention are chlormethiazole edisylate, doramapimod, 5-(2,6-Dichlorophenyl)-2-(2,4-difluorophenylsulfanyl)-6H-pyrimido[3,4-b]pyridazin-6-one, 4-Acetamido-N-(tert-butyl)benzamide, SCIO-469 (described in Clin Pharmacol. Ther. 2004, 75(2): Abst PII-7 and VX-702 described in Circulation 2003, 108(17, Suppl. 4): Abst 882.

Example of JAK inhibitors to be used in the combinations of the invention are Janus kinase (JAK) inhibitors, such as 3-[4(R)-Methyl-3(R)-[N-methyl-N-(7H-pyrrolo[2,3-d]pyrimidin-4-yl)amino]piperidin-1-yl]-3-oxopropanenitrile citrate (tofacitinib), ASP-015K, JTE-052, 3(R)-Cyclopentyl-3-[4-(7H-pyrrolo[2,3-d]pyrimidin-4-yl)-1H-pyrazol-1-yl]propanenitrile phosphate (Ruxolitinib), 5-Chloro-N2-[1(S)-(5-fluoropyrimidin-2-yl)ethyl]-N4-(5-methyl-1H-pyrazol-3-yl)pyrimidine-2,4-diamine (AZD-1480), 2-[1-(Ethylsulfonyl)-3-[4-(7H-pyrrolo[2,3-d]pyrimidin-4-yl)-1H-pyrazol-1-yl]azetidin-3-yl]acetonitrile (Baricitinib) and N-(Cyanomethyl)-4-[2-[4-(4-morpholinyl)phenylamino]-pyrimidin-4-yl]benzamide dihydrochloride (Momelotinib).

Examples of suitable NK1-receptor antagonists to be used in the combinations of the invention are nolpitantium besilate, dapitant, lanepitant, vofopitant hydrochloride, aprepitant, ezlopitant, N-[3-(2-Pentylphenyl)propionyl]-threonyl-N-methyl-2,3-dehydrotyrosyl-leucyl-D-phenylalanyl-allo-threonyl-asparaginyl-serine C-1.7-O-3.1 lactone, 1-Methylindol-3-ylcarbonyl-[4(R)-hydroxy]-L-prolyl-[3-(2-naphthyl)]-L-alanine N-benzyl-N-methylamide, (+)-(2S,3S)-3-[2-Methoxy-5-(trifluoromethoxy)benzylamino]-2-phenylpiperidine, (2R,4S)-N-[1-[3,5-Bis(trifluoromethyl)benzoyl]-2-(4-chlorobenzyl)piperidin-4-yl]quinoline-4-carboxamide, 3-[2(R)-[1(R)-[3,5-Bis(trifluoromethyl)phenyl]ethoxy]-3(S)-(4-fluorophenyl)morpholin-4-ylmethyl]-5-oxo-4,5-dihydro-1H-1,2,4-triazole-1-phosphinic acid bis(N-methyl-D-glucamine) salt; [3-[2(R)-[1(R)-[3,5-bis(trifluoromethyl)phenyl]ethoxy]-3(S)-(4-fluorophenyl)-4-morpholinylmethyl]-2,5-dihydro-5-oxo-1H-1,2,4-triazol-1-yl]phosphonic acid 1-deoxy-1-(methylamino)-D-glucitol (1:2) salt, 1'-[2-[2(R)-(3,4-Dichlorophenyl)-4-(3,4,5-trimethoxybenzoyl)morpholin-2-yl]ethyl]spiro[benzo[c]thiophen-1(3H)-4'-piperidine] 2(S)-oxide hydrochloride and the compound CS-003 described in Eur Respir J 2003, 22(Suppl. 45): Abst P2664.

The combinations of the invention may be used in the treatment of any disorder which associated with both muscarinic receptors and β2 adrenergic receptors activities. Thus, the present application encompasses methods of treatment of these disorders, as well as the use of the combinations of the invention in the manufacture of a medicament for the treatment of these disorders.

Preferred examples of such disorders are those respiratory diseases, wherein the use of bronchodilating agents is expected to have a beneficial effect, for example asthma, acute or chronic bronchitis, emphysema, Chronic Obstructive Pulmonary Disease

(COPD), bronchial hypperraeactivity or rhinitis, preferably asthma or Chronic Obstructive Pulmonary Disease (COPD).

The active compounds in the combinations of the invention may be administered by any suitable route, depending on the nature of the disorder to be treated, e.g. orally (as syrups, tablets, capsules, lozenges, controlled-release preparations, fast-dissolving preparations, lozenges, etc); topically (as creams, ointments, lotions, nasal sprays or aerosols, etc); by injection (subcutaneous, intradermic, intramuscular, intravenous, etc.) or by inhalation (as a dry powder, a solution, a dispersion, etc).

The active compounds in the combination, i.e. the dual muscarinic antagonist - β2 agonist of the invention, the corticosteroid and any other optional active compounds may be administered together in the same pharmaceutical composition or in different compositions intended for separate, simultaneous, concomitant or sequential administration by the same or a different route.

One execution of the present invention consists of a kit of parts comprising the dual muscarinic antagonist - β2 agonist of the invention together with instructions for simultaneous, concurrent, separate or sequential use in combination with a corticosteroid for the treatment of a respiratory disease as defined above.

Another execution of the present invention consists of a package comprising the dual muscarinic antagonist - β2 agonist of the invention and a corticosteroid for the simultaneous, concurrent, separate or sequential use in the treatment of a respiratory disease as defined above.

In a preferred embodiment of the invention the active compounds in the combination are administered by inhalation through a common delivery device, wherein they can be formulated in the same or in different pharmaceutical compositions.

In the most preferred embodiment the dual muscarinic antagonist - β2 agonist of the invention and the corticosteroid are both present in the same pharmaceutical composition and are administered by inhalation through a common delivery device.

Typically, the pharmaceutical compositions comprising the combination of the present invention and a pharmaceutically acceptable carrier are suitable for administration by inhalation and may further comprise a therapeutically effective amount of one or more

other therapeutic agents, as defined herein. However, any other form of topical, parenteral or oral application is possible. The application of inhaled dosage forms embodies the preferred application form, especially in the therapy of diseases or disorders of the lung.

The pharmaceutical formulations may conveniently be presented in unit dosage form and may be prepared by any of the methods well known in the art of pharmacy. All methods include the step of bringing the active ingredient(s) into association with the carrier. In general the formulations are prepared by uniformly and intimately bringing into association the active ingredient with liquid carriers or finely divided solid carriers or both and then, if necessary, shaping the product into the desired formulation.

Formulations of the present invention suitable for oral administration may be presented as discrete units such as capsules, cachets or tablets each containing a predetermined amount of the active ingredient; as a powder or granules; as a solution or a suspension in an aqueous liquid or a non-aqueous liquid; or as an oil- in-water liquid emulsion or a water-in-oil liquid emulsion. The active ingredient may also be presented as a bolus, electuary or paste.

A syrup formulation will generally consist of a suspension or solution of the compound or salt in a liquid carrier for example, ethanol, peanut oil, olive oil, glycerine or water with flavouring or colouring agent.

Where the composition is in the form of a tablet, any pharmaceutical carrier routinely used for preparing solid formulations may be used. Examples of such carriers include magnesium stearate, talc, gelatine, acacia, stearic acid, starch, lactose and sucrose.

A tablet may be made by compression or moulding, optionally with one or more accessory ingredients. Compressed tablets may be prepared by compressing in a suitable machine the active ingredient in a free-flowing form such as a powder or granules, optionally mixed with a binder, lubricant, inert diluent, lubricating, surface active or dispersing agent. Moulded tablets may be made by moulding in a suitable machine a mixture of the powdered compound moistened with an inert liquid diluent. The tablets may optionally be coated or scored and may be formulated so as to provide slow or controlled release of the active ingredient therein.

Where the composition is in the form of a capsule, any routine encapsulation is suitable, for example using the aforementioned carriers in a hard gelatine capsule. Where the composition is in the form of a soft gelatine capsule any pharmaceutical carrier routinely used for preparing dispersions or suspensions may be considered, for example aqueous gums, celluloses, silicates or oils, and are incorporated in a soft gelatine capsule.

Dry powder compositions for topical delivery to the lung by inhalation may, for example, be presented in capsules and cartridges of for example gelatine or blisters of for example laminated aluminium foil, for use in an inhaler or insufflator. Formulations generally contain a powder mix for inhalation of the compound of the invention and a suitable powder base (carrier substance) such as lactose or starch. Use of lactose is preferred. Alternatively, the active ingredient (s) may be presented without excipients.

The carrier for a pharmaceutical composition in the form of a dry powder is typically chosen from starch or a pharmaceutically acceptable sugar, such as lactose or glucose. Lactose is preferred.

Additional suitable carriers can be found in Remington: The Science and Practice of Pharmacy, 20th Edition, Lippincott Williams & Wilkins, Philadelphia, Pa., 2000.

The pharmaceutical compositions for inhalation are delivered with the help of inhalers, such as dry powder inhalers, aerosols or nebulisers. The inhaler is typically configured to deliver, upon actuation, a therapeutically effective amount of one or more other therapeutic agents, as defined herein.

Packaging of the compound of the invention in the inhaler may be suitable for unit dose or multi-dose delivery. In the case of multi-dose delivery, the compound of the invention can be pre-metered or metered in use. Dry powder inhalers are classified into three groups: (a) single dose, (b) multiple unit dose and (c) multi dose devices.

For inhalers of the first type (a), single doses have been weighed by the manufacturer into small containers, which are mostly hard gelatine capsules. A capsule has to be taken from a separate box or container and inserted into a receptacle area of the inhaler. Next, the capsule has to be opened or perforated with pins or cutting blades in order to allow part of the inspiratory air stream to pass through the capsule for powder entrainment or to discharge the powder from the capsule through these perforations by

means of centrifugal force during inhalation. After inhalation, the emptied capsule has to be removed from the inhaler again. Mostly, disassembling of the inhaler is necessary for inserting and removing the capsule, which is an operation that can be difficult and burdensome for some patients. Other drawbacks related to the use of hard gelatine capsules for inhalation powders are (a) poor protection against moisture uptake from the ambient air, (b) problems with opening or perforation after the capsules have been exposed previously to extreme relative humidity, which causes fragmentation or indenture, and (c) possible inhalation of capsule fragments. Moreover, for a number of capsule inhalers, incomplete expulsion has been reported.

Some capsule inhalers have a magazine from which individual capsules can be transferred to a receiving chamber, in which perforation and emptying takes place, as described in WO 92/03175. Other capsule inhalers have revolving magazines with capsule chambers that can be brought in line with the air conduit for dose discharge (e. g. WO 91/02558 and GB 2242134). They comprise the type of multiple unit dose inhalers (b) together with blister inhalers, which have a limited number of unit doses in supply on a disk or on a strip.

Blister inhalers provide better moisture protection of the medicament than capsule inhalers. Access to the powder is obtained by perforating the cover as well as the blister foil, or by peeling off the cover foil. When a blister strip is used instead of a disk, the number of doses can be increased, but it is inconvenient for the patient to replace an empty strip. Therefore, such devices are often disposable with the incorporated dose system, including the technique used to transport the strip and open the blister pockets.

Multi-dose devices (c) do not contain pre-measured quantities of the medicament containing powder. They consist of a relatively large container and a dose measuring principle that has to be operated by the patient. The container bears multiple doses that are isolated individually from the bulk of powder by volumetric displacement. Various dose measuring principles exist, including rotatable membranes (e.g. EP0069715) or disks (e.g. GB 2041763; EP 0424790; DE 4239402 and EP 0674533), rotatable cylinders (e.g. EP 0166294; GB 2165159 and WO 92/09322) and rotatable frustums (e.g. WO 92/00771), all having cavities which have to be filled with powder from the container. Other multi dose devices have measuring plungers with a local or circumferential recess to displace a certain volume of powder from the container to a delivery chamber or an air conduit (e.g. EP 0505321, WO 92/04068 and WO

92/04928), or measuring slides such as the Novolizer SD2FL (ex. Sofotec), also known as Genuair®, are described in WO 97/00703, WO 03/000325 and WO2006/008027 and in Greguletz et al., Am. J. Respir. Crit. Care Med., 2009, 179,:A4578; H. Chrystyn et al., Int. J. Clinical Practice, 66, 3, 309-317, 2012, and H. Magnussen et at. *Respiratory Medicine* (2009) 103, 1832-1837.

Reproducible dose measuring is one of the major concerns for multi dose devices.

The powder formulation has to exhibit good and stable flow properties, because filling of the dose measuring cups or cavities is mostly under the influence of the force of gravity. For reloaded single dose and multiple unit dose inhalers, the dose measuring accuracy and reproducibility can be guaranteed by the manufacturer. Multi dose inhalers on the other hand, can contain a much higher number of doses, whereas the number of handlings to prime a dose is generally lower.

Because the inspiratory air stream in multi-dose devices is often straight across the dose measuring cavity, and because the massive and rigid dose measuring systems of multi dose inhalers cannot be agitated by this inspiratory air stream, the powder mass is simply entrained from the cavity and little de-agglomeration is obtained during discharge.

Consequently, separate disintegration means are necessary. However in practice, they are not always part of the inhaler design. Because of the high number of doses in multi-dose devices, powder adhesion onto the inner walls of the air conduits and the de-agglomeration means must be minimized and/or regular cleaning of these parts must be possible, without affecting the residual doses in the device. Some multi dose inhalers have disposable drug containers that can be replaced after the prescribed number of doses has been taken (e.g. WO 97/000703). For such semi-permanent multi dose inhalers with disposable drug containers, the requirements to prevent drug accumulation are even stricter.

In another embodiment, the combination of the present invention can also be administered via single dose dry powder inhalers such as the devices described in WO 2005/113042 or in EP1270034. These devices are low resistance unit dosage form inhalers. The unit dosage form of the dry powder formulation are capsules typically made of gelatin or a synthetic polymer, preferably hydroxypropyl methyl cellulose

(HPMC) , also known as hypromellose. The hypromellose capsules are preferably packaged in a blister. The blister is preferably a peel foil blister that allows patients to remove capsules stored therein without damaging them and optimizes product stability.

Medicaments for administration by inhalation desirably have a controlled particle size. The optimum particle size for inhalation into the bronchial system is usually 1-10μm, preferably 2-5μm. Particles having a size above 20μm are generally too large when inhaled to reach the small airways. To achieve these particle sizes, the particles of the active ingredients as produced may be size reduced by conventional means, for example, by micronisation or supercritical fluid techniques. The desired fraction may be separated out by air classification or sieving. Preferably, the particles will be crystalline.

Achieving a high dose reproducibility with micronised powders is difficult because of their poor flowability and extreme agglomeration tendency. To improve the efficiency of dry powder compositions, the particles should be large while in the inhaler, but small when discharged into the respiratory tract. Thus, an excipient, for example a mono-, di- or polysaccharide or sugar alcohol, such as lactose, mannitol or glucose is generally employed. The particle size of the excipient will usually be much greater than the inhaled medicament within the present invention. When the excipient is lactose it will typically be present as lactose particles, preferably crystalline alpha lactose monohydrate, e.g., having an average particle size range of 20-1000 μm, preferably in the range of 90-150 μm. The average particle size can be measured using standard techniques known to those skilled in the art.

The median particle size approximately corresponds to the average and is the diameter where 50 mass-% of the particles have a larger equivalent diameter, and the other 50 mass-% have a smaller equivalent diameter. Hence the average particle size is generally referred to in the art as equivalent d50. The distribution of particle size around may affect flow properties, bulk density, etc. Hence to characterize a particle size diameter, other equivalent diameters can be used in addition to d50, such as d10 and d90. d10 is the equivalent diameter where 10 mass-% of the particles have a smaller diameter (and hence the remaining 90% is coarser). d90 is the equivalent diameter where 90 mass-% of the particles have a smaller diameter. In one embodiment, the lactose particles for use in formulations of the invention have a d10 of 90 - 160 μm, a d50 of 170 – 270 μm, and d90 of 290 – 400 μm. The d10, d50 and d90 values can be measured using standard techniques known to those skilled in the art.

Suitable lactose materials for use in the present invention are commercially available, e.g., from DMV International (Respitose GR-001, Respitose SV-001, Respitose SV-003 or a mixture thereof), Meggle (Capsulac 60, Inhalac 70, Inhalac 120, Inhalac 230, Capsulac 60 INH, Sorbolac 400, or a mixture thereof), and Borculo Domo (Lactohale 100-200, Lactohale 200-300 and Lactohale 100-300, or a mixture thereof).

In another embodiment, the carrier used may be in the form of a mixture of different types of carrier having different particles sizes. For example, a mixture of a fine carrier and a coarse carrier may be present in the formulation, wherein the average particle size of the fine carrier is lower than the average particle size of the coarse carrier. Preferably the fine carrier may have an average particle size range of 1 - 50 μm, preferably 2 - 20 μm, more preferably, 5 – 15 μm. The coarse carrier may have an average particle size range of 20 - 1000 μm, preferably 50-500 μm, more preferably 90-400 μm, being most preferably, 150-300 μm. The content of the fine carrier with respect to the coarse carrier may vary from 1% to 10%, preferably, from 3% to 6%, e.g., 5%, by weight of the total coarse carrier.

In one embodiment lactose particles for use in formulations of the invention is a mixture of a coarse lactose having a d10 of 90 - 160 μm, a d50 of 170 – 270 μm, and d90 of 290 – 400 μm and a fine lactose having a d10 of 2 - 4 μm, a d50 of 7 – 10 μm, and d90 of 15 – 24 μm.

The ratio by weight between the lactose particles and the active ingredients will depend on the inhaler device used, but is typically, e.g., 10:1 to 50.000:1, for example 20:1 to 10.000:1, e.g., 40-5.000:1.

Apart from applications through dry powder inhalers the compositions of the invention can also be administered in nebulisers, metered dose inhalers and aerosols which operate via propellant gases or by means of so-called atomisers, via which solutions of pharmacologically-active substances can be sprayed under high pressure so that a mist of inhalable particles results. The advantage of these atomisers is that the use of propellant gases can be completely dispensed with. Such atomisers are described, for example, in PCT Patent Application No. W0 91/14468 and International Patent Application No. WO 97/12687, reference here being made to the contents thereof.

Spray compositions for topical delivery to the lung by inhalation may for example be formulated as aqueous solutions or suspensions or as aerosols delivered from pressurised packs, such as a metered dose inhaler, with the use of a suitable liquefied propellant. Aerosol compositions suitable for inhalation can be either a suspension or a solution and generally contain the active ingredient (s) and a suitable propellant such as a fluorocarbon or hydrogen-containing chlorofluorocarbon or mixtures thereof, particularly hydrofluoroalkanes, e. g. dichlorodifluoromethane, trichlorofluoromethane, dichlorotetra-fluoroethane, especially 1,1,1,2-tetrafluoroethane, 1,1,1,2, 3,3,3-heptafluoro-n-propane or a mixture thereof. Carbon dioxide or other suitable gas may also be used as propellant. The aerosol composition may be excipient free or may optionally contain additional formulation excipients well known in the art such as surfactants e.g. oleic acid or lecithin and cosolvens e.g. ethanol. Pressurised formulations will generally be retained in a canister (e.g. an aluminium canister) closed with a valve (e.g. a metering valve) and fitted into an actuator provided with a mouthpiece.

Pressurized aerosol compositions will generally be filled into canisters fitted with a valve, especially a metering valve. Canisters may optionally be coated with a plastics material e. g. a fluorocarbon polymer as described in W096/32150. Canisters will be fitted into an actuator adapted for buccal delivery.

Typical compositions for nasal delivery include those mentioned above for inhalation and further include non-pressurized compositions in the form of a solution or suspension in an inert vehicle such as water optionally in combination with conventional excipients such as buffers, anti-microbials, tonicity modifying agents and viscosity modifying agents which may be administered by nasal pump.

Typical dermal and transdermal formulations comprise a conventional aqueous or non-aqueous vehicle, for example a cream, ointment, lotion or paste or are in the form of a medicated plaster, patch or membrane.

Preferably the composition is in unit dosage form, for example a tablet, capsule or metered aerosol dose, so that the patient may administer a single dose.

Each dosage unit contains suitably from 1 μg to 1000 μg of a dual muscarinic antagonist + β2 adgrenergic agonist compound according to the invention or a

pharmaceutical acceptable salt thereof and 10 μg to 1000 μg of a corticosteroid according to the invention.

The amount of each active which is required to achieve a therapeutic effect will, of course, vary with the particular active, the route of administration, the subject under treatment, and the particular disorder or disease being treated.

The active ingredients may be administered from 1 to 6 times a day, sufficient to exhibit the desired activity. Preferably, the active ingredients are administered once or twice a day.

The proportions in which (a) the corticosteroid and (b) the dual muscarinic antagonist – β2 adrenergic agonist may be used according to the invention are variable. Active substances (a) and (b) may possibly be present in the form of their pharmaceutically acceptable salts or solvates or hydrates. Depending on the choice of the compounds (a) and (b), the weight ratios, which may be used within the scope of the present invention, vary on the basis of the different molecular weights of the various salt forms.

The pharmaceutical combinations according to the invention may contain (a) the corticosteroid and (b) the dual muscarinic antagonist – β2 adrenergic agonist of the present invention generally in a ratio by weight (b):(a) ranging from 1:100 to 1000: 1, preferably from 1:50 to 500:1.

It is contemplated that all active agents would be administered at the same time, or very close in time. Alternatively, one or two actives could be taken in the morning and the other (s) later in the day. Or in another scenario, one or two actives could be taken twice daily and the other (s) once daily, either at the same time as one of the twice-a-day dosing occurred, or separately. Preferably at least two, and more preferably all, of the actives would be taken together at the same time. Preferably, at least two, and more preferably all actives would be administered as an admixture.

The active substance compositions according to the invention are preferably administered in the form of compositions for inhalation delivered with the help of inhalers, especially dry powder inhalers, however, any other form or parenteral or oral application is possible. Here, the application of inhaled compositions embodies the preferred application form, especially in the therapy of obstructive lung diseases or for the treatment of asthma.

The following preparations forms are cited as formulation examples:

Example 1 Inhalable powder

Ingredient	Amount in mg
trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate disaccharinate	50
Budesonide	200
Lactose	4750

Example 2 Inhalable powder

Ingredient	Amount in mg
(trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate disaccharinate	50
Mometasone furoate	200
Lactose	4750

Example 3 Inhalable powder

Ingredient	Amount in mg
(trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate disaccharinate	50
Fluticasone propionate	150
Lactose	4800

Example 4 Inhalable powder

Ingredient	Amount in mg
(trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate disaccharinate	50
Fluticasone furoate	150
Lactose	4800

Example 5 Inhalable powder

Ingredient	Amount in mg
L-tartrate salt of (trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate.	50
Mometasone furoate	200
Lactose	4750

Example6 Inhalable powder

Ingredient	Amount in mg
L-tartrate salt of (trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate.	50
Fluticasone propionate	150
Lactose	4800

Example 7 Aerosol

Ingredient	% by weight
trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-	0,25

methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate disaccharinate	
Fluticasone propionate	0,40
Isopropyl myristate	0,10
TG 227	ad 100

Example 8 Aerosol

Ingredient	% by weight
trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate disaccharinate	0,25
Mometasone furoate	0,40
Isopropyl myristate	0,10
TG 227	ad 100

Pharmacological activity

Surprisingly, an unexpectedly beneficial therapeutic effect can be observed in the treatment of inflammatory or obstructive diseases of the respiratory tract if a dual M3 muscarinic antagonist - β2 adrenergic agonist compound of the present invention is used with one or more corticosteroids..

In particular the combination of the MABA compound of the present invention (Cpd1) with a corticosteroid such as fluticasone or mometasone produces significantly more anti-inflammatory effects in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils when compared with the corresponding corticosteroid alone. This supra-additive effect is more appreciated when fluticasone is used as a corticosteroid.

Consequently, the combinations of the invention possess therapeutically advantageous properties, which make them particularly suitable for the treatment of respiratory diseases in all kind of patients.

Material and Methods

5 Healthy subjects were included for leukocyte experiments. Pulmonary function tests (forced spirometry) and arterial blood gas measurements were performed during the days prior to sample.

Neutrophils were isolated from peripheral blood of healthy volunteers according to standard procedures established in the laboratory (*Milara J et al., Respiration 2012; 83, 147-158*).

Isolated neutrophils were incubated with different drugs (MABA compound, mometasone or fluticasone) or vehicle for 30 minutes before incubation with LPS (1 mcg/mL) (Lipopolysaccharide, a representative stimulus as inflammatory mediator) for 6 hours in standard cell culture conditions (37°C and 5% CO_2). Supernatant were collected to measure IL-8 (the inflammatory marker).

IL-8 (Interleukin-8) was determined by ELISA according to the standard procedure.

Data was presented as mean±SEM. Statistical analysis of results was carried out by analysis of variance (ANOVA) followed by Bonferroni test, by Student's t test, or by non-parametric tests as appropriate (GraphPad Software Inc, San Diego, CA, USA). Significance was accepted when $P<0.05$.

Results

The results obtained are shown in Tables 1 and 2 and in Figures 1 and 2.

TABLE 1 – Effects of Cpd 1 and its combination with mometasone in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils from healthy subjects (5 volunteers run in triplicate)

Compound	% inhibition of IL-8 secretion
Vehicle	----
Cpd 1 (0.01 nM)	5.60
Mometasone (0.01 nM)	2.85
Cpd1 (0.01 nM) + Mometasone (0.01 nM) (calculated)	8.45
Cpd1 (0.01 nM) + Mometasone (0.01 nM) (measured)	8.73

As it can be clearly seen from Table 1 and figure 1, the combination of mometasone with Cpd1 (the MABA compound of the present invention) produces more effects in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils compared with the corresponding component alone.

When compound 1 is associated with mometasone, the inhibition is greater than the one obtained by mometasone alone or by Cpd1 alone (8.73% vs 2.85% when compared with mometasone and 8.73% vs 5.60%, when compared with Cpd 1 alone). A tendency to supra-additive inhibitory effect elicited by the association of the MABA compound of the present invention with mometasone is appreciated when compared with the calculated additive effect of both compounds.

TABLE 2 – Effects of Cpd 1 and its combination with fluticasone in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils from healthy subjects (5 volunteers run in triplicate)

Compound	% inhibition of anti-inflammatory effect
Vehicle	----
Cpd 1 (0.01 nM)	5.60
Fluticasone (0.1 nM)	10.18
Cpd1 (0.01 nM) + Fluticasone (0.1 nM) (calculated)	15.78
Cpd1 (0.01 nM) + Fluticasone (0.1 nM) (measured)	22.90*#,

* $p<0.05$ vs Fluticasone, # $p<0.005$ vs Cpd1

As it can be clearly seen from Table 2 and figure 2, the combination of fluticasone with the MABA compound of the present invention produces synergistic effects in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils when compared with the corresponding component alone.

When compound 1 is associated with fluticasone, the inhibition is greater than the one obtained by fluticasone alone or by Cpd1 alone. In addition the difference in inhibition is statistically significant (22.90% vs 10.18%, $p<0.05$ when compared with fluticasone and 22.90% vs 5.60%, $p<0.005$ when compared with Cpd 1 alone). This inhibitory effect elicited by the association of the MABA compound of the present invention with fluticasone is significantly higher when compared with the calculated additive effect of both compounds.

BRIEF DESCRIPTION OF FIGURES

Fig.1 shows the effects of Cpd 1 and its combination with mometasone in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils from healthy subjects.

Fig. 2 shows the effects of Cpd 1 and its combination with fluticasone in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils from healthy subjects.

CLAIMS

1. A combination which comprises (a) a corticosteroid and (b) a dual muscarinic antagonist - β2 adrenergic agonist compound which is trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate, or any pharmaceutically acceptable salt or solvate thereof.

2. A combination according to claim 1 wherein the dual muscarinic antagonist - β2 adrenergic agonist compound is trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate, disaccharanite.

3. A combination according to claim 1 wherein the dual muscarinic antagonist - β2 adrenergic agonist compound is L-tartrate salt of trans-4-[{2-[({[2-chloro-4-({[(2R)-2-hydroxy-2-(8-hydroxy-2-oxo-1,2-dihydroquinolin-5-yl)ethyl]amino}methyl)-5-methoxyphenyl]amino}carbonyl)oxy]ethyl}-(methyl)amino]cyclohexyl hydroxy(di-2-thienyl)acetate.

4. A combination according to claim 1 to 3, wherein the corticosteroid is selected from the group comprising budesonide, beclomethasone dipropionate, triamcinolone, mometasone furoate, ciclesonide, fluticasone propionate and fluticasone furoate.

5. A combination according to claim 4 wherein the corticosteroid is selected from the group comprising budesonide, mometasone furoate, fluticasone propionate and fluticasone furoate.

6. A combination according to claim 5 wherein the corticosteroid is budesonide.

7. A combination according to claim 5 wherein the corticosteroid is mometasone furoate.

8. A combination according to claim 5 wherein the corticosteroid is fluticasone propionate.

9. A combination according to claim 5 wherein the corticosteroid is fluticasone furoate.

10. A combination according to any one of the preceding claims wherein the active ingredients (a) and (b) form part of a single pharmaceutical composition.

11. A combination according to any one of the preceding claims which further comprises (c) another active compound selected from: (i) PDE IV inhibitors, (ii) leukotriene D4 antagonists, (iii) inhibitors of egfr-kinase, (iv) p38 kinase inhibitors, (v) JAK inhibitors and (vi) NK1 receptor agonists.

12. Use of (a) a corticosteroid as defined in any one of claims 1 and 4 to 9 and (b) a dual muscarinic antagonist - β2 adrenergic agonist compound as defined in any one of claims 1 to 3 for the preparation of a medicament, for simultaneous, concurrent, separate or sequential use in the treatment of a respiratory disease susceptible to amelioration by both β2 adrenergic receptor agonist and muscarinic receptor antagonist activities.

13. Use according to claim 12 wherein the respiratory disease is preferably asthma or chronic obstructive pulmonary disease (COPD).

14. A product comprising (a) corticosteroid as defined in any one of claims 1 and 4 to 9 and (b) a dual muscarinic antagonist - β2 adrenergic agonist compound as defined in any one of claims 1 to 3, as a combined preparation for simultaneous, concurrent, separate or sequential use in the treatment of a patient suffering from or susceptible to a respiratory disease as defined in claim 12 or 13.

15. A product according to claim 14, which further comprises an active compound (c) as defined in claim 11.

16. A kit of parts comprising (b) a dual muscarinic antagonist - β2 adrenergic agonist compound as defined in any one of claims 1 to 3, together with instructions for simultaneous, concurrent, separate or sequential use in combination with (a) a corticosteroid as defined in any one of claims 1 and 4 to 9 for the treatment of a human or animal patient suffering from or susceptible to a respiratory disease as defined in claim 12 or 13.

17. A kit according to claim 16 which further comprises an active compound (c), as defined in claim 11.

18. A package comprising (b) a dual muscarinic antagonist - β2 adrenergic agonist compound as defined in any one of claims 1 to 3 , and (a) a corticosteroid as defined in any one of claims 1 and 4 to 9 for the simultaneous, concurrent, separate or sequential use in the treatment of a respiratory disease as defined in claim 12 or 13.

19. A package according to claim 18, which further comprises an active compound (c), as defined in claim 11.

20. Use of (b) a dual muscarinic antagonist - β2 adrenergic agonist compound as defined in any one of claims 1 to 3 for the preparation of a medicament, for simultaneous, concurrent, separate or sequential use in combination with (a) a corticosteroid as defined in any one of claims 1 and 4 to 9 for the treatment of a respiratory disease as defined in claim 12 or 13.

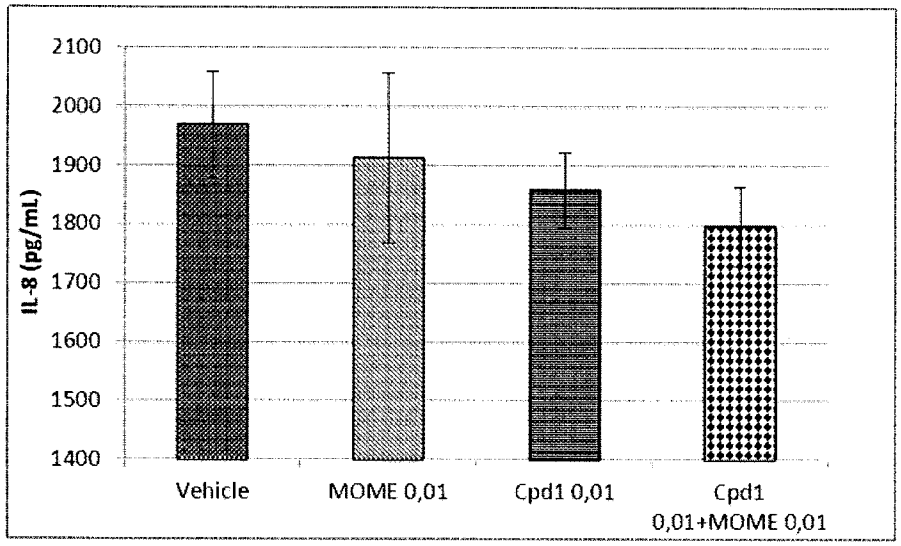
21. Use of (a) a corticosteroid as defined in any one of claims 1 and 4 to 9 for the preparation of a medicament, for simultaneous, concurrent, separate or sequential use in combination with (b) a dual muscarinic antagonist - β2 adrenergic agonist compound as defined in any one of claims 1 to 3 for the treatment of a respiratory disease as defined in claim 12 or 13.

22. A dual muscarinic antagonist - β2 adrenergic agonist compound as defined in any one of claims 1 to 3 for simultaneous, concurrent, separate or sequential use in combination with a corticosteroid as defined in any one of claims 1 and 4 to 9 for the treatment of a respiratory disease as defined in claim 12 or 13.

23. A corticosteroid as defined in any one of claims 1 and 4 to 9 for simultaneous, concurrent, separate or sequential use in combination with a dual muscarinic antagonist - β2 adrenergic agonist compound as defined in any one of claims 1 to 3 for the treatment of a respiratory disease as defined in claim 12 or 13.

24. A combination as defined in any one of claims 1 to 11, for simultaneous, concurrent, separate or sequential use in the treatment of a respiratory disease as defined in claim 12 or 13.

Fig. 1 Effects of Cpd 1 and its combination with mometasone in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils from healthy subjects.



5

Fig. 2 Effects of Cpd 1 and its combination with fluticasone in inhibiting IL-8 secretion induced by LPS in peripheral blood neutrophils from healthy subjects.