

Pharmaceutical Compounds and Compositions

The present invention relates to crystalline levosalbutamol sulphate, polymorphs thereof, processes for making the crystalline material, and compositions thereof.

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It also relates to a pharmaceutical composition comprising a therapeutically effective isomer of salbutamol in combination with a glucocorticoid, the composition being useful for the treatment of respiratory disorders including bronchoconstriction, asthma, COPD and related disorders thereof.

- 10 Asthma is described as a chronic disease that involves inflammation of the pulmonary airways and bronchial hyperresponsiveness that results in the clinical expression of a lower airway obstruction that usually is reversible. The pathophysiology of asthma or related disorders involves bronchoconstriction resulting from bronchial smooth muscle spasm and airway inflammation with mucosal edema. Treatment of asthma
- 15 and other related disorders have been known to employ β -2 agonists, also known as β -2 adrenoreceptor agonists. Such β -2 adrenoreceptor agonists are known to provide a bronchodilator effect to patients, resulting in relief from the symptoms of breathlessness. More particularly, β -2 adrenoreceptor agonists have been shown to increase the conductance of potassium channels in airway muscle cells, leading to
- 20 membrane hyperpolarization and relaxation. Short-acting beta2 adrenoreceptors like salbutamol and terbutaline are recommended for the relief of acute symptoms, while long-acting agents like salmeterol, formoterol and bambuterol are used preferably in combination with other drugs for long-term asthma control.

- Chronic Obstructive Pulmonary Disease (COPD) is a preventable and treatable
- 25 disease state characterized by airflow limitation that is not fully reversible. COPD (Chronic Obstructive Pulmonary Disease) is an umbrella term used to describe lung disease associated with airflow obstruction. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases, primarily caused by cigarette smoking.

Bronchodilators are the mainstay of therapy for patients with established chronic obstructive pulmonary disease (COPD) but, at present, the majority of patients use β -agonists.

5 Salbutamol pressurized inhalation is official in the British pharmacopoeia and are used for the treatment of asthma.

Dey pharmaceutical's patent US 6,702,997 relates to an albuterol inhalation solution, system, kit and method for relieving bronchospasm in children suffering from asthma which comprises about 0.63 mg or about 1.25 mg albuterol.

10 US6,251,368 relates to a pharmaceutical aerosol formulation that comprises particulate medicament selected from the group consisting of salmeterol, salbutamol, fluticasone propionate, beclomethasone dipropionate and physiologically acceptable salts and solvates thereof and a fluorocarbon or hydrogen-containing chlorofluorocarbon propellant, which formulation is substantially free of surfactant is disclosed

15 US 5,547,994 by Sepracor describes a method for treating asthma, using the optically pure R (-) isomer of albuterol, which is substantially free of the S(+) isomer, is a potent bronchodilator for relieving the symptoms associated with asthma in individuals.

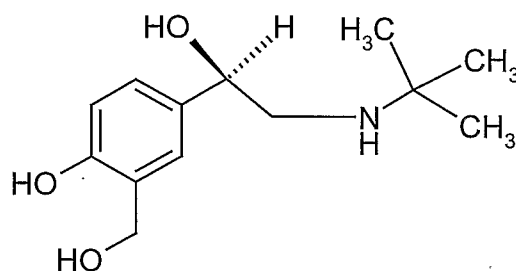
20 CN1413976 by Suzhou Junning New Drug Dev CT (CN), which describes the synthesis of levosalbutamol.

US patent application number US2004054215 by CIPLA Limited discloses a method
25 for obtaining an optically pure R-isomer of albuterol.

Several methods for preparation of levalbuterol have been described in the prior art such as US patent application number 20040115136 by King Code which describes a

method of preparation of levalbuterol tartrate. It further relates to levalbuterol L-tartrate possessing properties desirable for use in a metered dose inhaler.

Salbutamol (albuterol) is an antihistaminic compound and is a beta 2-adrenoceptor agonist used as a bronchodilator for the treatment of asthma and as a uterine relaxant for the suspension of premature labour. Salbutamol has been marketed as a racemic mixture, although the beta 2-agonist activity resides almost exclusively in the (R)-enantiomer. The enantioselective disposition of salbutamol and the possibility that (S)-salbutamol has adverse effects have led to the development of an enantiomerically pure (R)-salbutamol formulation known as levosalbutamol (levalbuterol) (Formula I).



Formula I

A process for the preparation of optically pure salbutamol from mono protected salbutamol precursor is disclosed in US5545745.

US2004114136 and WO2004052835 describe a process for preparing levalbuterol L-tartrate in crystalline form; a pharmaceutical composition comprising levalbuterol L-tartrate, in crystalline form; a metered dose inhaler comprising a canister containing an aerosol formulation of levalbuterol L-tartrate in crystalline form; and a method of affecting bronchodilation in a patient using levalbuterol L-tartrate, including levalbuterol L-tartrate specifically in crystalline form.

Levosalbutamol is prepared by hydrogenating R-benzyl salbutamol in the presence of palladium on carbon.

R-benzyl salbutamol can be prepared by the process described in United States patent number 5,545,745.

- 5 Studies have proved that racemic albuterol, a commonly used bronchodilator, is an exact 50:50 mixture of two enantiomers, R- and S- isomers of salbutamol. Only the R-enantiomer (levosalbutamol) is a potent β_2 -adrenoceptor stimulant, whereas the S-enantiomer (dextrosalbutamol) shows little or no adrenoceptor activity.
- 10 Among the different classes of drugs which are usually administered by inhalation for the treatment of respiratory diseases, glucocorticosteroids such as beclomethasone dipropionate (BDP), dexamethasone, flunisolide, budesonide, fluticasone propionate are of great importance. They can be administered in the form of a finely divided, i.e. micronised, powder, formulated as suspension in an aqueous phase containing any
- 15 necessary surfactants and/or cosolvents; when intended to be administered in the form of metered doses of aerosol spray, they should also contain a low-boiling propellant.

The effectiveness of the administration form depends on the deposition of an adequate amount of particles at the action site. One of most critical parameters determining the

20 proportion of inhalable drug which will reach the lower respiratory tract of a patient is the size of the particles emerging from the device. In order to ensure an effective penetration into the bronchioli and alveoli and hence ensure a high respirable fraction, the mean aerodynamic diameter (MMAD) of the particles should be lower than 5-6 microns. For nasal administration, particles with higher MMAD are required.

25

Fluticasone propionate is itself known from GB2088877 to have anti-inflammatory activity and to be useful for the treatment of allergic and inflammatory conditions of the nose, throat, or lungs such as asthma and rhinitis, including hay fever. Fluticasone propionate in aerosol form, has been accepted by the medical community as useful in

30 the treatment of asthma and is marketed under the trademarks Flovent I and

"Flonase". Fluticasone propionate may also be used in the form of a physiologically acceptable solvate.

5 HK1009406 relates to a metered dose inhaler for dispensing an inhalation drug formulation comprising fluticasone propionate, or a physiologically acceptable solvate thereof, and a fluorocarbon propellant, optionally in combination with one or more other pharmacologically active agents or one or more excipients.

10 We have appreciated that the use of a combination of salbutamol or a physiologically acceptable salt thereof and inhaled corticosteroid has clinical advantages in the treatment of COPD over the use of salbutamol alone or corticosteroid alone.

15 U.S. Pat. No. 6013245 relates to a pharmaceutical aerosol formulation which comprises particulate anhydrous beclomethasone dipropionate together with 1,1,1,2,3,3,3-heptafluoro-n-propane as propellant, which formulation is free of surfactant. The formulation may also contain salbutamol and includes a canister suitable for delivery and a method of treating respiratory disorders administering the formulation by inhalation.

20 U.S. Pat. No. 2004136920 relates to aerosol formulations to be administered as inhalation and which comprises particulate salbutamol and physiologically acceptable salts and solvates thereof and a fluorocarbon or hydrogen-containing chlorofluorocarbon propellant, substantially free of surfactant. The patent also describes a method of treating respiratory disorders which comprises administration
25 by inhalation of an effective amount of a pharmaceutical aerosol formulation as defined is also described.

The present invention aims to provide a potent pharmaceutical composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester,
30 derivative or polymorph thereof in combination with an inhaled corticosteroid.

The object of the present invention is to provide a pharmaceutical composition comprising at least two drugs, one of which is therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof in combination
5 with an inhaled corticosteroid and a pharmaceutical acceptable carrier or excipient and optionally one or more other therapeutic agents.

A further object of the present invention is to provide a pharmaceutical composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester,
10 derivative or polymorph thereof that avoids side effects associated with higher racemic dosages.

A still further object to provide a method for the manufacture of the pharmaceutical composition comprising the therapeutically effective isomer of salbutamol and in
15 combination with an inhaled corticosteroid.

Yet another object of the present invention is to provide a method for the treatment in a mammal, such as a human, of respiratory disorders such as asthma, disorders resulting in bronchoconstriction, which method comprises administration of a
20 therapeutically effective amount of a pharmaceutical composition according to present invention.

An object of the present invention is to provide a method for decreasing side effects of a drug combination comprising at least two drugs in a patient, comprising the step
25 of: administering by inhalation to a patient in need thereof an effective amount of a pharmaceutical composition comprising at least two drugs, and a propellant.

According to the present invention there is provided a pharmaceutical composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester,

derivative or polymorph thereof, a glucocorticoid and a pharmaceutically acceptable carrier or excipient and optionally one or more other therapeutic agents.

5 There is also provided a process for the manufacture of a pharmaceutical composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof in combination with a glucocorticoid drug along with at least one pharmaceutically acceptable carrier, which method comprises mixing the ingredients to form the said composition.

10 The invention also provides a composition of the invention for use as a medicament.

The composition of the invention is also provided for treating respiratory disorders and related conditions, including bronchoconstriction, asthma and COPD.

15 The present invention also provides for a method for the treatment in a mammal, such as a human, of respiratory disorders such as asthma, disorders resulting in bronchoconstriction, and chronic obstructive pulmonary disease (COPD) which method comprises administration of a therapeutically effective amount of a pharmaceutical composition according to present invention.

20

Beta2 adrenoreceptors are known to provide a bronchodilator effect to patients by acting on the β -2 adrenergic receptors in the airway smooth muscles and the bronchial smooth muscles, resulting in relief from the symptoms of breathlessness. More particularly, they have been shown to increase the conductance of potassium channels
25 in airway muscle cells, leading to membrane hyperpolarization and relaxation. They are thus preferred in case of asthma treatment that requires the dilation of the bronchial smooth muscles and relieves the patient of breathlessness associated with asthma. More particularly the short acting beta2 adrenoreceptors are very useful since they provide a quicker onset of action and hence faster relief.

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The present invention relates to one such short acting beta₂ adrenoreceptor, salbutamol. The salbutamol is available as a racemic mixture comprising R and S form. But only the R-enantiomer (levosalbutamol) is a potent β_2 -adrenoceptor stimulant, whereas the S-enantiomer (dextrosalbutamol) shows little or no
5 adrenoceptor activity. The bronchodilatory property of racemic salbutamol is attributable entirely to (R)- salbutamol, which has an approximately 100 fold greater binding affinity for beta₂ receptors as compared to (S)- salbutamol. In vitro, (S)-salbutamol has been reported to promote intracellular Ca²⁺ influx in airway smooth muscle-cells and augment cholinergic activation of airway smooth muscles. Thus in
10 the absence of (R)-salbutamol, (S)-salbutamol has the potential to induce bronchoconstriction in asthmatic patients. This divergent pharmacology accentuates the need of levosalbutamol over racemic salbutamol in the treatment of asthma and other airway diseases.

15 Also levosalbutamol is a more potent bronchodilator when administered as the single enantiomer compared with the same amount in a racemic mixture. Levosalbutamol produces comparable efficacy at nearly one-fourth the dose of racemic salbutamol, simultaneously reducing the beta-mediated side effects.

20 Accordingly the present invention further provides aerosol formulations in accordance with the invention which contain two or more particulate medicaments. Medicaments may be selected from suitable combinations of the medicaments mentioned hereinbefore or may be selected from any other suitable drug useful in inhalation therapy. Preferably, the medicament may be presented in a form which is
25 substantially completely insoluble in the selected propellant.

Appropriate medicaments may thus be selected from, for example, analgesics, e.g. codeine, dihydromorphine, ergotamine, fentanyl or morphine; anginal preparations, e.g. diltiazem; antiallergics, e.g. cromoglycate, ketotifen or nedocromil; antiinfectives e.g. cephalosporins, penicillins, streptomycin, sulphonamides, tetracyclines and

- pentamidine; antihistamines, e.g. methapyrilene; anti-inflammatories, e.g. flunisolide, budesonide, tipredane or triamcinolone acetonide; antitussives, e.g. noscapine; bronchodilators, e.g. ephedrine, adrenaline, fenoterol, formoterol, isoprenaline, metaproterenol phenylephrine, phenylpropanolamine, pirbuterol reproterol rimiterol, 5 terbutaline, isoetharine, tulobuterol orciprenaline, or (-)-amino-3,5-dichloro-[alpha]-[[[6-[2-(2-pyridinyl)ethoxy]hexyl] amino]methyl]benzenemethanol; diuretics, e.g. amiloride; anticholinergics e.g. ipratropium, atropine or oxitropium; hormones, e.g. cortisone, hydrocortisone or prednisolone; xanthines e.g. aminophylline, choline theophyllinate, lysine theophyllinate or theophylline; and therapeutic proteins and 10 peptides, e.g. insulin or glucagon. It will be clear to a person skilled in the art that, where appropriate, the medicaments may be used in the form of salts (e.g. as alkali metal or amine salts or as acid addition salts) or as esters (e.g. lower alkyl esters) or as solvates (e.g. hydrates) to optimise the activity and/or stability of the medicament and/or to minimise the solubility of the medicament in the propellant.
- 15 Commercially available pharmacopoeial composition of salbutamol containing the racemic form comprises 100 to 200 mcg of salbutamol but a composition according to the present invention contains almost half the dose, or even less, and is therapeutically more effective by the use of the R form of salbutamol; levosalbutamol. Due to the reduced dosage, there are less cardiovascular complications, which are associated 20 with higher doses of bronchodilators. Therefore the use of such therapeutically effective isomer results in increased patient compliance.

Hence the present invention provides a pharmaceutical composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof that avoids side effects associated with higher racemic dosages.

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The term 'levosalbutamol' is used in the entire specification and claims in a broad sense to include not only levosalbutamol per se but also its pharmaceutically available salts, derivatives or polymorphs thereof. The pharmaceutically available salts of levosalbutamol include levosalbutamol sulphate, levosalbutamol tartrate,

levosalbutamol hydrochloride. The salt of levosalbutamol used is preferably levosalbutamol sulphate.

The active compounds and the various derivatives thereof may be made according to
5 procedures known in the art, as will be clear to the skilled person.

The invention employs the most active, therapeutically speaking, isomer of salbutamol. The compositions are substantially free of the less therapeutically effective isomer, meaning that this isomer will not be present in any significant
10 amount. Suitably, such isomers will be present at no more than 10% w/w of active, more preferably 1% w/w or less. Thus, for example, compositions containing levosalbutamol, are substantially free of the S-isomer of this compound.

Whilst any suitable form of composition may be used, particularly preferred
15 compositions are aerosol, DPI or inhalation solution/suspension formulations containing levosalbutamol (e.g. as the free base or the sulphate salt) in combination with an antiinflammatory steroid such as a beclomethasone ester (e.g. the dipropionate) or a fluticasone ester (e.g. the propionate) or an antiallergic such as cromoglycate (e.g. the sodium salt). Combinations of salbutamol and fluticasone
20 propionate or beclomethasone dipropionate or budesonide are preferred. It will be understood that for inhalable compositions such as aerosol formulations, the actives will be provided in suitably inhalable form.

In the compositions of the invention, we prefer to use polymorphic forms of
25 levosalbutamol sulphate named herewith as Form I, Form II and Form III. These are novel compounds and constitute a further aspect of the invention.

Accordingly, in one aspect, the invention provides crystalline levosalbutamol sulphate (Form I) is characterised by a powder XRD pattern with peaks at 10.8, 11.9, 13.0,
30 18.3, 28.5 ± 0.2 degrees 2 theta.

In another aspect, there is provided crystalline levosalbutamol sulphate (Form II) is characterised by a powder XRD pattern with peaks at 8.7, 9.6, 15.2, 15.7, 19.1, 27.2, 30.7 ± 0.2 degrees 2 theta.

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In another aspect, there is provided crystalline levosalbutamol sulphate (Form III) is characterised by a powder XRD pattern with peaks at 5.5, 6.9, 7.3, 18.7 ± 0.2 degrees 2 theta.

10 The invention also provides various processes for making Form I, II and III.

A process for preparing crystalline levosalbutamol sulphate Form I, comprises a) preparing levosalbutamol in an organic solvent b) adjusting the pH by addition of sulphuric acid at from 1 to 10°C c) isolating the product (Form I) at from 0 to 10°C.

15

A process for preparing crystalline levosalbutamol sulphate Form I, comprises a) dissolving any form of levosalbutamol sulphate in water b) combining the solution from step a) with a water miscible organic solvent so as to cause precipitation c) isolating Form I thereon.

20

A process for preparing crystalline levosalbutamol sulphate Form II, comprises a) dissolving any form of levosalbutamol sulphate in water b) distilling to residue c) stripping the residue with an organic solvent d) slurrying the solid in an organic solvent e) isolating crystalline Form II.

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A further process for preparing Form II comprises jet milling any other form of levosalbutamol sulphate, for example jet milling crystalline Form I.

A process for preparing crystalline levosalbutamol sulphate Form III, comprises a) preparing levosalbutamol in an organic solvent b) adjusting the pH by addition of sulphuric acid at 25 to 30° C c) isolating the product (Form III) at 25 to 30° C .

5 Another process for preparing Form III comprises a) dissolving any form of levosalbutamol sulphate in water b) combining the solution from step a) with a water-miscible organic solvent so as to cause precipitation c) isolating Form III therefrom at 25 to 30° C.

10 The invention also provides a pharmaceutical composition comprising a compound of the invention and a pharmaceutically acceptable carrier.

The novel compounds, and compositions thereof, are also provided for use as medicaments, particularly in the treatment of respiratory disorders and related
15 conditions.

Figure 1 shows the X-ray powder diffraction pattern of levosalbutamol sulphate Form I.

Figure 2 shows an IR spectrum of levosalbutamol sulphate Form I.

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Figure 3 shows the X-ray powder diffraction pattern of levosalbutamol sulphate Form II.

Figure 4 shows an IR spectrum of levosalbutamol sulphate Form II.

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Figure 5 shows the X-ray powder diffraction pattern of levosalbutamol sulphate Form III.

Figure 6 shows an IR spectrum of levosalbutamol sulphate Form III.

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Table 1 gives the numerical XRD data for Figure 1 (Form I).

Table 2 gives the numerical XRD data for Figure 3 (Form II).

5 Table 3 gives the numerical XRD data for Figure 5 (Form III).

Levosalbutamol sulphate crystalline Form I is characterized by an X-ray powder diffraction pattern having significant reflections expressed as 2 theta values at about 10.781, 11.941, 13.002, 18.341, 28.541 ± 0.2 degrees, as will be clear from Table 1.

10

The X-ray powder diffractogram of levosalbutamol sulphate crystalline Form I is shown in FIG.1. The major peaks and their intensities of X-ray powder diffractogram are shown in Table 1. The intensities of the reflections are also expressed as percent of most intense reflection.

15

Other preferred significant reflections for Form I expressed as 2 theta values include 12.66, 15.819, 17.4, 20.939, 21.72, 22.5, 23.14, 24.341, 26.12, 31.28, 31.93 ± 0.2 degrees. The X-ray powder diffractograms for all the polymorphic Forms disclosed herein were collected on Rigaku d-max 2200 model X-ray diffractometer using Cu K α radiation ($\lambda = 1.5405 \text{ \AA}$).

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Levosalbutamol sulphate crystalline Form I is also characterised by an IR spectrum with peaks at 3568, 3307, 2980, 2799, 2561, 2458, 1615, 1508, 1440, 1380, 1342, 1258, 1200, 1112, 1082, 1029, 976, 915, 836, 793, 775, 752, 648, 617, 535, 497, 453 cm^{-1} .

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Figure 2 shows the IR spectrum for Form I. The IR spectra for all the polymorphic Forms disclosed herein were collected using the Spectrum-1 make of Perkin Elmer Sample and analysed as KBr pellets in the region of 4000-400 cm^{-1} .

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In the preparation of levosalbutamol sulphate crystalline Form I, preferably R-benzyl salbutamol is hydrogenated using a catalyst, preferably a palladium on carbon catalyst, in a large volume of a suitable organic solvent. Preferably an alcoholic solvent is used, more preferably ethyl alcohol. Suitably the process is performed under hydrogen pressure, preferably at 30psi. The catalyst is preferably then filtered and the pH of the filtrate is adjusted, preferably to 5-5.5 and preferably at 0-10 °C with sulfuric acid, suitably concentrated sulphuric acid, to provide crystals, which are filtered and dried to afford levosalbutamol sulphate Form I. The product (Form I) may be obtained by isolating at 0-10° C.

Levosalbutamol sulphate crystalline Form II is characterized by an X-ray powder diffraction pattern having significant reflections expressed as 2 theta values at about 8.701, 9.636, 15.180, 15.657, 19.139, 27.199, 30.702 ± 0.2 degrees, as will be clear from Table 2.

The X-ray powder diffractogram of levosalbutamol sulphate Form II is shown in FIG. 3. The major peaks and their intensities of X-ray powder diffractogram are shown in Table 2. The intensities of the peaks are expressed as percent of most intense reflection.

Other preferred significant reflections for Form II expressed as 2 theta values include peaks at about 8.701, 9.636, 15.180, 18.657, 17.44, 19.139, 21.699, 22.201, 22.837, 23.339, 23.76, 24.361, 25.022, 25.399, 26.059, 26.321, 27.199, 30.702 ± 0.2 degrees.

Levosalbutamol sulphate crystalline Form II is also characterised by an IR spectrum with peaks at 3393, 3026, 2982, 2822, 2463, 1630, 1614, 1513, 1484, 1448, 1380, 1321, 1279, 1258, 1235, 1204, 1155, 1093, 1066, 1036, 1023, 919, 900, 838, 829, 818, 808, 788, 618, 596, 540, 493, 453, 440 cm⁻¹.

Figure 4 shows the IR spectrum for Form II.

A process for the preparation of levosalbutamol sulphate crystalline Form II, comprises dissolving any form of levosalbutamol sulphate in water and distilling it to residue. The residue is further stripped with an organic solvent, which is preferably
5 water miscible and is preferably acetone, and the solid further slurried in a solvent, preferably the same solvent, and isolating the solid, preferably by filtering the solid and drying under vacuum to give levosalbutamol sulphate Form II.

Levosalbutamol sulphate crystalline Form III is characterized by an X-ray powder
10 diffraction pattern having significant reflections expressed as 2 theta values at about 5.496, 6.901, 7.340, 18.660 ± 0.2 degrees, as will be clear from Table 3.

The X-ray powder diffractogram of levosalbutamol sulphate Form III is shown in FIG. 5. The major peaks and their intensities of X-ray powder diffractogram are
15 shown in Table 3. The intensities of the peaks are also expressed as a percent of the most intense reflection.

Other preferred significant reflections for Form III expressed as 2 theta values include peaks at about 5.496, 6.901, 7.340, 8.18, 8.399, 10.978, 11.758, 14.298, 16.321,
20 17.98, 18.18, 18.660, 18.86, 19.189, 20.179, 20.72, 20.019, 22.219, 23.121, 23.64, 23.858, 24.638, 25.339, 27.62, 28.79, 29.319, 30.80, 32.341, 33.218, 33.781, 34.181 ± 0.2 degrees.

Levosalbutamol sulphate crystalline Form III is also characterised by an IR spectrum
25 with peaks at 3533, 3412, 3086, 2979, 2823, 2799, 1613, 1547, 1505, 1437, 1397, 1380, 1365, 1353, 1303, 1256, 1243, 1198, 1110, 1133, 1086, 1075, 1055, 1029, 990, 949, 919, 838, 792, 737, 723, 640, 618, 563, 536, 480, 442, 425 cm^{-1} .

Figure 6 shows the IR spectrum for Form III.

In a process for the preparation of levosalbutamol sulphate crystalline Form III, preferably R-benzyl salbutamol is hydrogenated using a catalyst, preferably a palladium on carbon catalyst in a suitable organic solvent, preferably an alcoholic solvent, more preferably ethyl alcohol. Preferably this is done under hydrogen
5 pressure, preferably at about 30psi. Form III can be isolated by adjusting the pH by addition of sulphuric acid at ambient temperature (25 to 30° C) and isolating the product at ambient temperature (25 to 30° C). Preferably, these steps are done by filtering the catalyst and washing, for example with denatured alcohol. The pH of the filtrate is preferably adjusted to 5-5.5 at ambient temperature (25 to 30° C) with
10 sulfuric acid, preferably in concentrated form, to give crystals, which are filtered and dried to afford levosalbutamol sulphate Form III. The product (Form III) may be obtained by isolating at 25 to 30° C.

Another process for the preparation of levosalbutamol sulphate crystalline Form II
15 comprises jet milling levosalbutamol sulphate. For example, crystalline levosalbutamol Form I may be jet milled so as to give Form II.

It will be understood that crystalline levosalbutamol sulphate and the polymorphic Forms thereof disclosed herein may be formulated with conventional excipients,
20 auxiliaries and carriers into a wide variety of pharmaceutical compositions, including but not limited to tablets, capsules, pellets, caplets, MDI, DPI, and Respule formulations, and oral liquids such as syrups. Where appropriate plain or sustained release formulations may be provided. Those skilled in the art of pharmaceutical formulation will be aware of the conventional ingredients which may be employed to
25 formulate the above compositions. Such formulations may be made in accordance with conventional manufacturing procedures.

In particular, the compounds of the present invention may be combined with one or more other pharmaceutically active compounds, as will be clear to those skilled in the
30 art. Any suitable combination of active materials is envisaged, provided the

combination is acceptable from a pharmaceutical and regulatory standpoint. The compounds of the invention may, for example be combined with corticosteroids such as fluticasone, beclomethasone or budesonide; anticholinergic agents such as ipratropium, tiotropium or atropine; mucolytic agents such as ambroxol; xanthine derivatives such as theophylline; antihistamines; analgesics, and bronchodilators. As will be clear, the additional active or actives may be provided in any suitable form, including the pharmaceutically acceptable derivatives thereof, including salts, esters, polymorphs, and the optically active forms as well as the racemates.

10 The invention thus provides a pharmaceutical composition comprising crystalline levosalbutamol sulphate, particularly Form I or Form II or Form III thereof, in combination with one or more pharmaceutically active compounds and, optionally, a pharmaceutically acceptable carrier.

15 The compositions of the present invention are preferably administered by the inhalation route so as to provide an effective amount of local action and thus avoid undesirable systemic effects. The present compositions may further comprise pharmaceutically acceptable excipients in order to provide a suitable formulation and may be made available in the form of a metered dose inhaler.

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An aerosol formulation according to the present invention may optionally comprise in addition to levosalbutamol in combination with anti-inflammatory steroid or inhaled glucocorticoid and at least one propellant, other pharmaceutically acceptable agents like cosolvents, antioxidants or surfactants.

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For aerosol formulations, a propellant is included in the composition. Suitable propellants include propellant 11 (dichlorodifluoromethane), propellant 12 (monofluorotrichloromethane), Propellant 114, 1,1,1,2-tetrafluoroethane (HFA134a) and 1,1,1,2,3,3,3-heptafluoropropane (HFA227), or mixtures of two or more such halogen-substituted hydrocarbons.

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The aerosol formulations of the invention may be prepared by dispersal of the medicament in the selected propellant in an appropriate container, e.g. with the aid of sonication. The process is desirably carried out under anhydrous conditions to obviate
5 any adverse effects of moisture on suspension stability.

The formulations according to the invention form weakly flocculated suspensions on standing but, surprisingly, these suspensions have been found to be easily redispersed by mild agitation to provide suspensions with excellent delivery characteristics
10 suitable for use in pressurised inhalers, even after prolonged storage. Minimising and preferably avoiding the use of formulation excipients e.g. surfactants, cosolvents etc in the aerosol formulations according to the invention is also advantageous since the formulations may be substantially taste and odour free, and less irritant and less toxic than conventional formulations.

15

In a preferred embodiment of the present invention an aerosol composition may comprise a therapeutically effective isomer of salbutamol a salt, solvate, ester, derivative or polymorph thereof with an anti-inflammatory steroid or inhaled glucocorticoid and either propellant 11 or propellant 114 or a combination thereof and
20 propellant 12.

In another preferred embodiment of the present invention the aerosol may comprise a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof with inhaled glucocorticoid and either propellant 11 or propellant
25 114 or a combination thereof and propellant 12 with a surfactant.

During the trial for this formulation it was observed that in the absence of a surfactant the drug failed to form a homogenous dispersion. Various surfactants known in the art were tried like oils such as corn oil, olive oil, cottonseed oil and sunflower seed oil,
30 mineral oils like liquid paraffin, oleic acid and also phospholipids such as lecithin, or

sorbitan fatty acid esters like sorbitan oleate. Lecithin gave a comparatively good suspension quality when levosalbutamol sulphate was used in combination with fluticasone and budesonide. The preferred surfactant was oleic acid in case of levosalbutamol sulphate used in combination with beclomethasone.

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The surfactant can be used in a concentration of 0.001-100% by weight of the total active material. Preferably in a range of 1%-50%. More preferably in a concentration of 5%-30%. The concentration of surfactant according to the present invention is preferably 10% (all by weight of the total active material). Typically, the active material will constitute two actives e.g. levosalbutamol and the glucocorticoid.

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In the compositions for inhalation particle size is particularly important. The preferred particle size is between 2 μm to 5 μm . It has also been found that the particle size has a considerable influence on the proportion of active substance in the aerosol which is delivered for inhalation.

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In another trial, drugs were mixed with propellant 11 or propellant 114 or a combination thereof, filled in canisters, crimped and charged with propellant 12. It was found that this gave a low FPD (fine particle dose). Hence further trials were undertaken where both the drugs and/or surfactant were micro-milled with propellant 11 or propellant 114 or a combination thereof to form a slurry and then filled in canisters, charging with propellant 12. This resulted in a better FPD as compared to the CFC aerosols where the micro-milling as described herein was not done. Hence micro-milling is preferably done in order to achieve a better FPD.

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25

In a broad aspect, the invention provides a process for the manufacture of a pharmaceutical composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof and a glucocorticoid in a propellant, which process comprises mixing the said ingredients to form said composition.

30

In a further embodiment of the present invention there is provided a process for the manufacture of a pharmaceutical aerosol composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof and a glucocorticoid which process comprises (a) adding both the drugs, optionally with surfactant, with either propellant 11 or propellant 114 or a combination thereof to a canister (b) crimping the canister with a suitable valve and (c) charging propellant 12 through the valve. Preferably, in step (a) one or more of the actives are milled or micromilled with the propellant.

In yet another preferred aspect of the present invention, an aerosol composition may comprise a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof with a glucocorticoid and either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof.

In a further aspect of the present invention there is provided a process for the manufacture of the above aerosol composition which process comprises (a) adding the therapeutically effective isomer of salbutamol and glucocorticoid to a canister (b) crimping the canister with a metered valve (c) charging the canister with either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof. Optionally, in step (a), there may also be added a cosolvent or bulking agent; a surfactant; or a cosolvent and surfactant.

In another preferred aspect of the present invention the aerosol composition may comprise a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof with a glucocorticoid, either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof and a cosolvent. In such a case the cosolvent has a greater polarity than the propellant.

Typically the cosolvent is present in an amount of 0.01 to 5 % by weight of the composition. The cosolvent used may be any suitable cosolvent – for example selected from the group of glycols, particularly propylene glycol, polyethylene glycol and glycerol or alcohols like ethanol. Typically the cosolvent is ethanol.

5

In a preferred aspect of the present invention there is provided a process for the manufacture of the above composition which process comprises (a) adding both drugs to the canister (b) adding the cosolvent to (a) and sonicating (c) crimping the canister with a metered valve (d) charging the canister with either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof.

10

In yet another preferred embodiment, an aerosol composition may comprise a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof with a glucocorticoid, and either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof, surfactant and cosolvent.

15

The surface-active agent (or surfactant) stabilizes the formulation and helps in the lubrication of a valve system in the inhaler. Some of the most commonly used surface active agents are those known in the art and be selected from among Polysorbate 20, Polysorbate 80, Myvacet 9-45, Myvacet 9-08, isopropylmyristate, oleic acid, Brij, ethyloleate, glyceryl trioleate, glyceryl monolaurate, glyceryl monooleate, glyceryl monostearate, glyceryl monoricinoleate, cetylalcohol, sterylalcohol, cetylpyridinium chloride, block polymers, natural oils, polyvinyl pyrrolidone, sorbitan fatty acid esters such as sorbitan trioleate, polyethoxylated sorbitan fatty acid esters (for example polyethoxylated sorbitan trioleate), sorbimacrogol oleate, synthetic amphotensides (tritons), ethylene oxide ethers of octylphenolformaldehyde condensation products, phosphatides such as lecithin, polyethoxylated fats, polyethoxylated oleotriglycerides and polyethoxylated fatty alcohols.

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The surface-active agents are preferably used in an amount of 0.02-10% by weight of the total amount of active material.

5 In another aspect of the present invention there is provided a process for the manufacture of the above composition which process comprises (a) adding the drugs to a canister (b) adding cosolvent and surfactant to (a) and sonicating (c) crimping the canister with a metered valve (d) charging the canister with either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof.

10

In yet another aspect of the present invention the aerosol composition may comprise a therapeutically effective isomer of salbutamol, a glucocorticoid, a bulking agent and a propellant, which is preferably HFA 134a or HFA 227 or a combination thereof. The bulking agent acts as a carrier for the drug to reach the lungs. The bulking agent may be present in a concentration of 10-500% by weight of the total amount of active material. More preferably in a range of 10-300% by weight of the total amount of active material. The bulking agent may be selected from the class of saccharides, including monosaccharides, disaccharides, polysaccharides and sugar alcohols such as arabinose, glucose, fructose, ribose, mannose, sucrose, trehalose, lactose, maltose, starches, dextran or mannitol.

20

In a preferred aspect of the present invention there is provided a process for the manufacture of the above aerosol composition which process comprises (a) adding the active ingredients to a canister (b) adding a bulking agent to (a) (c) crimping the canister with a metered valve (d) charging the canister with propellant.

25

In a preferred aspect of the present invention the aerosol composition may comprise at least one therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof, a glucocorticoid, a surfactant and either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a

30

combination thereof. The surfactant may be any suitable surfactant – for example those listed above or selected from the class of salts of stearic acids or esters such as ascorbyl palmitate, isopropyl myristate and tocopherol esters. Preferably the magnesium salt of stearic acid, isopropyl myristate. The surfactant is preferably used
5 in an amount of 0.01% to 1% by weight of the total amount of active material.

In a preferred aspect of the present invention there is provided a process for the manufacture of the above aerosol composition which process comprises (a) adding the drugs to a canister (b) adding surfactant to (a) (c) crimping the canister with a
10 metered valve (d) charging the canister with either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof.

The compositions of the present invention may optionally contain antioxidants such as citric acid, or benzalkonium chloride.

15

The combination of levosalbutamol and a glucocorticoid may be provided as a dry powder formulation or in the form of an inhalation solution/suspension. For dry powder inhalation, the drugs may be used alone or optionally together with a finely divided pharmaceutically acceptable carrier, which is preferably present and may be
20 chosen from materials known as carriers in dry powder inhalation compositions, for example saccharides, including monosaccharides, disaccharides, polysaccharides and sugar alcohols such as arabinose, glucose, fructose, ribose, mannose, sucrose, trehalose, lactose, maltose, starches, dextran or mannitol. An especially preferred carrier is lactose. The dry powder may be in capsules of gelatin or HPMC, or in
25 blisters or alternatively, the dry powder may be contained as a reservoir in a multi-dose dry powder inhalation device. The particle size of the active ingredient and that of the carrier where present in dry powder compositions, can be reduced to the desired level by conventional methods, for example by grinding in an air-jet mill, ball mill or vibrator mill, microprecipitation, spray-drying, lyophilisation or
30 recrystallisation from supercritical media.

According to the present invention there is also provided a process for manufacture of a dry powder inhaler comprising levosalbutamol and a glucocorticoid, which process comprises mixing the active ingredients optionally with a suitable carrier, and
5 providing the ingredients in a suitable dry powder inhaler.

For inhalation solutions, the drugs may be combined with suitable excipients such as tonicity adjusting agents, pH regulators, chelating agents, wetting agents in a suitable vehicle. The preferred tonicity adjusting agent is sodium chloride. The pH regulators
10 may be selected from pharmacologically acceptable inorganic acids or organic acids or bases. Preferred inorganic acids are selected from the group consisting of hydrochloric acid, hydrobromic acid, nitric acid, sulphuric acid, phosphoric acid and the like. Preferred organic acids and salts of organic acids, such as but not limited to acetates, lactates, malates, tartrates, citrates, ascorbates, succinates, butyrates,
15 valerates and fumarates. Preferred inorganic bases are selected from the group consisting of sodium hydroxide, potassium hydroxide, ammonium hydroxide, sodium carbonate, calcium hydroxide. Preferred organic bases are selected from the group consisting of methyl amine, ethyleneimine, hydroquinone, ethyleneimine, ethylamine, dimethylamine, ethanolamine, butylamine, diethylamine. The preferred base is
20 sodium hydroxide. Preferably a nasal inhalation formulation as provided by the present invention has a pH in the range of 3 to 5.

Suitable chelating or complexing agents may be used in the compositions of the present invention, and may be molecules which are capable of entering into complex
25 bonds. Preferable those compounds should have the effect of complexing cations most preferably metal cations, The preferred agent is ethylenediaminetetraacetic acid (EDTA) or a salt thereof, such as the disodium salt. Suitable wetting agents may be used in the present invention with good emulsifying and wetting properties. Some typical examples include sorbitan esters, PEG, etc which are obvious to a person
30 skilled in the art.

Liquid vehicles for use in the compositions of the invention (particularly inhalation solutions or suspensions) include, but are not limited to, polar solvents, including, but not limited to, compounds that contain hydroxyl groups or other polar groups. Such solvents include, but are not limited to, water or alcohols, such as ethanol, isopropanol, and glycols including propylene glycol, polyethylene glycol, polypropylene glycol, glycol ether, glycerol and polyoxyethylene alcohols.

Further polar solvents also include protic solvents, including, but not limited to, water, aqueous saline solutions with one or more pharmaceutically acceptable salt(s), alcohols, glycols or a mixture thereof. For a saline solution as the solvent or as a component thereof, particularly suitable salts are those which display no or only negligible pharmacological activity after administration.

An Anti-microbial preservative agent may be added for multi-dose packages. Suitable preservatives will be apparent to the skilled person, particularly benzalkonium chloride or benzoic acid or benzoates such as sodium benzoate, sorbic acid or sorbates such as potassium sorbates in the concentration known from the prior art.

According to the present invention there is also provided a process for the manufacture of an inhalation solution comprising levosalbutamol and glucocorticoid. The process preferably comprises the following steps :

1. Dissolving levosalbutamol along with isotonicity agent, chelating agent and wetting agent in purified water followed by filtration.

2. In another vessel, sonication of the glucocorticoid in part quantity of water followed by appropriate sterilization method.

3. Both the above solutions are mixed to provide the final inhalation suspension and the pH is adjusted (if required). The suspension is filled in unit dose or multidose vials.

In another alternative embodiment, the inhalation solution of the present invention may be administered by nebulizer. Such nebulizer including, but not limited to, a jet nebulizer, ultrasonic nebulizer and breath actuated nebulizer. Preferably, the nebulizer is a jet nebulizer connected to an air compressor with adequate air flow. The nebulizer
 5 being equipped with a mouthpiece or suitable face mask. Specifically, a nebulizer (with face mask or mouthpiece) connected to a compressor may be used to deliver the inhalation solution of the present invention to a patient.

The present invention further provides for a method for the treatment in a mammal,
 10 such as a human, of respiratory disorders such as asthma, and disorders resulting in bronchoconstriction, which method comprises administration of a therapeutically effective amount of a pharmaceutical composition according to present invention.

It will be readily apparent to one skilled in the art that varying substitutions and
 15 modifications may be made to the invention disclosed herein without departing from the spirit of the invention. Thus, it should be understood that although the present invention has been specifically disclosed by the preferred embodiments and optional features, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art, and such modifications and variations are considered to
 20 be falling within the scope of the invention.

The following examples are for the purpose of illustration of the invention only and are not intended in any way to limit the scope of the present invention.

25 Example 1: CFC inhaler

A)

Sr.No	Ingredients	Qty /can
1.	Levo-Salbutamol Sulphate	10.08 mg
2.	Fluticasone Propionate	8.24 mg

	(micro-milled)	
3.	Lecithin 10%	1.832 mg
4.	Propellant 11	3.0 gms
5.	Propellant 12	7.7 gms

- a) Add Levosalbutamol sulphate and lecithin with propellant 11
- (b) Fill the slurry in the canisters.
- (c) Crimp with a suitable valve and
- 5 (d) Charge propellant 12 through the valve.

B)

Sr.No	Ingredients	Qty /can
1.	Levo-Salbutamol Sulphate	15.12 mg
2.	Beclomethasone Propionate (50 mcg)	12 mg
3.	Oleic acid 10%	2.712 mg
4.	Propellant 11	4.7 gms
5.	Propellant 12	11.6 gms

- a) Add the drugs and oleic acid with propellant 11
- 10 b) (b) Fill the slurry in the canisters.
- c) (c) Crimp with a suitable valve and
- d) (d) Charge propellant 12 through the valve.

C)

Sr.No	Ingredients	Qty /can
1.	Levo-Salbutamol Sulphate	10.08 mg
2.	Budesonide	24 mg
3.	Lecithin 10%	3.40 mg

4.	Propellant 11	4.7 gms
5.	Propellant 12	11.6 gms

- a) Add the drugs and lecithin with propellant 11
- b) (b) Fill the slurry in the canisters.
- c) (c) Crimp with a suitable valve and
- 5 d) (d) Charge propellant 12 through the valve.

Example 2: HFA inhaler

A)

Sr.No	Ingredients	Qty /can
1.	Levosalmol sulphate	12.00mg
2.	Fluticasone Propionate (micro-milled)(50 mcg)	8.24 mg
3.	Propellant 134a	12.8gm

- 10 a) Add both the drugs to the canister.
- b) Crimp the canister with a metered valve
- c) Charge the canister with 1,1,1,2-tetrafluoroethane (HFA134a) .

B)

Sr.No	Ingredients	Qty /can
1.	Levo-Salbutamol Sulphate	15.12 mg
2.	Beclomethasone Propionate(50 mcg)	12 mg
3.	Abs. Alc.2.5%	0.455
4.	HFA 134a	17.74 gms

- 15 a) Add both the drugs and alcohol and a part of HFA134a to the canister.
- b) Crimp the canister with a metered valve and sonicate.
- c) Charge the canister with 1,1,1,2-tetrafluoroethane (HFA134a) .

C)

Sr.No	Ingredients	Qty /can
1.	Levo-Salbutamol Sulphate	10.08 mg
2.	Budesonide(100 mcg)	24 mg
3.	HFA 134a	18.2 gms

- 5 a) Add both the drugs to the canister.
 b) Crimp the canister with a metered valve
 c) Charge the canister with 1,1,1,2-tetrafluoroethane (HFA134a) .

Example 3: HFA inhaler

10 A)

Sr.No	Ingredients	Qty /can
1.	Levosalbutamol sulphate	10.08mg
2.	Fluticasone Propionate (micro-milled)	8.24 mg
3.	Propellant 227	11.2 gms

- a) Add both the drugs to the canister.
 b) Crimp the canister with a metered valve
 c) Charge the canister with 1,1,1,2,3,3,3-heptafluoroethane (HFA227)

15

B)

Sr.No	Ingredients	Qty /can
1.	Levosalbutamol sulphate	10.08mg
2.	Budesonide	24 mg
3.	HFA 227	20.6 gms

- a) Add both the drugs to the canister.
- b) Crimp the canister with a metered valve
- c) Charge the canister with 1,1,1,2,3,3,3-heptafluoroethane (HFA227)

5 Example 4: HFA inhaler

A)

Sr.No	Ingredients	Qty /can
1.	Levo-Salbutamol Sulphate	10.08 mg
2.	Fluticasone Propionate (micro-milled)	8.24 mg
3.	Abs. Alc.2%	0.256
4.	Lecithin 0.02%	0.003664 mg
5.	HFA 134a	12.54 gms

- a) Add both the drugs to the canister.
- b) Add alcohol and surfactant solution to (a) and sonicate
- 10 c) Crimp the canister with a metered valve
- d) Charge the canister with 1,1,1,2-tetrafluoroethane (HFA134a).

B)

Sr.No	Ingredients	Qty /can
1.	Levo-Salbutamol Sulphate	15.12 mg
2.	Beclomethasone Propionate(50 mcg)	12 mg
3.	Abs. Alc.2.5%	0.455
4.	Oleic acid 0.02%	0.00542
5.	HFA 134a	17.74 gms

- 15 a) Add both the drugs to the canister.
- b) Add alcohol and surfactant solution to (a) and sonicate
- c) Crimp the canister with a metered valve

d) Charge the canister with 1,1,1,2-tetrafluoroethane (HFA134a).

C)

Sr.No	Ingredients	Qty /can
1.	Levo-Salbutamol Sulphate	10.08 mg
2.	Budesonide	24 mg
3.	Abs. Alc.2%	0.364
4.	Lecithin 0.02%	0.006816 mg
5.	HFA 134a	17.83 gms

5

- a) Add both the drugs to the canister.
- b) Add alcohol and surfactant solution to (a) and sonicate of the same
- c) Crimp the canister with a metered valve
- d) Charge the canister with 1,1,1,2-tetrafluoroethane (HFA134a).

10

Example 5: Dry powder for inhalation

Sr.No	Ingredients	mg/cap
1.	Levo-Salbutamol Sulphate	100.00 mcg
2.	Beclomethasone dipropionate	100.00 mcg
3.	Lactose q.s.	25.00 mg

Levosalbutamol sulphate and beclomethasone dipropionate are blended together with lactose and filled in capsules

15

Example 6: Nebulising suspension

Sr.No	Ingredients	Quantity (%w/w)
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1.	Levo-Salbutamol Sulphate equiv to levosalbutamol	15.500
2.	Beclomethasone dipropionate	20.000
3.	Sodium chloride	0.900
4.	Tween 80	0.100
5.	Disodium edetate	0.020
6.	Sodium citrate	q.s
7.	Purified water	q.s. to 2.00ml

1. Dissolving levosalbutamol alongwith isotonicity agent, chelating agent and wetting agent in purified water followed by filtration.
 2. In another vessel, sonication of the glucocorticoid in part quantity of water followed by appropriate sterilization method.
 3. Both the above solutions are mixed to provide the final inhalation suspension and the pH is adjusted (if required). The suspension is filled in unit dose or multidose vials.
- 10 The following Examples illustrate preparation of crystalline polymorphic Forms I, II and III of levosalbutamol sulphate.

Example 7

- 15 R-benzyl salbutamol (20.0 kg.), methanol (61.0 ltr.), denatured alcohol (72 ltrs.) was charged in an autoclave, palladium (5%) on charcoal (1.30 kg) was charged and stirred under 30 psi hydrogen pressure. After completion of reaction the catalyst was filtered and washed with methanol (60 lts.) and denatured alcohol (60 ltrs.). The pH of the clear filtrate was adjusted with sulphuric acid to 5 -5.5 pH at 0-10°C and the resulting solid was stirred at 0-10°C for 1 hr., filtered and washed with methanol (20 ltrs.). The product was dried under vacuum at 30°C for 1 hr. and further at 50-60°C for additional 1 hr. to give R-salbutamol Form I (19.0 kg.).

Example 8

R-benzyl salbutamol (10.0 kg.), methanol (30.0 ltr.), denatured alcohol (36 ltrs.) was charged in an autoclave, wet palladium (5%) on charcoal (0.65 kg) was charged and stirred under 30 psi hydrogen pressure. After completion of reaction the catalyst was
5 filtered and washed with denatured alcohol (25 ltrs.). The pH of the clear filtrate was adjusted with sulphuric acid to 5 -5.5 pH at ambient temperature (25 to 30° C) and the resulting solid was filtered and washed with methanol (10 ltrs.) at 25 to 30° C. The product was dried under vacuum at 50-60°C temp to give R-salbutamol sulphate Form III (19.0 kg.).

10

Example 9

R-salbutamol sulphate (14.80 Kg) was dissolved in water (60.0 ltrs.) and filtered to get a clear solution. The filtrate was distilled under vacuum below 60°C to residue. The residue was stripped with acetone (74.0 ltrs.) twice, further acetone (148.0 ltrs.)
15 was added and the resulting slurry was stirred for 2 hrs. The slurry was filtered and dried under vacuum at 60°C for 10-12 hrs to give R-salbutamol sulphate Form II (11.1 kg.)

Example 10

R-salbutamol sulphate (10 Kg) was dissolved in water (30.0 ltrs.) and stirred for 10-15 min. The resulting clear solution was filtered. Methanol (150 ltrs.) was added slowly to the clear filtrate at room temperature and stirred for 30 mins. and further chilled to 0-5°C. The resulting solid was filtered and washed with methanol. The product was dried under vacuum at 60°C for 3-4 hrs to give R-salbutamol sulphate
25 Form I (8 kg.)

Example 11

R-salbutamol sulphate (20 Kg) was dissolved in water (60.0 ltrs.) and filtered to get a clear solution ,charge 300 ltr acetone slowly at 25-30°C and the resulting mixture was

stirred for 2 hrs at room temp. The resulting slurry was filtered and dried under vacuum at 80°C for 10-12 hrs to give R-salbutamol sulphate Form III (17 kg.)

Example 12

- 5 R-salbutamol sulphate (10 gms) was dissolved in water (30 ml). Methanol (150 ml) was charged at 25-30°C and Isopropyl alcohol (75ml) was added and the mixture was cooled to 5-10°C for 2 hrs. filtered and dried at 80°C under vacuum for 15-20 hrs. to give Form II.

10 **Example 13**

R-salbutamol sulphate was dissolved in methanol at reflux temperature. The reaction mass was then cooled to room temperature and further chilled to 5-10°C . The resulting solid was filtered and dried at 80°C to give R-salbutamol sulphate Form II

15 **Example 14**

R-salbutamol sulphate Form I was subjected to jet milling to get R-salbutamol sulphate Form II having a particle size of 90% less than 5 micron and 100 % below 12.5 micron.

- 20 Note that in Examples 9 to 13 any form of R-salbutamol sulphate may be used as the starting material.

TABLE 1

LEVOSALBUTAMOL S04 - Form I					
Peak No.	2 θ (deg)	d (Å)	Height	Height %	FWHM
1	10.781	8.1998	10389	59.5	0.237
2	11.941	7.4053	2043	11.7	0.237
3	12.660	6.9865	1090	6.2	0.232
4	13.005	6.8036	1080	6.2	0.167
5	15.819	5.5975	1576	9.0	0.266
6	17.400	5.0924	2170	12.4	0.236
7	18.341	4.8332	2847	16.3	0.268
8	19.019	4.6624	621	3.6	0.271
9	20.939	4.2390	2564	14.7	0.265
10	21.720	4.0883	3195	18.3	0.282
11	22.500	3.9482	2001	11.5	0.202
12	23.140	3.8406	17446	100.0	0.234
13	24.341	3.6537	1870	10.7	0.243
14	26.120	3.4087	1108	6.4	0.285
15	28.541	3.1249	1379	7.9	0.281
16	31.280	2.8572	914	5.2	0.378
17	31.939	2.7997	955	5.5	0.451
18	33.980	2.6361	686	3.9	0.361
19	34.279	2.6138	419	2.4	0.350
20	35.739	2.51036	712	4.1	0.329
21	36.340	2.4702	635	3.6	0.391

TABLE 2

LEVOSALBUTAMOL S04 - Form II					
Peak No.	2 θ (deg)	d (Å)	Height	Height %	FWHM
1	8.701	10.1542	8249	100.0	0.205
2	9.636	9.1706	2610	31.6	0.195
3	13.422	6.5914	365	4.4	0.184
4	15.180	5.8318	6090	73.8	0.213
5	15.657	5.6550	2247	27.2	0.201
6	17.440	5.0809	2091	25.3	0.193
7	19.139	4.6335	1416	17.2	0.272
8	19.360	4.5811	900	10.9	0.385
9	19.583	4.5294	666	8.1	0.376
10	20.221	4.3879	462	5.6	0.156
11	21.439	4.1413	7819	94.8	0.256
12	21.699	4.0921	3525	42.7	0.356
13	22.201	4.0008	2317	28.1	0.128
14	22.837	3.8907	1299	15.7	0.091
15	23.339	3.8083	4096	49.7	0.308
16	23.760	3.7417	2345	28.4	0.236
17	24.361	3.6508	1107	13.4	0.165
18	25.022	3.5558	829	10.0	0.080
19	25.399	3.5038	1127	13.7	0.176
20	26.059	3.4166	1162	14.1	0.271
21	26.321	3.3832	1437	17.4	0.256
22	27.199	3.2759	2718	32.9	0.255
23	28.740	3.1037	622	7.5	0.193
24	29.263	3.0493	356	4.3	0.628

25	30.077	2.9687	721	8.7	0.162
26	30.702	2.9097	1586	19.2	0.211
27	31.640	2.8255	631	7.6	0.351
28	32.001	2.7944	700	8.5	0.464
29	32.319	2.7677	680	8.2	0.354
30	33.859	2.6452	368	4.5	0.382
31	34.242	2.6165	730	8.8	0.315
32	35.002	2.5615	424	5.1	0.244
33	35.299	2.5406	316	3.8	0.542
34	35.838	2.5036	376	4.6	0.239
35	36.238	2.4769	427	5.2	0.232
36	36.737	2.443	254	3.1	0.313
37	37.999	2.3660	297	3.6	0.245
38	38.265	2.3502	319	3.9	0.658
39	38.777	2.3203	491	6.0	0.380

TABLE 3

LEVOSALBUTAMOL S04 - Form III					
Peak No.	2 θ (deg)	d (Å)	Height	Height %	FWHM
1	5.496	16.0657	2337	41.8	0.206
2	6.901	12.799	320	5.7	0.295
3	7.340	12.034	1938	34.6	0.217
4	8.181	10.7983	2348	42.0	0.645
5	8.399	10.5187	5559	99.4	0.251
6	10.978	8.0527	577	10.3	0.190
7	11.758	7.5203	978	17.5	0.178
8	12.778	6.9221	365	6.5	0.186
9	14.298	6.1895	565	10.1	0.233
10	14.701	6.0206	428	7.7	0.165
11	16.321	5.4266	4839	86.5	0.292
12	16.981	5.2172	498	8.9	0.134
13	17.980	4.9293	1110	19.8	0.319
14	18.180	4.8758	1421	25.4	0.532
15	18.660	4.7512	4455	79.6	0.432
16	18.860	4.7013	3247	58.0	0.243
17	19.189	4.6215	636	11.4	0.100
18	20.179	4.3969	797	14.2	0.529
19	20.720	4.2833	2355	42.1	0.315
20	22.019	4.0335	5594	100.0	0.306
21	22.219	3.9976	2598	46.4	0.595
22	23.121	3.8436	761	13.6	0.563
23	23.640	3.7604	2729	48.8	0.460
24	23.858	3.7265	2189	39.1	0.547

25	24.638	3.6103	654	11.7	0.168
26	25.339	3.5120	1235	22.1	0.276
27	25.721	3.4607	445	8.0	0.215
28	26.299	3.3859	414	7.4	0.352
29	26.518	3.3585	550	9.8	0.354
30	26.879	3.3142	493	8.8	0.249
31	27.620	3.2270	1316	23.5	0.274
32	28.799	3.0974	719	12.9	0.655
33	29.319	3.0437	827	14.8	0.654
34	30.800	2.9006	565	10.1	0.319
35	31.242	2.8606	430	7.7	0.207
36	32.341	2.7659	867	15.5	0.232
37	33.218	2.6948	719	12.9	0.313
38	33.781	2.6512	565	10.1	0.245
39	34.181	2.6211	1029	18.4	0.267
40	36.646	2.4502	325	5.8	0.557
41	37.140	2.4187	376	6.7	0.252
42	37.522	2.3950	478	8.5	0.306
43	39.397	2.2852	356	6.4	0.427

CLAIMS

1. Crystalline levosalbutamol sulphate (Form I) characterised by a powder XRD pattern with peaks at 10.8, 11.9, 13.0, 18.3, 28.5 ± 0.2 degrees 2 theta.
- 5 2. Crystalline levosalbutamol sulphate according to claim 1 substantially as shown in Figure 1.
3. Crystalline levosalbutamol sulphate according to claim 1 or 2 further
10 characterised by having an IR spectrum substantially as shown in Figure 2.
4. Crystalline levosalbutamol sulphate according to any one of claims 1 to 3 characterised by a powder XRD pattern with peaks substantially as shown in Table 1.
- 15 5. Crystalline levosalbutamol sulphate (Form II) according to claim 1 characterised by a powder XRD pattern with peaks at 8.7, 9.6, 15.2, 15.7, 19.1, 27.2, 30.7 ± 0.2 degrees 2 theta.
6. Crystalline levosalbutamol sulphate according to claim 5 substantially as
20 shown in Figure 3.
7. Crystalline levosalbutamol sulphate according to claim 5 or 7 further characterised by having an IR spectrum substantially as shown in Figure 4.
- 25 8. Crystalline levosalbutamol sulphate according to any one of claims 5 to 7 characterised by a powder XRD pattern with peaks substantially as shown in Table 2.
9. Crystalline levosalbutamol sulphate (Form III) characterised by a powder XRD pattern with peaks at 5.5, 6.9, 7.3, 18.7 ± 0.2 degrees 2 theta.

30

10. Crystalline levosalbutamol sulphate according to claim 9 substantially as shown in Figure 5.

11. Crystalline levosalbutamol sulphate according to claim 9 or 10 further
5 characterised by having an IR spectrum, substantially as shown in Figure 6.

12. Crystalline levosalbutamol sulphate according to any one of claims 9 to 11 characterised by a powder XRD pattern with peaks substantially as shown in Table 3.

10 13. A process for preparing crystalline levosalbutamol sulphate Form I according to any one of claims 1 to 4 which process comprises a) preparing levosalbutamol in an organic solvent b) adjusting the pH by addition of sulphuric acid at from 0 to 10°C c) isolating the product (Form I) at from 0 to 10 °C.

15 14. A process according to claim 13 wherein the organic solvent is an alcoholic solvent.

15. A process according to claim 14 wherein the solvent comprises denatured alcohol or methanol, or a mixture of the two.

20

16. A process according to claim 13, 14 or 15 wherein in step b) the pH is adjusted to from 5 to 5.5.

17. A process for preparing crystalline levosalbutamol sulphate Form II according
25 to any one of claims 5 to 8 which process comprises a) dissolving any form of levosalbutamol sulphate in water b) distilling to residue c) stripping the residue with an organic solvent d) slurring the solid in an organic solvent e) isolating crystalline Form II.

18. A process according to claim 17 wherein step a) comprises dissolving crystalline levosalbutamol sulphate Form I or Form III in water.

19. A process according to claim 17 or 18 wherein in step c) or step d) or both the
5 solvent is acetone.

20. A process for preparing crystalline levosalbutamol sulphate Form III according to any one of claims 9 to 12 which process comprises a) preparing levosalbutamol in an organic solvent b) adjusting the pH by addition of sulphuric acid
10 at 25 to 30°C c) isolating the product (Form III) at 25 to 30° C.

21. A process according to claim 20 wherein the organic solvent is an alcoholic solvent.

15 22. A process according to claim 21 wherein the solvent comprises denatured alcohol or methanol or a mixture of the two.

23. A process according to claim 20, 21 or 22 wherein in step b) the pH is adjusted to from 5 to 5.5.

20

24. A process for preparing crystalline levosalbutamol sulphate Form I according to any of claims 1 to 4, which process comprises a) dissolving any form of levosalbutamol sulphate in water b) combining the solution from step a) with a water miscible organic solvent so as to cause precipitation c) isolating Form I thereon.

25

25. A process according to claim 24 wherein the water-miscible organic solvent is methanol.

26. A process according to claim 24 or 25 wherein prior to step c) the solution is
30 cooled to from 0°C to 5°C.

27. A process for preparing crystalline levosalbutamol sulphate Form II according to any one of claims 5 to 8, which process comprises jet milling any other form of levosalbutamol sulphate.

5

28. A process according to claim 27 wherein crystalline levosalbutamol sulphate Form I is jet milled to give said Form II.

29. A process for preparing crystalline levosalbutamol sulphate Form III according to any one of claims 9 to 12, which process comprises a) dissolving any form of levosalbutamol sulphate in water b) combining the solution from step a) with a water-miscible organic solvent so as to cause precipitation c) isolating Form III therefrom at ambient temperature.

10 30. A process according to claim 29 wherein the water-miscible organic solvent is acetone.

31. A process according to claim 29 or 30 wherein the process is carried out at from 25°C to 30°C.

20

32. A pharmaceutical composition comprising a compound according to any one of claims 1 to 12, and a pharmaceutically acceptable carrier.

33. A pharmaceutical composition comprising a compound according to any one of claims 1 to 12 in combination with one or more pharmaceutically active compounds and, optionally, a pharmaceutically acceptable carrier.

25 34. A pharmaceutical composition according to claim 33 wherein the further active compound is one or more of fluticasone propionate, beclomethasone dipropionate, budesonide, ipratropium bromide, ambroxol or theophylline.

30

35. A compound according to any one of claims 1 to 12, or a composition according to claim 32, 33 or 34, for use as a medicament.

5 36. A compound or composition according to claim 35 for use in the treatment of respiratory disorders and related conditions.

37. A combination comprising a compound according to any one of claims 1 to 12 and one or more pharmaceutically active compounds and optionally at least one
10 pharmaceutically acceptable carrier; for simultaneous, separate or sequential use.

38. A pharmaceutical composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof, a glucocorticoid and a pharmaceutically acceptable carrier or excipient and optionally
15 one or more other therapeutic agents.

39. A pharmaceutical composition according to claim 38, wherein the said glucocorticoid is fluticasone propionate or beclomethasone dipropionate or budesonide.
20

40. A pharmaceutical composition according to claim 38 or 39, wherein the said therapeutically effective isomer of salbutamol is levosalbutamol or a salt, solvate, ester, derivative or polymorph thereof.

25 41. A pharmaceutical composition according to claim 40, wherein the said salt of levosalbutamol is selected from levosalbutamol sulphate, levosalbutamol hydrochloride, or levosalbutamol tartrate.

42. A pharmaceutical composition according to claim 40 or 41, wherein the said
30 salt of levosalbutamol is levosalbutamol sulphate.

43. A pharmaceutical composition according to claim 42, wherein levosalbutamol sulphate is present as levosalbutamol sulphate according to any one of claims 1 to 12 or as a mixture of two or more of the claimed compounds.

5

44. A pharmaceutical composition according to any one of claims 38 to 43 comprising suitable pharmaceutically acceptable excipients to form an aerosol formulation, a dry powder formulation or an inhalation solution/suspension.

10 45. A pharmaceutical composition according to any one of claims 38 to 44, wherein the said drug combination is levosalbutamol sulphate and fluticasone propionate.

15 46. A pharmaceutical composition according to any one of claims 38 to 44, wherein the said drug combination is levosalbutamol sulphate and beclomethasone dipropionate.

47. A pharmaceutical composition according to any one of claims 38 to 44, wherein the said drug combination is levosalbutamol sulphate and budesonide.

20

48. A pharmaceutical composition according to any one of claims 38 to 47 further comprising a propellant selected from the group comprising propellant 11, propellant 12, propellant 114, 1,1,1,2-tetrafluoroethane (HFA134a) and 1,1,1,2,3,3,3-heptafluoropropane (HFA227), or mixtures of two or more such halogen-substituted hydrocarbons.

25

49. A pharmaceutical composition according to claim 48, wherein the propellant comprises at least one propellant which is propellant 11, propellant 12, or propellant 114.

30

50. A pharmaceutical composition according to claim 49, wherein a therapeutically effective isomer of milled levosalbutamol and a glucocorticoid is mixed with propellant 11 or propellant 114 or a combination thereof.

5 51. A pharmaceutical composition according to claim 48, 49 or 50 further comprising a surfactant.

52. A pharmaceutical composition according to claim 51, wherein the surfactant is an oil such as corn oil, olive oil, cottonseed oil and sunflower seed oil; a mineral oil
10 such as liquid paraffin; oleic acid; a phospholipid such as lecithin; or a sorbitan fatty acid ester such as sorbitan oleate; or mixtures of two or more thereof.

53. A pharmaceutical composition according to claim 51 or 52, wherein the surfactant is present at a concentration of 0.001-100% by weight of the active
15 material.

54. A pharmaceutical composition according to claim 53, wherein the surfactant is present at a concentration of 1%-50% by weight of the active material.

20 55. A pharmaceutical composition according to claim 54, wherein the surfactant is present at a concentration of 5%-30% by weight of the active material.

56. A pharmaceutical composition according to claim 48, wherein the propellant comprises either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-
25 heptafluoroethane (HFA227) or a combination thereof.

57. A pharmaceutical composition according to claim 56, which comprises at least one cosolvent.

58. A pharmaceutical composition according to claim 57, wherein the cosolvent is a glycol, such as propylene glycol, or polyethylene glycol; glycerol or ethanol, or a mixture of two or more thereof.

5 59. A pharmaceutical composition according to claim 57 or 58 wherein the cosolvent is present in a range of 0.01 to 5% by weight of the composition.

60. A pharmaceutical composition according to claim 56, 57, 58 or 59 which further comprises a surfactant.

10

61. A pharmaceutical composition according to claim 60, wherein the surfactant is selected from the group comprising Polysorbate 20, Polysorbate 80, Myvacet 9-45, Myvacet 9-08, isopropylmyristate, oleic acid, Brij, ethyloleate, glyceryl trioleate, glyceryl monolaurate, glyceryl monooleate, glyceryl monostearate, glyceryl
15 monoricinoleate, cetylalcohol, sterylalcohol, cetylpyridinium chloride, block polymers, natural oils, polyvinyl pyrrolidone, sorbitan fatty acid esters such as sorbitan trioleate, polyethoxylated sorbitan fatty acid esters such as polyethoxylated sorbitan trioleates, sorbimacrogol oleate, synthetic amphotensides (tritons), ethylene oxide ethers of octylphenolformaldehyde condensation products, phosphatides such
20 as lecithin, polyethoxylated fats, polyethoxylated oleotriglycerides and polyethoxylated fatty alcohols.

62. A pharmaceutical composition according to claim 60 or 61, wherein the surfactant is present at a concentration of 0.02-10% by weight of the active material.

25

63. A pharmaceutical composition according to any of claims 56 to 62, which further comprises a bulking agent.

64. A pharmaceutical composition according to claim 63, wherein the said bulking
30 agent is selected from the group comprising saccharides, including monosaccharides,

disaccharides, polysaccharides and sugar alcohols such as arabinose, glucose, fructose, ribose, mannose, sucrose, trehalose, lactose, maltose, starches, dextran or mannitol.

5 65. A pharmaceutical composition according to claim 63 or 64, wherein the bulking agent is present in a concentration of 10 to 500% by weight of the active material.

10 66. A pharmaceutical composition according to claim 65, wherein the bulking agent is present in a concentration of 10 to 300% by weight of the active material.

67. A pharmaceutical composition according to any of claims 56 to 66, which comprises surfactant selected from the group of salts of stearic acids or esters such as ascorbyl palmitate, isopropyl myristate and tocopherol esters.

15 68. 68. A pharmaceutical composition according to any one of claims 56 to 67, wherein each drug is milled.

20 69. A pharmaceutical composition according to any one of claims 38 to 47 in the form of a dry powder formulation..

70. A pharmaceutical composition according to claim 69 wherein the composition comprises, in addition to active material, pharmaceutically acceptable excipients suitable to form a composition for a dry powder inhaler.

25 71. A pharmaceutical composition according to claim 69 or 70 wherein the composition comprises, in addition to active material, a finely divided pharmaceutically acceptable carrier.

72. A dry powder inhaler comprising a composition according to any of claims 69 to 71.

73. A process for preparing a dry powder inhaler according to claim 72, which process comprises mixing the active ingredients optionally with a suitable carrier, and providing the composition in a dry powder inhaler.

74. A pharmaceutical composition according to any one of claims 38 to 47 in the form of an inhalation suspension.

75. A pharmaceutical composition according to claim 74, comprising pharmaceutically acceptable excipients suitable to form an inhalation suspension.

76. A pharmaceutical composition according to claim 74 or 75 comprising, in addition to active material, a polar solvent, a tonicity-adjusting agent, a wetting agent, a chelating agent and optionally an acid.

77. A process for preparing a pharmaceutical composition according to claim 74, 75 or 76, which process comprises suspending the active ingredients optionally together with chelating agents, tonicity adjusting agents and wetting agents and any other suitable excipients, in a liquid vehicle, and optionally adjusting the pH.

78. A process for the manufacture of a pharmaceutical composition comprising a therapeutically effective isomer of salbutamol or a salt, solvate, ester, derivative or polymorph thereof and a glucocorticoid in a propellant, which process comprises mixing the said ingredients to form said composition.

79. A process according to claim 78 comprising (a) adding the therapeutically effective isomer of salbutamol with the glucocorticoid, and optionally surfactant, with either propellant 11 or propellant 114 or a combination thereof to a canister (b)

crimping the canister with a suitable valve and (c) charging propellant 12 through the valve.

5 80. A process according to claim 79, wherein the therapeutically effective isomer of salbutamol and/or the glucocorticoid are milled with propellant 11 or propellant 114 or a combination thereof.

10 81. A process according to claim 78 comprising (a) adding a therapeutically effective isomer of salbutamol, and glucocorticoid and optionally cosolvent or bulking agent; surfactant; or cosolvent and surfactant to a canister, (b) crimping the canister with a metered valve (c) charging the canister with either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof.

15 82. A process according to claim 81 wherein the therapeutically effective isomer of salbutamol and cosolvent or bulking agent, surfactant, or cosolvent and surfactant is micro-milled with either 1,1,1,2-tetrafluoroethane (HFA134a) or 1,1,1,2,3,3,3-heptafluoroethane (HFA227) or a combination thereof.

20 83. A composition according to any one of claims 38 to 71 or 74 to 76 for use as a medicament.

25 84. A composition according to any one of claims 38 to 71 or 74 to 76 for use in treating respiratory disorders and related conditions, including bronchoconstriction, asthma and COPD.

30 85. A method for the treatment in a mammal, such as a human, of respiratory disorders such as asthma, disorders resulting in bronchoconstriction, which method comprises administration of a therapeutically effective amount of a pharmaceutical composition according any one of claims 38 to 71 or 74 to 76.

86. Use of a combination of salbutamol or a physiologically acceptable salt thereof and a glucocorticoid for treatment in the long-term management of asthma and COPD.

5

87. A combination comprising a therapeutically effective isomer or salbutamol or a salt, solvate, ester, derivative or polymorph thereof and a glucocorticoid and optionally at least one pharmaceutically acceptable carrier; for simultaneous, separate or sequential use.

10