Composition for inhalation

Field of the invention

The present invention relates to a formulation comprising formoterol and budesonide for use in the treatment of inflammatory conditions/disorders, especially respiratory diseases such as asthma, COPD and rhinitis.

Background of the invention

Stability is one of the most important factors which determines whether a compound or a mixture of compounds can be developed into a therapeutically useful pharmaceutical product.

Combinations of formoterol and budesonide are known in the art, see for example WO 93/11773 discloses such a combination that is now marketed as Symbicort® in a dry powder inhaler. There are a variety of other inhalers by which a respiratory product can be administered, such as pressurised metered dose inhalers (pMDI's). Formulations for pMDI's may require certain excipients as disclosed in WO 93/05765.

It has now been found that certain HFA formulations comprising formoterol and budesonide together with polyvinylpyrrolidone (PVP) and polyethylene glycol (PEG) exhibit excellent physical suspension stability.

Description of the invention

In accordance with the present invention, there is provided a pharmaceutical composition comprising formoterol, budesonide, HFA 227, PVP and PEG characterised in that the PVP is present from about 0.0005 to about 0.03 %w/w and the PEG is present from about 0.05 to about 0.35% w/w.

Preferably the PVP is present in an amount of 0.001 % w/w. Preferably the PVP is PVP K25.

Preferably the PEG is present in an amount of 0.3 % w/w. Preferably the PEG is PEG 1000.

Preferably the concentrations of formoterol/budesonide are such that the formulation delivers formoterol/budesonide at 4.5/40 mcg, 4.5/80 mcg, 4.5/160 mcg or 4.5/320mcg per actuation.

The formoterol can be in the form of a mixture of enantiomers. Preferably the formoterol is in the form of a single enantiomer, preferably the R, R enantiomer. The formoterol can be in the form of the free base, salt or solvate, or a solvate of a salt, preferably the formoterol is in the form of its fumarate dihydrate salt. Other suitable physiologically salts that can be used include chloride, bromide, sulphate, phosphate, maleate, tartrate, citrate, benzoate, 4-methoxybenzoate, 2- or 4-hydroxybenzoate, 4-chlorobenzoate, p-toluenesulphonate, benzenesulphonate, ascorbate, acetate, succinate, lactate, glutarate, gluconate, tricaballate, hydroxynapaphthalenecarboxylate or oleate.
Preferably the second active ingredient is budesonide, including epimers, esters, salts and solvates thereof. More preferably the second active ingredient is budesonide or an epimer thereof, such as the 22R-epimer of budesonide.

The pharmaceutical compositions according to the invention can be used for the treatment or prophylaxis of a respiratory disorder, in particular the treatment or prophylaxis of asthma, rhinitis or COPD.
In a further aspect the invention provides a method of treating a respiratory disorder, in particular asthma, rhinitis or COPD, in a mammal, which comprises administering to a patient a pharmaceutical composition as herein defined.

The compositions of the invention can be inhaled from any suitable MDI device. Doses will be dependent on the severity of the disease and the type of patient, but are preferably 4.5/80 mcg or 4.5/160 mcg per actuation as defined above.

The concentration of PVP (0.001%w/w) used in this formulation has been found to give consistently stable formulations over the required dose range, incorporating a wide range of concentrations of the active components, and at a much lower concentration than indicated in the prior art.

The invention is illustrated by the following examples.

Experimental section

Two methods can be used to evaluate physical suspension stability: Optical suspension characterisation (OSCAR), and TURBISCAN. Both methods are used to semi-quantify sedimentation/creaming rates. OSCAR measurements are performed using the PET bottles directly. For TURBISCAN analysis, the suspensions are transferred to custom designed pressure cells for measurement of light transmittance and backscattering.

METHODOLOGY

OSCAR

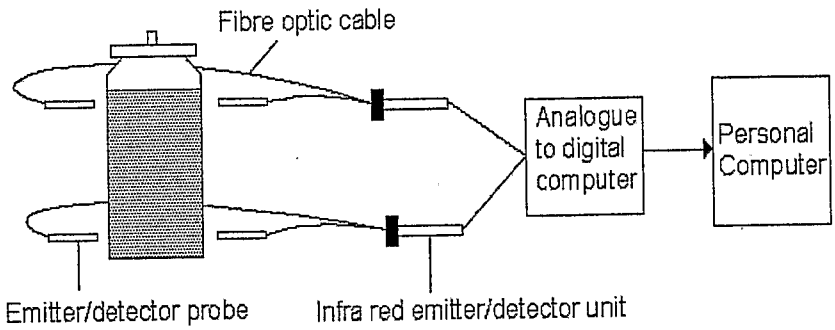
Optical Suspension Characterisation (OSCAR) equipment is custom designed for the rapid and reproducible semi-quantification of metered dose inhaler suspension characteristics.

The OSCAR equipment utilises changes in light transmission with time, to characterise a pre-agitated suspension formulation (a schematic diagram of the equipment is shown in Figure 1). The equipment consists of a twin headed test assembly. The head on the left side of the equipment is used with dilute suspensions and the right for concentrated suspensions. The selector switch mounted between the two test heads is used to alternate concentration choice. The output from the selected test head is directed to the equipment mounted voltage display and to the computer for data logging. The analogue signals from photodetectors are digitised and the values collected in data files, these are then processed using a suitable software package. There are two equipment mounted voltage displays, one each for the upper and lower photodetectors. The upper and lower photodetectors are height adjustable and a position readout display is provided to indicate the set height for each test run.

The Reagecon Turbidity standards (2500-4000 NTU) are used to calibrate the sensitivity of the OSCAR equipment. In this case, the 3000 NTU turbidity calibration standard is used as a standard calibration check. However any of the turbidity standards can be used to adjust the sensitivity of the probes to a specific voltage appropriate to the formulation.

Samples for test on the OSCAR equipment are presented in PET bottles crimped with non-metering valves.

Figure 1: Schematic for OSCAR set-up



For background information and prior art for this method refer to papers from Drug Delivery to the Lungs IX, 1997, Method Development of the OSCAR technique for the characterization of metered dose inhaler formulations, Authors N. Govind, P. Lambert And Drug delivery to the Lungs VI, 1995, A Rapid Technique for Characterisation of the Suspension Dynamics of metered Dose Inhaler Formulations, Author, PA Jinks (3M Healthcare Ltd)

TURBISCAN

Turbiscan MA 2000 is a concentrated dispersion and emulsion stability and instability analyser, or a vertical scan macroscopic analyser. It consists of a reading head moving along a flat-bottomed, 5ml cylindrical glass cell, which takes readings of transmitted and backscattered light every 40 μm on a maximum sample height of 80mm. The scan can be repeated with a programmable frequency to obtain a macroscopic fingerprint of the sample.

The reading head uses a pulsed near infrared light source (wavelength = 850 nm) and two synchronous detectors:

Transmission detector: Picks up light transmitted through the solution in the tube, at 0°

Backscattering detector: Receives the light back scattered by the product at 135°.

The profile obtained characterises the samples homogenieity, concentration and mean particle diameter. It allows for quantification of the physical processes the sample is

undergoing. As well as detecting destabilisation, Turbiscan allows comparison of, for example, the sedimentaion rate of different suspensions.

Turbiscan may be used in several modes, eg transmitted or backscattering modes. Turbiscan has been used here in these examples to measure the transmitted light as a funtion of time

Dispersion instability is the result of two physical processes: a) particle size increases as a result of the formation of aggregates, due to flocculation b) particle migration resulting in creaming or sedimentation. When a product is stable (ie no flocculation, creaming or sedimentation), the transmitted and backscattered light will remain constant i.e. scans of these will show a constant level profile. If the product undergoes changes in particle size, variations in the transmitted/ backscattered light show as change in the direction of the scan from horizontal or steady state profile.
For pressurised systems a cell capable of handling pressurised samples is required. Such a cell was used for the evaluations of these HFA formulations. The scans were performed in the AUTO mode.
The % transmission averages shown in the figure (see later) were taken from a zone around the middle of the suspension sample.

INITIAL EVALUATION

For the initial evaluation, only OSCAR was used.

Formulations containing formoterol fumarate dihydrate, budesonide, 0.001% w/w PVP K25 and either 0.1 % w/w or 0.3% PEG 1000 in HFA-227 were prepared in polyethylene terephlate (PET) bottles crimped with a continuous valve. For all formulations, the formoterol fumurate dihydrate concentration remained constant at 0.09mg/ml (equivalent to 4.5 mcg formoterol fumurate dihydrate per actuation) and the budesonide concentration varied between approximately 1mg/ml to 8 mg/ml (equivalent to 40 mcg to 320 mcg per actuation).

Early OSCAR data for Symbicort pMDI formulations

Budesonide dose ex-actuator	Formoterol dose ex-actuator	PVP K25 concentration (% w/w)	Time seconds	Transmittance (mV) Lower sensor	
				PEG concn %w/w	
				0.1	0.3
40 µg	4.5 µg	0.001	30 seconds		257
			60 seconds		264
80 µg	4.5 µg	0.001	30 seconds	202	
			60 seconds	240	
		0.002	30 seconds	184	
			60 seconds	185	
160 µg	4.5 µg	0.001	30 seconds	208	114
			60 seconds	304	191
		0.002	30 seconds	248	
			60 seconds	327	
320 µg	4.5 µg	0.001	30 seconds		475
			60 seconds		570
		0.002	30 seconds		930
			60 seconds		1443

OSCAR analysis of these formulations gave relatively low light transmittance values at the lower sensor, which is indicative of stable suspensions with low flocculation characteristics. Early indications were that the 0.001% w/w PVP with 0.3% PEG 1000 would give the best suspension.

FURTHER EVALUATION: various concentrations of PVP K25 with a constant PEG 1000 concentration of 0.3% w/w.

OSCAR, Turbiscan and photographic methods were used to evaluate the formulations. OSCAR and Turbiscan techniques have been described earlier. Samples with varying concentrations of PVP were analysed to determine suspension stability over time.

PHOTOGRAPHIC ANALYSIS

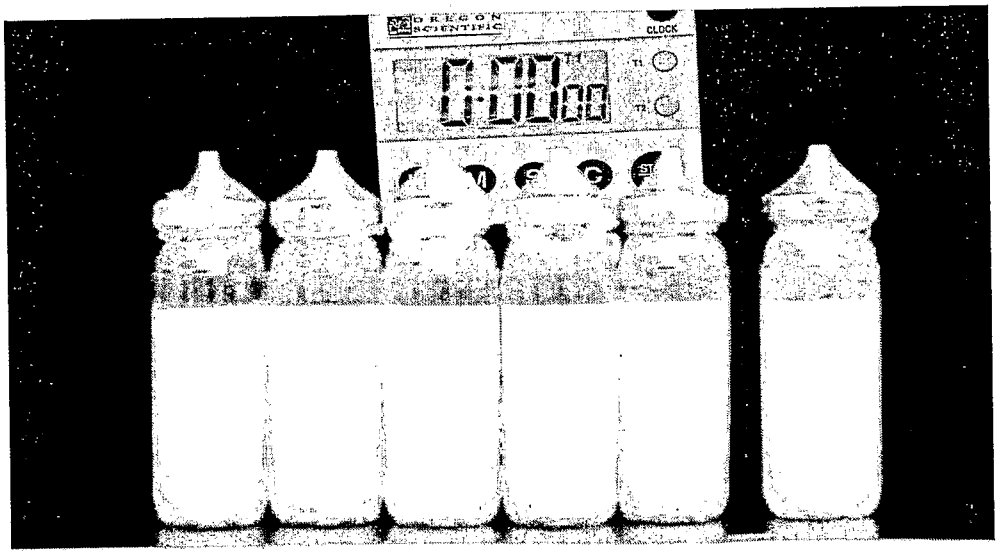
For the photographic analysis , samples were prepared in PET bottles and photographed digitally over time, using a black background. These photographs (some of which are shown here) show the behaviour of the suspension over time and allow easy comparison of the effectiveness of the various concentrations of PVP. The concentration of PVP varied from 0.0001 to 0.05 % w/w. From left to right on the photographs the concentration of PVP is as follows:

0.0001 far left	0.0005	0.001	0.01	0.03	0.05 far right

DIGITAL PHOTOGRAPHY OF FORMULATIONS SHOWING DEGREE OF DISPERSION OVER TIME

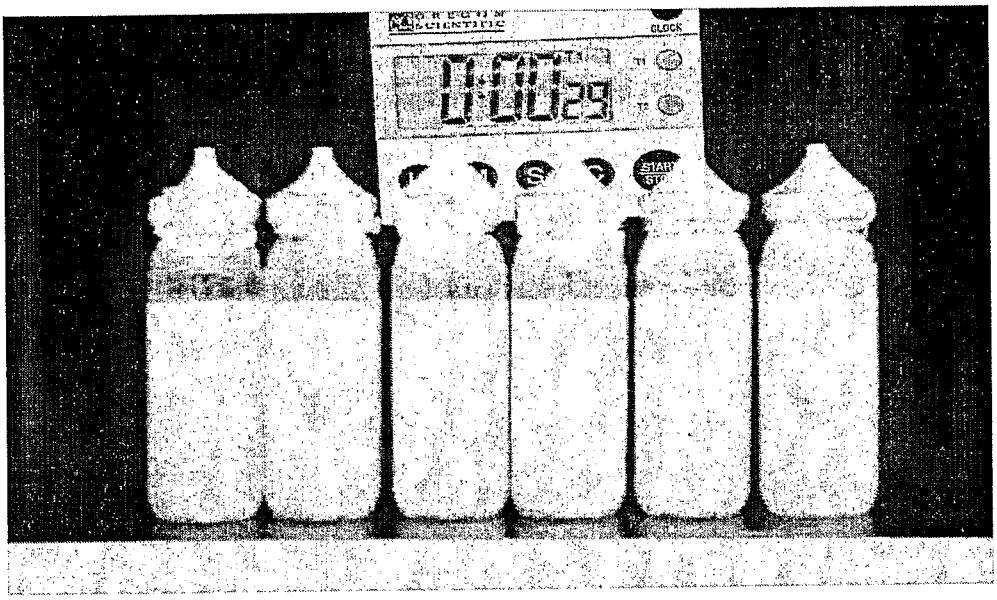
Budesonide 160µg/shot, Formoterol 4.5µg/shot with various PVP K25 concentrations and 0.3% PEG 1000 at 0, 15, 30, and 60 seconds standing time.

0 Seconds



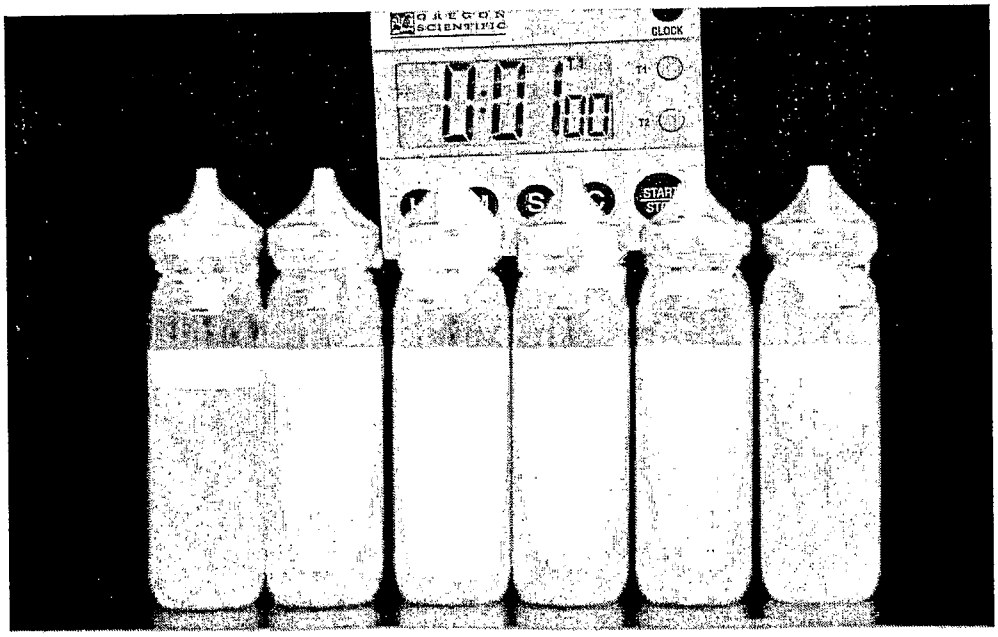
0.0001 0.0005 0.001 0.01 0.03 0.05 %w/w PVP

30 Seconds



5

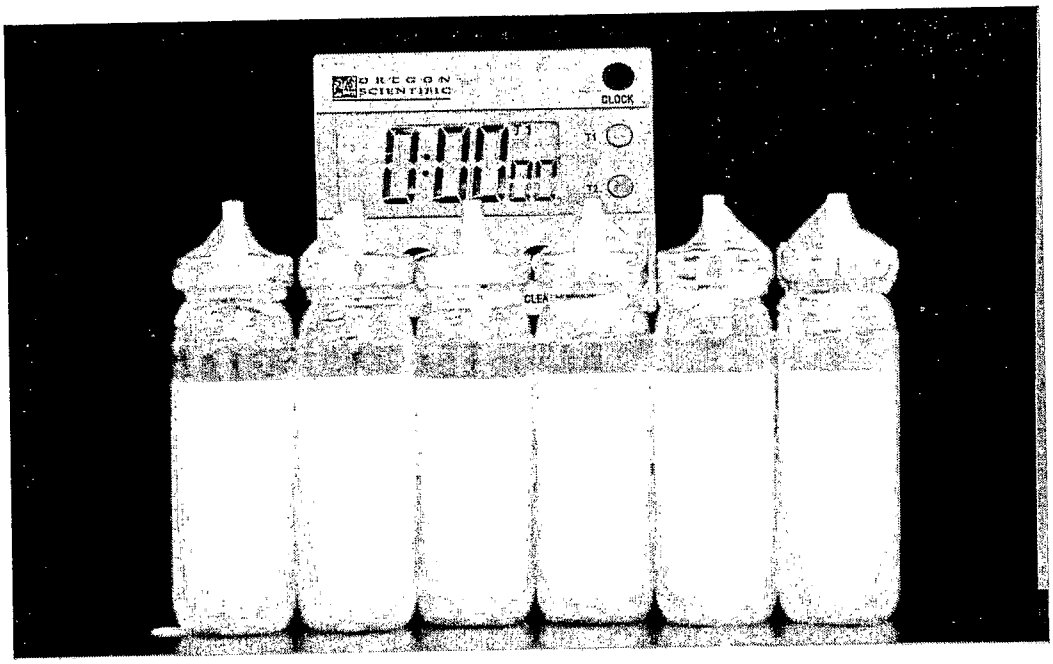
60 Seconds



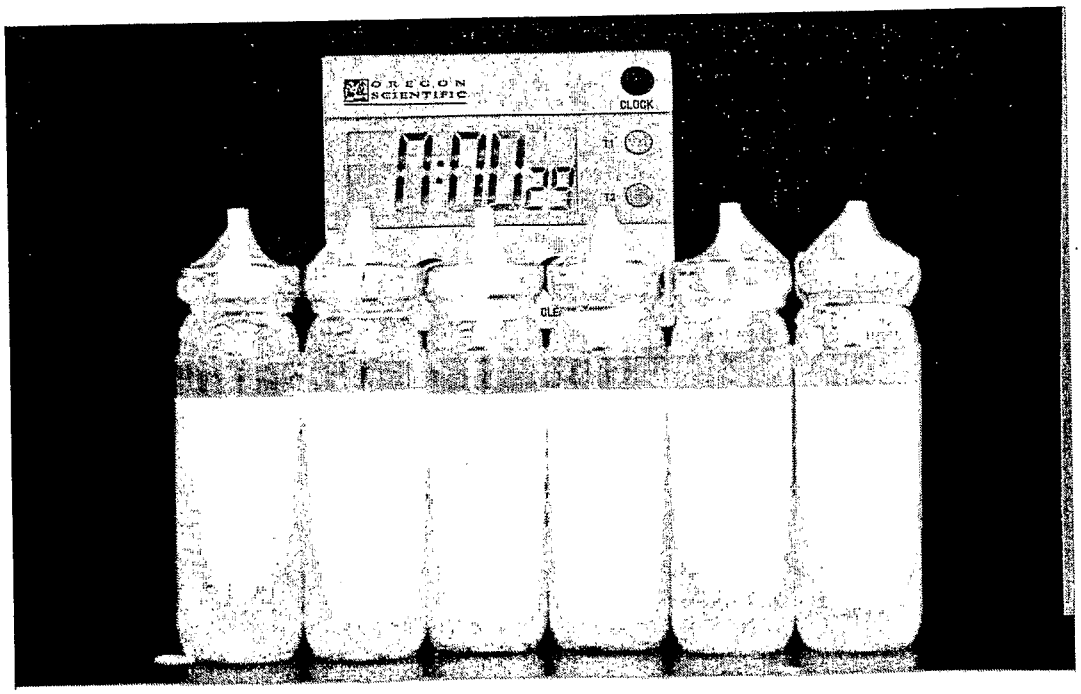
10

Budesonide 80µg/shot, Formoterol 4.5µg/shot with various PVP K25 concentrations and 0.3% PEG 1000 at 0, 30, and 60 seconds standing time.

0 Seconds



30 Seconds



60 Seconds

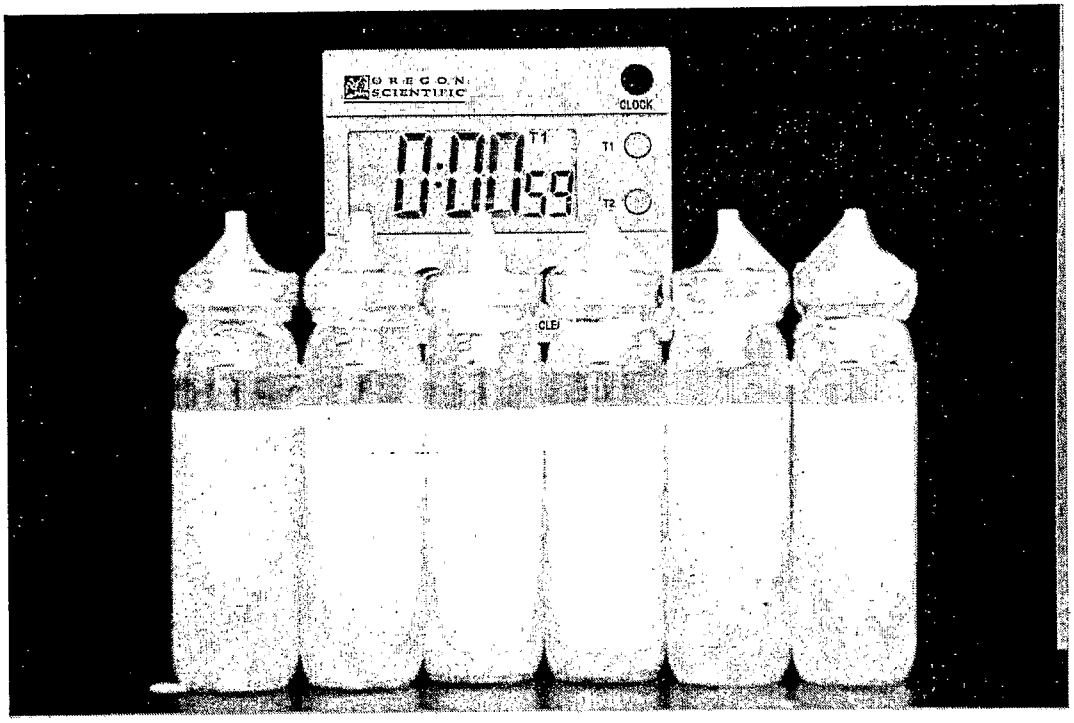


TABLE OF DEGREEE OF DISPERSION OF SUSPENSIONS OVER TIME: (ALL SAMPLES)

Photographs were taken of all doses (320µg/4.5µg to 40µg/4.5µg) at 0, 15, 30, 60, 90 seconds, and 2, 5 and 10 minutes. As this produced too many photographs to reproduce here, a chart has been constructed to give a reprentation of the degree of dispersion over time.

If the sample was fully suspended, the sample was rated 0 e.g. at 0 minutes they were fully dispersed. From there, the samples have been rated in increments of 1-5 at 20% intervals to express the degree of dispersion i.e. 0 was fully suspended and 5 fully creamed. This allows some comparison across the whole dose range and PVP concentration range used.

(Note concentration of Formoterol is 4.5µg/shot in all the samples)

(Samples are all fully dispersed at 0 seconds and therefore all have a score of 0)

Fully dispersed – 0	
More than 80% dispersed ie less than 20% clear liquid present	1
More than 60% dispersed ie less than 40% clear liquid present	2
Less than 40% dispersed ie more than 60% clear liquid present	3
Less than 20% dispersed ie more than 80% clear liquid present	4
Fully creamed	5

TABLE OF DEGREEE OF DISPERSION OF SUSPENSIONS OVER TIME: ALL SAMPLES

Dose	Time	PVP concentration (% w/w)					
µg/shot Budesonide	Sec/mins	0.0001	0.0005	0.001	0.01	0.03	0.05
320	15	**2**	**1**	**0-1**	**0-1**	**0-1**	**0-1**
	30	3	3	**2**	**1-2**	**2**	**2**
	60	4	4	3-4	**2**	3	3-4
	90	4	5	5	3	5	5
	2	5	5	4-5	4-5	5	5
	5	5	5	5	5	5	5
	10	5	5	5	5	5	5
160	15	3	**2**	**0-1**	**0-1**	**2**	**2**
	30	3	**2**	**1**	**1**	**2**	**2**
	60	5	4	**1**	**2**	4	5
	90	5	5	**1**	**2**	5	5
	2	5	5	**1**	**2**	5	5
	5	5	5	**2**	4	5	5
	10	5	5	**2**	4	5	5
80	15	**2**	**1**	**0**	**0**	**1**	**1**
	30	3	**2**	**1**	**1**	**2**	**2**
	60	4	**2**	**1**	**1-2**	3	3
	90	5	**3**	**1-2**	**1-2**	4	3
	2	5	**3-4**	**1**	**1**	5	4
	5	5	4	**2**	**2**	5	5
	10	5	5	3	3	5	5
40	15	**1**	**1**	**0**	**0**	**1**	**2**
	30	**2**	**1**	**1**	**2**	**2**	3
	60	**1-2**	**1**	**1**	**2**	**2**	3
	90	**1-2**	**1-2**	**1-2**	**2**	2-3	4
	2	**2**	**2**	**2**	3	4	5
	5	3	**2**	**2**	3	4	5
	10	4-5	3	**2**	4	5	5

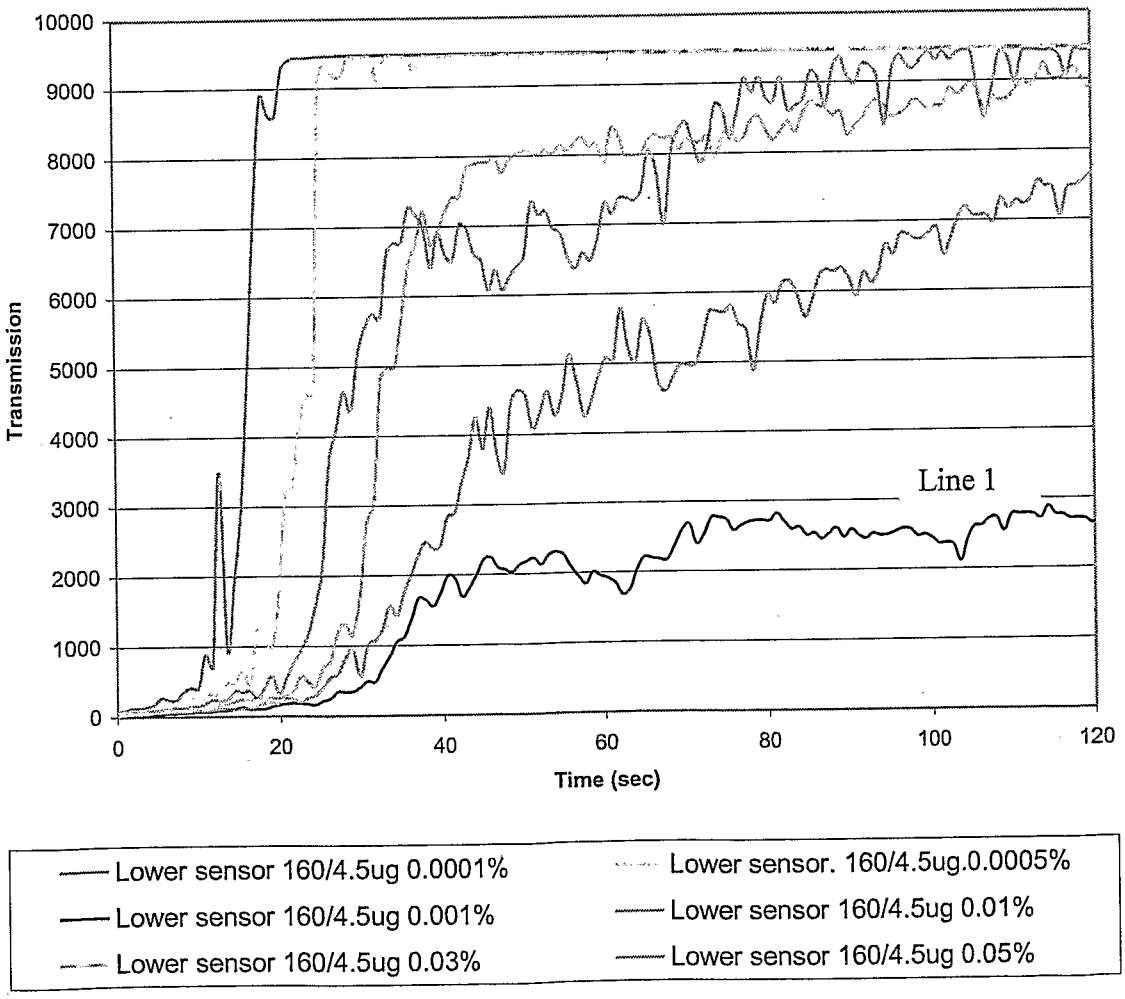
Suspensions considered excellent are highlighted in bold.

It can be seen that the formulations with 0.001% w/w PVP gave the best suspension stability overall.

OSCAR DATA (Graphs of light transmission versus time)

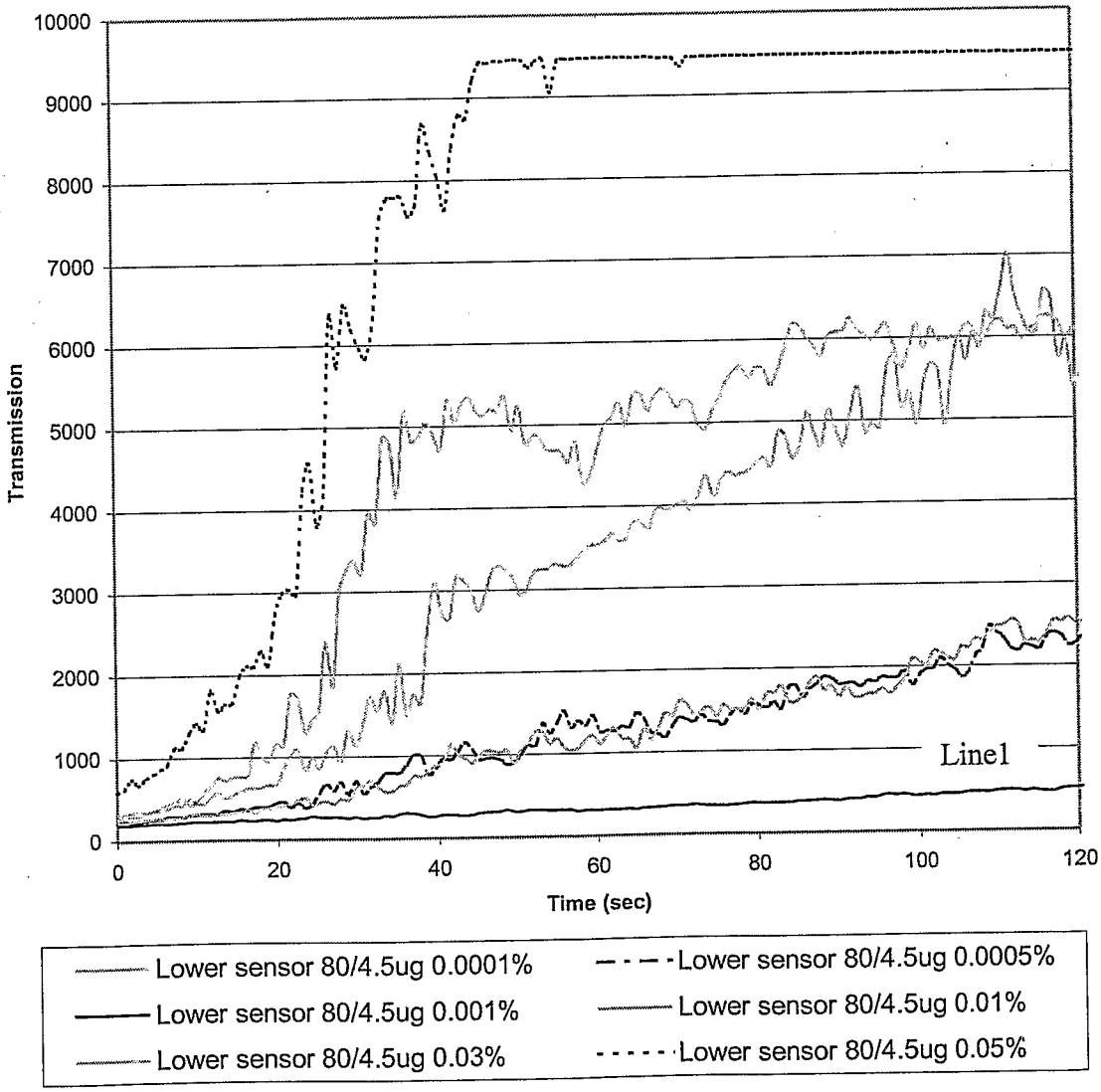
Figure 2 shows the average OSCAR transmission readings (lower sensor only) for various concentrations of PVP K25. A low transmission reading indicates that the suspension is dispersed preventing light being transmitted. Hence, it can be seen that the lowest line is the most stable formulation. This is the 0.001% PVP sample.

Figure 2: Averages of OSCAR data for formulation containing 160/4.5ug Budesonide/Formoterol. 0.3% w/w PEG 1000. 0.0001% - 0.05% w/w PVP K25.



In Figure 3, the bottom line, again with low transmission readings, clearly shows that the formulation containing 0.001% PVP is the most stable.

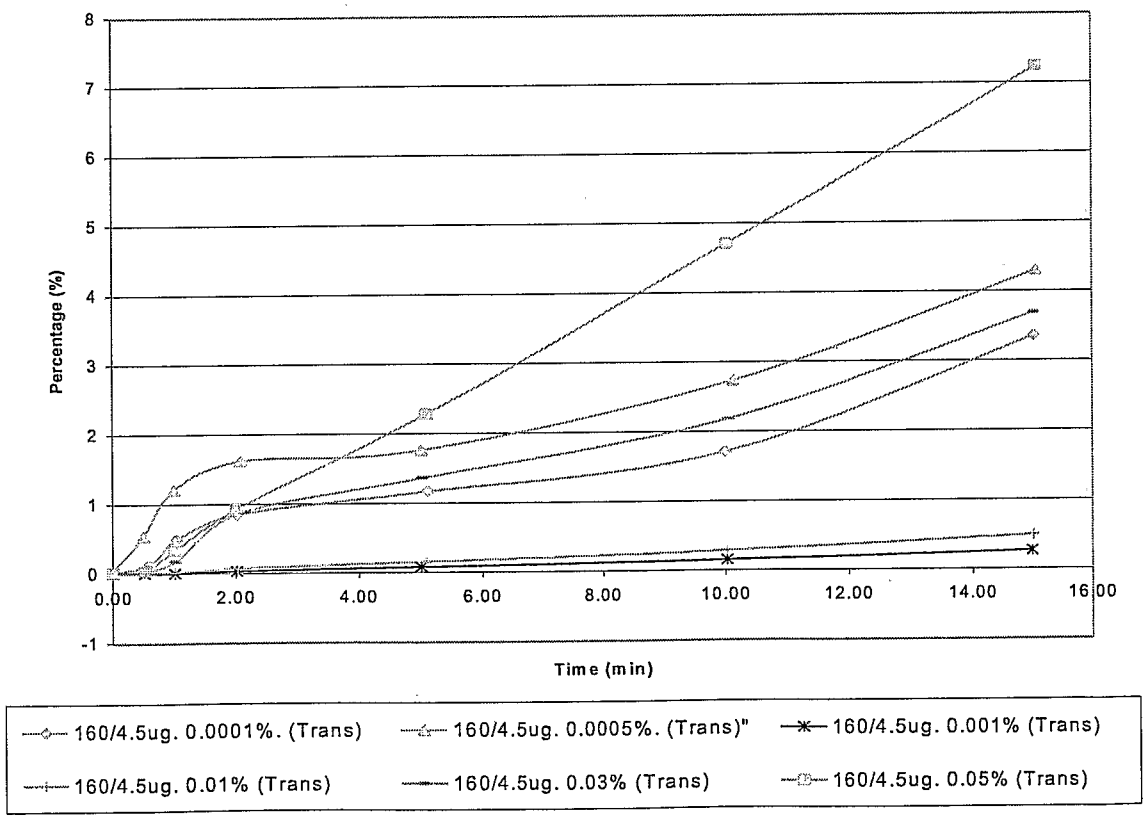
Figure 3: Averages of OSCAR data for formulation containing 80/4.5ug Budesonide/Formoterol. 0.3% w/w PEG 1000. 0.0001% - 0.05% w/w PVP K25, in HFA 227.



TURBISCAN DATA(Graphs of percentage (%) light transmission versus time)

Data from the Turbiscan can be intepretated in a similar vein to the OSCAR data in that a low percentage (%) transmission indicates the suspension is dispersed . The % transmission averages quoted here were taken from a zone around the middle of the suspension sample. In Figure 4 the most stable formulation is the lowest line with the lowest % transmission, i.e. the bold black line with 0.001%w/w PVP

Figure 4: Averages of Turbiscan data for formulation containing 160/4.5ug Budesonide/Formoterol. 0.3% w/w PEG 1000. 0.0001% - 0.05% w/w PVP K25, in HFA 227.



Figures 5 and 6 show that the suspension with 0.001% w/w PVP is the most stable (bottom bold line) with the lowest % transmission.

5

Figure 5: Averages of Turbiscan data for formulation containing 80/4.5ug Budesonide/Formoterol. 0.3% w/w PEG 1000. 0.0001% - 0.05% w/w PVP K25, in HFA 227.

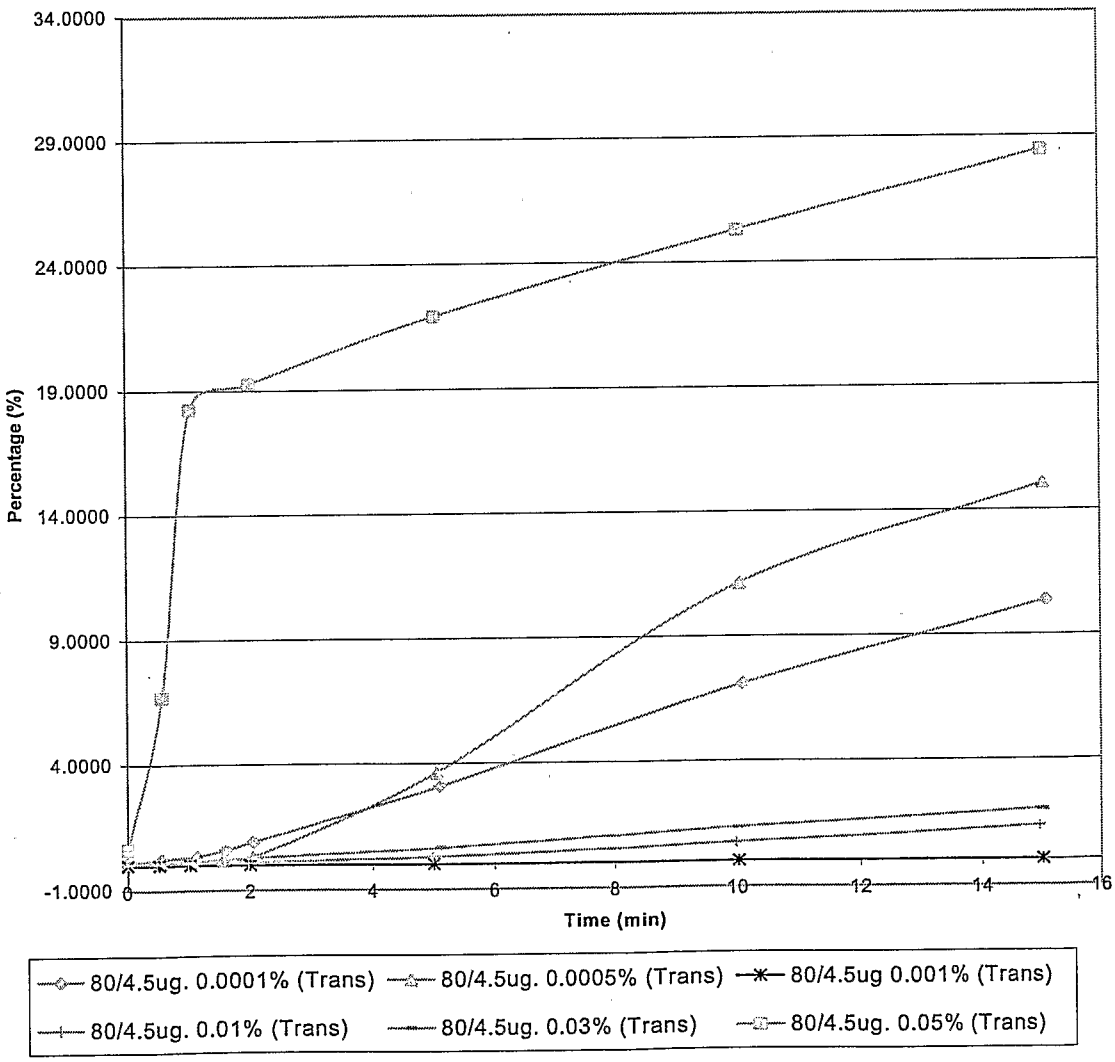
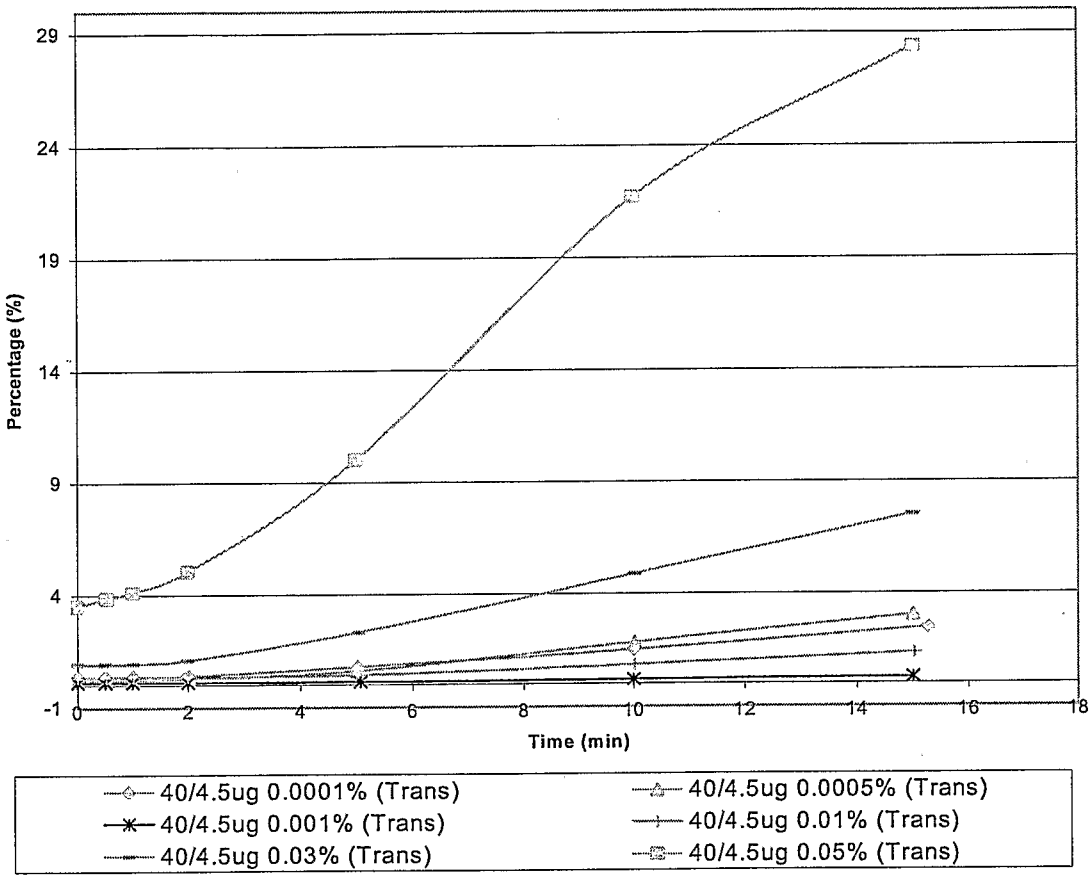


Figure 6: Averages of Turbiscan data for formulation containing 40/4.5ug Budesonide/Formoterol. 0.3% w/w PEG 1000. 0.0001% - 0.05% w/w PVP K25, in HFA 227.



FURTHER EVALUATION: Determination of the optimum PEG 1000 concentration.

For this evaluation, photography, turbiscan and force to fire data (valve performance) was used to determine the optimum PEG concentration.

METHODOLOGY - Force to fire (return force at 0.5mm stem return)

Force to fire testing was performed using the Lloyd LRX testing machine. The pMDI unit to be tested was placed valve down in a can holder on the lower platform of the unit. The upper crosshead was then moved to just above the base of the can. Can actuations were performed using a standard protocol. During measurement, force data is captured by

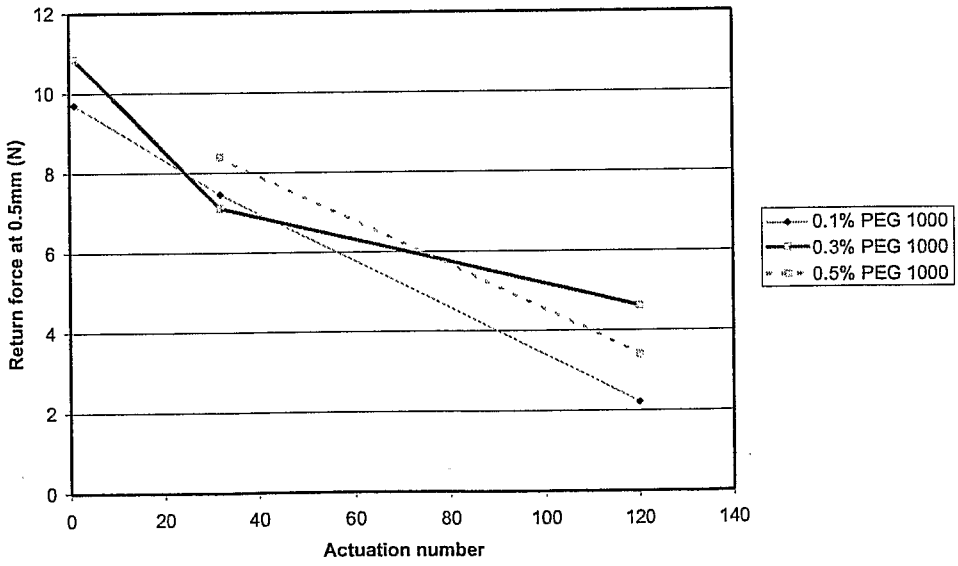
means of the load cell located at the top of the upper crosshead. This program was designed to output the return force at 0.5mm stem return as this is the point at which the metering chamber is considered to refill.

A low return force is indicative of high friction and potential sticking problems. It also suggests there may be a problem with low actuation weights as the propellant enters the metering chamber more slowly and has time to vaporise. Force to fire testing was performed at preset actuations.

DATA

FORCE TO FIRE DATA

Graph 1 Effect of PEG 1000 concentration on stem return force for the 4.5/160 µg formoterol/budesonide formulation

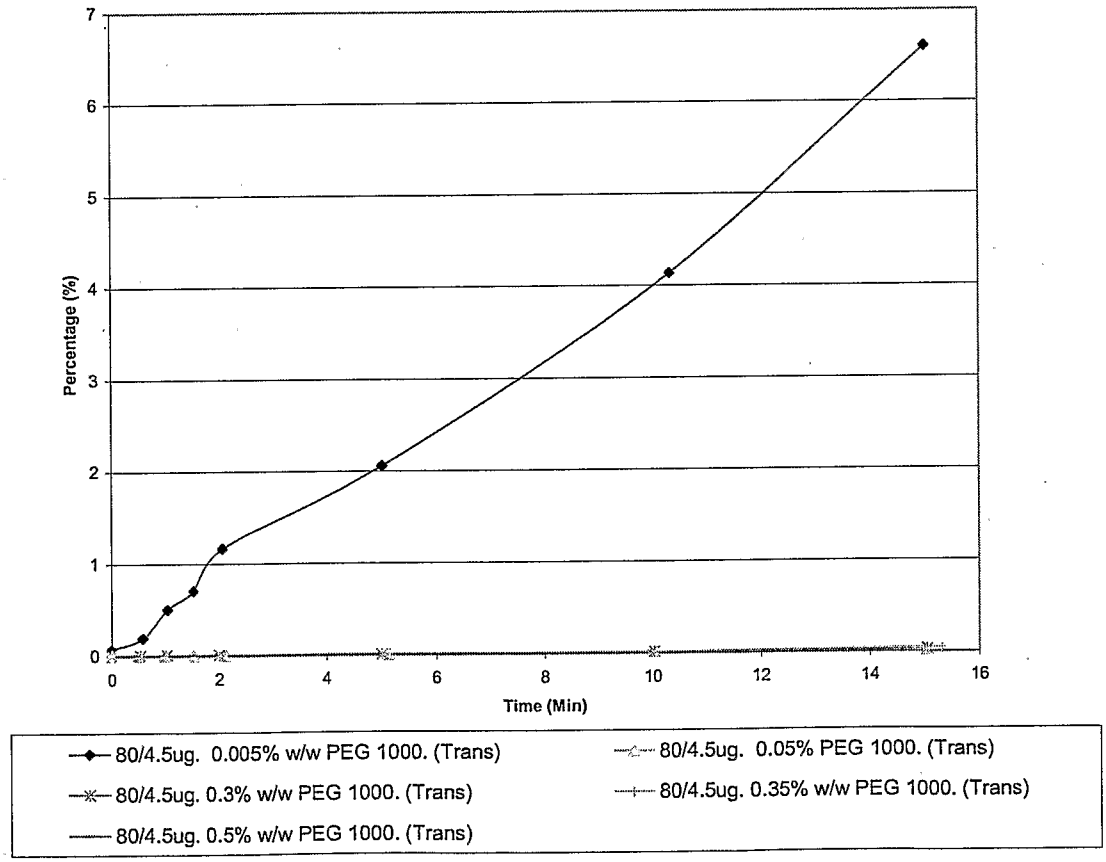


The above graph shows that at 120 actuations, the return force is greater for the 0.3% w/w PEG 1000 concentration than for the other concentrations of 0.5% and 0.1%. In general, the higher the return force the lesser the chance of the valve stem sticking. The above data shows that in this case 0.3% would be preferred.

TURBISCAN DATA

The Turbiscan data (figure 7) shows that there is little difference between the stability of suspensions made with varying levels of PEG 1000 except for the 0.005% w/w level which was unsatisfactory.

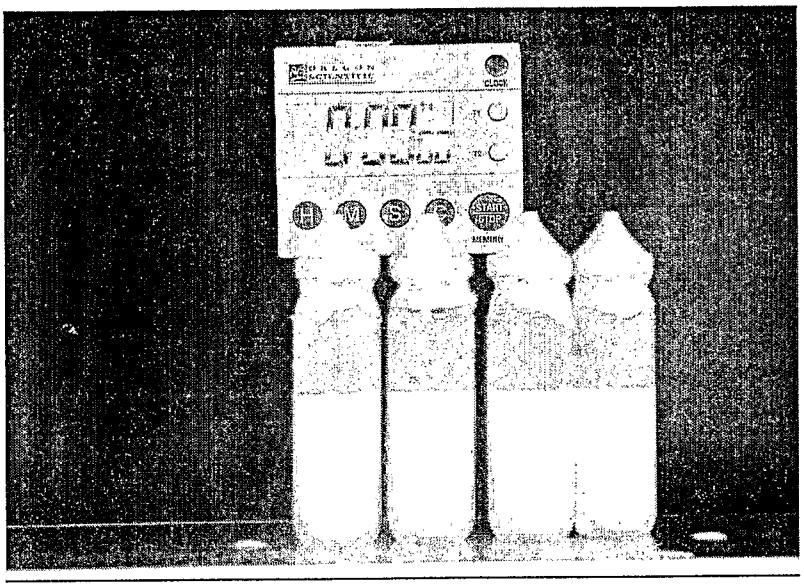
Figure 7:Averages of Turbiscan data for formulation containing 80/4.5ug Budesnoide/Formoterol. 0.001% w/w PVP K25. 0.005% - 0.5% w/w PEG 1000, in HFA 227.



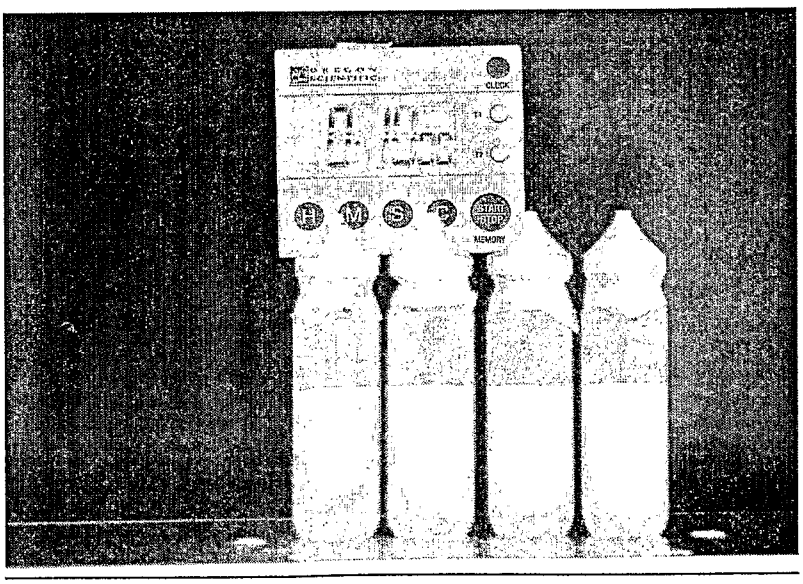
PHOTOGRAPHIC ANALYSIS

Digital photographs of suspensions containing Budesonide, Formoterol, HFA 227, 0.001%w/w PVP and varying levels of PEG 1000 show little variation in suspension stability over time (0 seconds to 10 minutes) except for the 0.005% w/w PEG level (in agreement with the Turbiscan data). Two photographs are shown below for examples.

Budesonide 80µg/shot, Formoterol 4.5µg/shot with 0.001% PVP K25 and various concentrations of PEG 1000 at 0 (1) and 10 minutes (2) standing time



PEG concn = left – right 0.005, 0.05, 0.35 and 0.5 % w/w



PRODUCT PERFORMANCE DATA

In addition to the above, product performance data for formulations containing formoterol fumurate dihydrate/budesonide at the following strengths, 4.5/80 mcg per actuation and

4.5/160 mcg per actuation, with 0.001% PVP K25 and either 0.1% or 0.3% PEG 1000 were stable for up to 12 months at 25°C/60% RH.

Product performance data for Symbicort formulations containing 0.001% PVP K25 and 0.1% PEG 1000 in HFA-227

Product strength (μg) (FFD/budesonide)	**Fine particle fraction (% cumulative undersize for 4.7 μm cut-off)**			
	Drug	Initial	25°C/60% RH 6 months	25°C/60% RH 12 months
4.5/80	Budesonide	51.3	52.8	62.0
	FFD	55.4	53.5	59.7
4.5/160	Budesonide	50.0	48.8	47.0
	FFD	54.2	52.1	51.3

Product performance data for Symbicort formulations containing 0.001% PVP K25 and 0.3% PEG 1000 in HFA-227

Product strength (μg) (FFD/budesonide)	**Fine particle fraction (% cumulative undersize for 4.7 μm cut-off)**			
	Drug	Initial	25°C/60% RH 6 months	25°C/60% RH 12 months
4.5/80	Budesonide	55.8	50.6	51.3
	FFD	64.2	57.6	58.7
4.5/160	Budesonide	48.7	50.2	52.3
	FFD	55.6	59.1	61.2

Claims.

1. A pharmaceutical composition comprising formoterol, budesonide, HFA 227, PVP and PEG.

2. A formulation according to claim 1 characterised in that the PVP is present from about 0.0005 to about 0.05 %w/w and the PEG is present from about 0.05 to about 0.35% w/w.
3. A pharmaceutical composition according to claim 1 or 2 in which the PVP is PVP K25.
4. A pharmaceutical composition according to claim 1 to 3 in which the PVP is present in an amount of 0.001% w/w.
5. A pharmaceutical composition according to any one of claims 1 to 4 in which the PEG is PEG 1000.
6. A pharmaceutical composition according to any one of claims 1 to 5 in which the PEG is present in an amount of 0.3% w/w.
7. A pharmaceutical composition according to any one of claims 1 to 6 in which formoterol is in the form of its fumarate dihydrate salt
8. A pharmaceutical composition according to any one of claims 1 to 7 in which the formoterol is in the form of the single R, R-enantiomer.
9. A pharmaceutical composition according to any one of claims 1 to 8 in which the second active ingredient is the 22R-epimer of budesonide.
10. A pharmaceutical composition according to any one of claims 1 to 9 for use for the treatment or prophylaxis of a respiratory disorder.
11. A pharmaceutical composition according to any one of claims 1 to 9 for use for the treatment or prophylaxis of asthma, rhinitis or COPD.
12. A method of treating a respiratory disorder in a mammal which comprises administering to a patient a pharmaceutical composition according to any one of claims 1 to 9.