56224002.38

The invention relates to pharmaceutical forms of pimobendan for oral administration. Pimobendan is 4,5-dihydro-6-[2-(4-methoxyphenyl)-1H-benzimidazol-5-yl]-5-methyl-3(2H)-pyridazinone which was described in European Patent No. 8391; pimobendan is a substance having cardiotonic, hypotensive and antithrombotic activities.

Unlike other substances having different structures mentioned in this patent specification, the resorption of pimobendan when administered orally is prone to considerable inter- and intra-individual fluctuations if the active substance is incorporated in known or conventional pharmaceutical forms for oral administration. The reason for this is that pimobendan is characterised by a low solubility in aqueous media and a very highly pH-dependent solubility.

Depending on the buffer system used, about 100 to 300 mg/l dissolve at a pH between 1 and 3 (corresponding to a 0.01 to 0.03% solution), but at pH 5 only about 1 mg/l will dissolve in water (corresponding to a 0.0001% solution or 1 ppm).

In in vivo tests on humans with pimobendan packed into hard gelatin capsules, one test subject showed no blood level of pimobendan, a second test subject showed a very low blood level and a third showed higher blood levels, but overall the blood levels of pimobendan fluctuated very considerably from one individual to another and the levels were too low. These unsatisfactory resorption characteristics can be explained primarily by the high pH-dependency of the solubility of pimobendan in aqueous media and by fluctuating pH conditions in the gastrointestinal tracts of the test subjects. It is known that the pH of the gastric juices, particularly in patients who have been fasting, can fluctuate between 1 and 6, but in patients

who have not fasted it is more frequently between 3 and 5 than 1 to 2.

It was therefore obvious to increase the solubility of pimobendan by the simultaneous administration of an acid. In vitro tests showed, however, that pimobendan in 0.1 N hydrochloric acid (pH value 1.1) dissolved in a quantity of only 100 mg/l (corresponding to a 0.01% solution). In a fumaric acid solution, pH 2.27, only 50 mg/l dissolve (corresponding to a 0.005% solution), in a 20% (by weight) tartaric acid solution, pH 1.2, 960 mg/l dissolve (corresponding to a 0.096% solution), and in a 40% tartaric acid solution, pH 0.7, only 3.9 g/l dissolve (corresponding to a 0.39% solution). None of these levels is sufficient, or the addition of acid required is no longer practicable for dissolving a sufficient quantity of the active substance and thereby ensuring reliable resorption, even if such quantities of these acids are administered orally simultaneously with the active substance.

Surprisingly, the applicants have now succeeded in overcoming the low solubility and high pH dependency of the solubility of pimobendan and ensuring a very satisfactory and more constant resorption, even if there are considerable pH fluctuations in the gastrointestinal tract, by intimately mixing the pimobendan with citric acid in a ratio by weight of at least or less than 1:5 and subsequently processing it with conventional excipients to form a powder, pellets or granules for oral administration. The granules, powder or pellets may also be compressed with suitable excipients to form tablets which may, if desired, also be covered with a flavour-masking coating.

Citric acid is a safe and well tolerated excipient which increases the solubility of pimobendan by a factor of 100, compared with artificial gastric juice (pH 1.2). Thus, 7.6 g/l will dissolve in an aqueous solution of pH 1.4 containing 20% by weight of citric acid, whilst in

an aqueous solution of pH 1.0 containing 40% by weight of citric acid as much as 12.1 g of pimobendan will dissolve per litre. However, these quantities of dissolved pimobendan are sufficient to ensure adequate resorption of the active substance even in patients who, when given conventional pimobendan preparations by oral route, showed no blood levels or very low and sharply fluctuating blood levels of pimobendan.

Citric acid is difficult to process into solid preparations. To avoid the formation of salts of pimobendan with citric acid, which would increase the hygroscopicity of the formulation, it is at first sight obvious to process the active substance and acid in two separate granulates. However, it has been found (see Examples 1b to 1d and 2a) that when separated in this way the citric acid cannot fully develop its solubilising activity. However, it has been found that by intimately mixing pimobendan with citric acid to form a powder mixture which is subsequently processed into granules, a pellet or tablets, it is possible to obtain preparations with small amounts of citric acid which ensure adequate dissolution and sufficiently high blood levels. Technically, this can be achieved for example by non-aqueous granulation, e.g. by granulation with alcohol or by the use of suitable granulating methods which make it possible to add the granulating liquid in accurately metered amounts, with simultaneous drying. Another possibility is the preparation of granules by dry granulation, these granules containing the active substance and citric acid intimately mixed. Owing to the hygroscopic properties of the citric acid, care must be taken to ensure that the preparation forms disintegrate rapidly in the release medium; in the case of tablets, this is achieved by the addition of disintegrants, e.g. Amberlite® IRP 88 (methacrylic resin with exchangeable protons), Crospovidone® (crosslinked polyvinylpyrrolidone) and microcrystalline cellulose,

which will simultaneously improve the poor compression properties of citric acid.

A weight ratio of pimobendan to citric acid of between 1:10 and 1:20 is preferred. The upper limit is defined by the ability of the preparations to be swallowed.

The prevention of sharply fluctuating blood levels (both inter- and intra-individually) by the addition of citric acid can be explained as follows: when the intimate mixture of active substance and citric acid comes into contact with gastric juice, an acidic microsphere is formed around the particles owing to the high rate of dissolution of the citric acid. This microsphere is always acidic, irrespective of the pH of the gastrointestinal juices, and ensures that the finely divided active substance will reliably dissolve and therefore be freely available for resorption.

Solubility tests have shown, for pH values between 1 and 6, that the active substance dissolves out of this intimate mixture virtually irrespective of the pH. In addition, the active substance also forms supersaturated solutions with the citric acid which remain stable for hours. This ensures a high level of resorption in any case, even in patients with abnormally high pH levels in their gastrointestinal juices. Of the many acids tested for this purpose, citric acid has unexpectedly proved outstanding; apart from acting as an acid, it serves as a solubilising agent and also as a stabiliser for the active substance solution obtained. An important prerequisite for the dissolving of the active substance independently of the local physiological pH value is the intimate mixing of the pimobendan with the citric acid. For this, it is necessary that both substances be present in powder form or as very small crystals, so that they will make contact with each other over a large surface area.

Tests on dogs after oral administration of a form

according to Example 1a containing 5 mg of pimobendan, by comparison with a form according to Example 1b containing 5 mg of pimobendan and 50 mg of citric acid, showed that the pimobendan plasma level was approximately trebled by the form containing the citric acid compared with the form containing no citric acid. The tests were each carried out on 5 experimental animals. The mean curve values found are shown in Figures 1 and 2. The plasma level values are shown in nanograms per millilitre as a function of time.

Human trials using oral pimobendan forms according to Examples 3b and 3c (capsules) on 11 test subjects gave the mean curves for the plasma levels shown in Figure 3. The maxima occurred at 1 to 1.5 hours after administration. In addition to the capsule formulations according to Examples 3b and 3c, the plasma level curves of the tablet form according to Example 2b and the capsule form according to Example 4 were each tested on 11 test subjects. It was found that the tablet containing only 50 mg of citric acid according to Example 2b is bioequivalent to the capsule formulation containing 209 mg of citric acid according to Example 4. The plasma levels were obtained by high pressure liquid chromatographic methods, resulting in the mean curves for the plasma levels shown in Figure 4 (mean values ± standard deviations).

By way of a comparison, a tablet formulation according to Example 3a was administered orally, i.e. a formulation with no citric acid. This resulted in the curves for the plasma levels shown in Figures 5a to c on three test subjects. If Figures 5a to c are compared with Figure 4, the superiority of the citric acid preparation, which is made apparent by the reduced fluctuations in plasma levels, over a preparation without citric acid becomes very clear.

It goes without saying, that instead of using pimobendan, one of its possible enantiomers can also be

used with equal success.

As a further illustration, by way of example, of the object of this invention, reference is made to the following Examples of oral preparations. In these Examples:

Amberlite® IRP 88 = methacrylic resin with exchangeable H^+

Collidone® 25 = polyvinylpyrrolidone, average molecular weight 25,000

Avicel® = microcrystalline cellulose

Polyplasdone® XL = crosslinked polyvinylpyrrolidone = polyvinylpolypyrrolidone

Compritol® 888 = glyceryl monobehenate

Tween® 80 = polyoxyethylene-(20)-sorbitan monooleate

Explotab® = sodium carboxymethyl starch

Aerosil® 130 V = highly dispersed, X-ray amorphous silicon dioxide.

Example 1

Tablets containing 5 mg of pimobendan

a) Tablets without citric acid

Composition:

1 tablet contains (mg)

(1) Pimobendan	5.0
(2) Microcrystalline cellulose	58.0
(3) Sec. calcium phosphate	72.0
(4) Corn starch	54.0
(5) Amberlite® IRP 88	10.0
(6) Magnesium stearate	1.0
	200.0

Preparation:

Some of the corn starch is dissolved in water with heating and the mixture of ingredients (1) to (4) is granulated therewith. (5) and (6) are added to the dried granules. Tablets 8 mm in diameter and weighing 200 mg are compressed from the finished mixture.

Measurement of rate of dissolution:
According to USP XXII, paddle method, 150 rpm, in McIlvaine buffer, pH 5.5.
$\bar{x}$ from 3 individual measurements in each case.

Results:

After 5 min.: 8.5%
10 min.: 10.2%
15 min.: 10.7%
20 min.: 10.8%
30 min.: 10.8% pimobendan dissolved.

b) Tablets containing 50 mg of citric acid

Composition:

1 tablet contains (mg)

(1) Pimobendan	5.0
(2) Citric acid	50.0
(3) Microcrystalline cellulose	42.0
(4) Collidone® 25	0.5
(5) Sec. calcium phosphate	52.0
(6) Corn starch	39.5
(7) Amberlite® IRP 88	10.0
(8) Magnesium stearate	1.0
	200.0

Preparation:

Some of the corn starch is dissolved in water with heating and ingredient (1), some of (3), (5) and some of (6) are granulated therewith. (2) and the remainder of (3) and (6) are granulated with the aqueous solution of (4). The granules are dried and mixed together. (7) and (8) are added to the mixture of dried granules to form the final mixture. This is then compressed to form tablets 8 mm in diameter and weighing 200 mg.

Note:

Active substance and acid are presented in separate granules for ease of manufacture but are mixed together.

Measurement of rate of dissolution: as in Example 1a.

Results:

After 5 min.: 7.7%
10 min.: 19.2%
15 min.: 34 %
20 min.: 40.6%

30 min.: 43% pimobendan dissolved.

c) Tablets containing 103 mg of citric acid

Composition:

1 tablet contains (mg)

(1) Pimobendan	5.0
(2) Citric acid	103.0
(3) Microcrystalline cellulose	35.0
(4) Collidone® 25	1.0
(5) Sec. calcium phosphate	31.5
(6) Corn starch	81.5
(7) Amberlite® IRP 88	10.0
(8) Magnesium stearate	3.0
	270.0

Preparation:

Analogous to Example 1b.

Tablets: 9 mm diameter, 270 mg in weight.

Note:

The active substance and acid are present in separate granulates for ease of manufacture but are mixed together.

d) Tablets containing 206 mg of citric acid

Composition:

1 tablet contains (mg)

(1) Pimobendan	5.0
(2) Citric acid	206.0
(3) Avicel®	50.0

(4) Collidone® 25	2.0
(5) Sec. calcium phosphate	63.0
(6) Corn starch	46.0
(7) Amberlite® IRP 88	20.0
(8) Magnesium stearate	3.0
	395.0

Preparation:

Analogous to Example 1b.

Tablets: 11 mm in diameter, weight 395 mg.

Note:

The active substance and acid are present in separate granulates for ease of manufacture but are mixed together.

Measurement of rate of dissolution: analogous to Example 1a.

Result:

After 5 min.: 23.8%
10 min.: 59%
15 min.: 67%
30 min.: 69% pimobendan dissolved.

Example 2

Tablets containing 2.5 mg of pimobendan

a) Tablets containing 103 mg of citric acid

Composition:

1 tablet contains (mg)

(1) Pimobendan	2.5
(2) Corn starch	23.0

(3) Microcrystalline cellulose	26.0
(4) Anhydrous calcium phosphate	31.5
(5) Polyplasdone® XL	59.0
(6) Citric acid, fine particles (anhydrous)	103.0
(7) Compritol® 888	5.0
	250.0

Preparation:

(1) to (4) are granulated with aqueous starch solution. The other tablet ingredients are added to the dry granules to make the final mixture. From this, tablets are compressed measuring 9 mm in diameter and weighing 250 mg.

Note:

The active substance and acid occur separately, for ease of manufacture, but are subsequently mixed together.

Measurement of speed of dissolution: analogous to Example 1a.

Results:

After 5 min.: 18.7%
10 min.: 20.5%
20 min.: 21.8%
30 min.: 22.2%
60 min.: 22.7% pimobendan dissolved.

b) Tablets containing 50 mg of citric acid

Composition:

1 tablet contains (mg)

(1) Pimobendan	2.5
(2) Anhydrous powdered citric acid	50.0
(3) Avicel® PH 101	13.0

(4) Anhydrous calcium hydrogen phosphate	15.0
(5) Undried corn starch	6.0
(6) Collidone® 25	0.5
(7) Insoluble polyvinylpyrrolidone	59.0
(8) Compritol® 888	3.0
(9) Magnesium stearate	1.0
	150.0

Preparation:

(6) is dissolved in ethanol and the mixture of ingredients (1) to (5) is granulated therewith. (7) to (9) are added to the dry granules to form the mixture ready for compression. This mixture is compressed to form tablets measuring 8 mm in diameter.

Note:

Active substance and acid are present together in the same granulate.

Measurement of rate of dissolution: analogous to Example 1a.

Result:

After 15 min.: 71.1%
30 min.: 85% pimobendan dissolved.

Example 3

Capsules containing 5 mg of pimobendan

a) Capsules without citric acid

Composition:

1 capsule contains (mg)

Pimobendan	5.0
Lactose	90.25

Corn starch	36.0
Tween® 80	0.5
Explotab®	8.0
Magnesium stearate	0.25
	140.0

Preparation:

The individual powders are intensively mixed together and packed into size 4 hard gelatin capsules (140 mg per capsule).

b) Capsules containing 230 mg of citric acid

Composition:

1 capsule contains (mg)

(1) Pimobendan	5.0
(2) Citric acid	230.45
(3) Collidone® 25	3.78
(4) Magnesium stearate	0.77
	240.00 mg

Preparation:

(1) and (2) are intensively mixed together and granulated with an alcoholic solution of (3). (4) is added to the dried granulate. The final mixture thus obtained is packed into size 1 hard gelatin capsules (240 mg per capsule).

Note:

Active substance and acid are present together in one and the same granulate.

Measurement of rate of dissolution: analogous to Example 1a.

Result:
After 5 min: 100% pimobendan dissolved.

c) Capsules containing 207 mg of citric acid

Composition:

1 capsule contains (mg)

(1) Pimobendan, finely ground	5.0
(2) Citric acid	206.5
(3) Microcrystalline cellulose	40.0
(4) Aerosil® 130 V	11.0
(5) Collidone® 25	4.0
(6) Magnesium stearate	1.5
	268.0

Preparation:

(1) is triturated with (2). (3) and (4) are added to the triturated material. The mixture is granulated with an alcoholic solution of (5). (6) is mixed into the dry granulate. The finished mixture is packed into size 1 capsules (268 mg per capsule).

Note:

Active substance and acid are present in one and the same granulate.

Measurement of rate of dissolution: analogous to Example 1a.

Result:
After 5 min.: 84.1%
10 min.: 90.2%
15 min.: 91.7%
30 min.: 92.5% pimobendan dissolved.

Example 4

Capsules containing 2.5 mg of pimobendan

Capsules containing 209 mg of citric acid

Composition:

1 capsule contains (mg)

(1) Pimobendan	2.5
(2) Powdered citric acid	209.0
(3) Microcrystalline cellulose	40.0
(4) Silicon dioxide	11.0
(5) Polyvinylpyrrolidone	4.0
(6) Magnesium stearate	1.5
	268.0

Preparation:

Analogous to Example 3c.

Note:

Active substance and acid are present in one and the same granulate.

Measurement of rate of dissolution: analogous to Example 1a.

Result:

After 15 min.: 96.5%

30 min.: 99.1% pimobendan dissolved.

Example 5

Film coated tablet containing 2.5 mg of pimobendan

Tablets containing 50 mg of citric acid

Composition:

1 tablet contains (mg)

(1) Pimobendan	2.5
(2) Powdered anhydrous citric acid	50.0
(3) Avicel® PH 101	13.0
(4) Anhydrous calcium hydrogen phosphate	15.0
(5) Undried corn starch	6.0
(6) Collidone® 25	0.5
(7) Insoluble polyvinylpyrrolidone	59.0
(8) Compritol® 888	3.0
(9) Magnesium stearate	1.0
	150.0

Preparation:

The preparation is as described in Example 2b, but the finished mixture is compressed into biconvex tablets. These are coated with 5 mg of hydroxypropylmethylcellulose per tablet.

Note:

Active substance and acid are together in the same granulate.

Measurement of rate of dissolution: analogous to Example 1a.

Results:

After 10 min.: 76.8%

30 min.: 86.1% pimobendan dissolved.

Patent Claims

1. Pharmaceutical forms of pimobendan for oral administration, containing pimobendan and citric acid in an intimate mixture in a ratio by weight of at least or less than 1:5, together with conventional excipients.

2. Pharmaceutical forms according to claim 1 in the form of granulates, powders or pellets, optionally packed into capsules.

3. Pharmaceutical forms according to claim 2, the granulates, powders or pellets being compressed with suitable excipients into tablets which are optionally provided with a flavour-masking coating.

4. Pharmaceutical forms according to claims 1 to 3, characterised by a weight ratio of pimobendan to citric acid of between 1:10 and 1:20.

5. Pharmaceutical forms according to claims 1 to 4 containing, as excipient, a disintegrant.

6. Process for preparing pharmaceutical forms of pimobendan for oral administration, characterised in that pimobendan and citric acid are intimately mixed in a ratio by weight of at least or less than 1:5 and are either granulated non-aqueously moistened or are granulated with water by suitable granulating methods which allow accurately metered addition of the granulating liquid with simultaneous drying, or by means of dry granulation.

7. Process according to claim 6, characterised in that the granulates are processed into pellets.

* C L M S *

8. Process according to claims 6 and 7, characterised in that the granulates or pellets are compressed with suitable excipients into tablets which are optionally given a flavour-masking coating.

9. Process according to claims 6 and 7, characterised in that the granulates and pellets are packed into capsules.

* C L M S *