IMMEDIATE RELEASE TABLET

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Field of the invention

The invention relates to a solid dosage form of a low molecular weight thrombin inhibitor formulated as immediate release (IR) tablets as well as a process for manufacture thereof. The invention also relates to the medical use of the formulation in the prophylaxis and / or treatment of thromboembolism.

Background of the invention

The thrombin inhibitor, used in the formulation of the present invention is a low molecular weight drug with pH dependent solubility. It is characterised by a low solubility at basic pH which is dramatically increased in the protonated form at acidic pH. Thus, upon administration in conventional IR formulations, fast dissolution of the drug is obtained in acidic pH while markedly slower dissolution is obtained at more neutral pH. This variability in dissolution is not acceptable for safe, efficient and convenient therapy. The present invention provides an immediate release formulation based on conventional manufacturing processes with careful chosen excipients that provides a dissolution which is not , or very little dependent on pH.

Several different ways have been suggested in order to prepare immediate-release solid dosage forms.

Lachman (The theory and practice of industrial pharmacy 1986, 343, appA) describes the composition and manufacturing of two different standard granulates for IR tablets. These two compositions gave very poor quality of the granulates, which gave unacceptable tablets with very low hardness. These compositions do not work with the low molecular weight thrombin inhibitors used in connection with the present invention. The tablets do

not answer to the definition of a rapidly dissolving drug product presented in Guidance for Industry. Waiver of in Vivo Bioavailability and Bioequivalens Studies for Immediate Release Solids Dosage Forms Containing Certain Active Moieties/Active Ingredients Based on Biopharmaceutics Classification System. Tablets must release 85% or more of stated amount within 30 min.

Description of the invention

It has now been found that low molecular weight peptide-based thrombin inhibitors with pH-dependent solubility - including their salts - can be formulated as IR tablets with no or very little pH depending dissolution.

Therefore, the object of the present invention is to provide a novel pharmaceutical formulation comprising a low molecular weight peptide-based thrombin inhibitor formulated as an IR-tablet with no or very little pH depending dissolution and a process for the preparation of such formulation.

Thrombin inhibitors referred to in this application are low molecular weight peptide-based thrombin inhibitors with pH dependent solubility. The term "low molecular weight peptide-based thrombin inhibitors" will be well understood by one skilled in the art to include thrombin inhibitors with one to four peptide linkages, and/or with a molecular weight below 1000, and includes those described generically and, more preferably, specifically in the review paper by Claesson in Blood Coagul. Fibrin. (1994) 5, 411, as well as those disclosed in US Patent No. 4,346,078; International Patent Applications WO 97/23499, WO 97/02284, WO97/46577, WO 98/01422, WO 93/05069, WO93/11152, WO 95/23609, WO95/35309, WO 96/25426, WO 94/29336, WO WO 93/18060 and WO 95/01168; and European Patent Applications 623 596, 648 780, 468 231, 559 046, 641 779, 185 390, 526 877, 542 525, 195 212, 362 002, 364 344, 530 167, 293 881, 686 642, 669 317 and 601 459.

Preferred low molecular weight peptide-based thrombin inhibitors include those known collectively as the "gatrans". Particular gatrans which may be mentioned include HOOC-CH_2(R)Cha-Pic-Nag-H (known as inogatran; see International Patent Application WO 93/11152 and the list of abbreviations therein) and HOOC-CH_2-(R)Cgl-Aze-Pab-H (known as melagatran; see International Patent Application WO 94/29336 and the list of abbreviations therein).

The preferred low molecular weight peptide-based thrombin inhibitor is selected from the group consisting of inogatran, *(Glycine, N-[2-[2-[[[3-[(aminoimino-methyl)amino]propyl]amino]carbonyl]-1-piperidinyl]-1-(cyclohexylmethyl)-2-oxoethyl]-, [2R-[2S]]-)*, melagatran, *(Glycine, N-[2-[2-[[[[4 (aminoiminomethyl)phenyl]-methyl]amino]carbonyl]-1-azetidinyl]-1-cyclohexyl-2-oxoethyl]-, [2R-[2S]]-)* and compound A, *(Glycine, N-[1-cyclohexyl-2-[2-[[[[4-[(hydroxyimino)aminomethyl]-phenyl]methyl]amino]carbonyl]-1-azetidinyl]-2-oxoethyl]-, ethyl ester, [S-(R*, S*)]-)*.

The particularly preferred low molecular weight thrombin inhibitor Compound A is effective for the treatment of thrombo-embolism. Compound A is described in the International Patent Application WO 97/23499. Compound A is a low molecular weight thrombin inhibitor with good oral bioavaibility, low variability and limited food interaction. No solid dosage forms containing this thrombin inhibitor have been reported.

In order to produce tablets which provides a dissolution which is not or very little dependent on pH compound A should have a particle size less than 300 μm, preferably less than 150 μm and with a preferred mean particle size less than 80 μm. With other low molecular weight thrombin inhibitor with low solubility at basic pH and pH dependent solubility the requirements on the particle size will depend on the level of low solubility.

It has been found that by carefully selecting excipients the pH dependent dissolution could be reduced and giving a tablet release of more than 85% within 30 minutes in acidic as

well as neutral environment. This in spite of Compound A having an extremely pH dependent solubility.

The formulation according to the invention comprises the thrombin inhibitor, a filler or a combination of fillers, said filler/fillers having disintegrant properties (due to swelling) and, optionally, non swelling filler(s) disintegrant(s), binder(s) and/or lubricant(s).

The amount of filler/fillers having disintegrant properties constitutes more than 35% (w/w), preferably more than 50% (w/w) of the formulation.

Some excipients can serve multiple purposes, e.g. be a filler and a disintegrant at the same time. An excipient used in higher amounts than 35 % is in the invention defined as a filler but may contribute with other important properties for the formulation e.g. disintegration, binding or lubrication.

The filler with disintegrant properties is selected from the group consisting of cellulose per se (such as microcrystalline cellulose), microfine cellulose) starch per se (such as maize starch, sodium starch glycollate, potato starch, rice starch, wheat starch).

The nonswelling filler is selected from the group sugars (such as mannitol, sorbitol, dextrose, xylitol, sucrose, laktos).

The disintegrant is selected from the group consisting of cellulose per se (such as microcrystalline cellulose, microfine cellulose, cross-linked sodium carboxymethyl cellulose, cross-linked hydroxypropyl cellulose), starch per se (such as sodium starch glycollate, pregelatinised starch, maize starch, potato starch, rice starch, wheat starch) and others (such as cross linked polyvinylpyrrolidone, cationic exchange resin).

The binder is selected from the group consisting of cellulose per se (such as sodium carboxymethylcellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, methyl

cellulose), polymers (such as polyvinylpyrrolidone, polyethylene glycol), gelatins (such as hydrolysed gelatin), and traditional binders (such as starch, natural gums).

The lubricant is selected from the group consisting of insoluble lubricants (such as magnesium stearate, calcium stearate, zink stearate, stearic acid, oils, talc, sodium stearyl fumarate), and soluble lubricants (such as polyethylene glycol, sodium benzoate, sodium lauryl sulphate).

In the formulation according to the invention the different constituents are preferably included in the following proportions, calculated by per cent w/w of the finished tablet:

Thrombin inhibitor: 1 - 35 %, preferably 1 - 15 %.

Filler: 35 - 90 %, preferably 45 - 80 %, when microcrystalline cellulose 50 - 90 %, preferably 60 - 80 % and most preferably 72 - 76 %, when nonswelling filler 0-50% when mannitol 0 - 15 %, preferably 5 - 10 %.

Disintegrant: 0 - 35 %, preferably 7 - 35 %, when sodium starch glycollate 3 - 20 %, preferably 5 - 10 %.

Binder: 0- 15 %, preferably 4 - 12 %, when polyvinylpyrrolidone 3 - 15 %, preferably 5 - 10 %.

Lubricant: 0 - 5 %, preferably 0.5 - 1.5 %, when sodium stearyl fumarate 0.5 - 1.5 %, preferably above 1 %.

In the invention it was found that a formulation comprising the active component with a particle size less than 300 µm, preferably less than 150 µm and with a preferred mean particle size less than 80 µm, fillers (e.g. microcrystalline cellulose (50-90%, preferably 74%), mannitol (0 - 15 %, preferably 8.5 %) disintegrant

(e.g. sodium starch glycollate 3 - 20 %, preferably 8.5 %), moistened with with a suitable binder (e.g. polyvinylpyrrolidone K 90 (3- 15 %, preferably 8 %) and final mixed with suitable lubricant (e.g. sodium stearyl fumarate (0.5 - 1.5 %, preferably 1 %) provided a tablet having good technical properties and a very small pH dependent dissolution.

The formulations according to the invention can preferably be prepared either by direct compression or by wet granulation technique.

Direct compression

A low molecular weight thromin inhibitor is mixed with the filler of fillers and if necessary the disintegrant. This mixture is then mixed with the lubricant and compressed to the tablets.

Wet granulation

A low molecular weight thrombin inhibitor is mixed with the filler of fillers, and if necessary the disintegrant. The mixture is then moistured with a suitable solvent in which the binder may be dissolved. After drying the granulate is milled and then mixed with the lubricant and compressed to tablets

Working Examples

Example 1 Drug dissolution from tablets according to the invention

IR tablets of the thrombin inhibitor, Compound A, were prepared by mixing Compound A microcrystalline cellulose, sodium starch glycollate and mannitol The mixture was moistured with a suitable amount of polyvinylpyrrolidone K 90 dissolved in water. After drying, the granulate was milled and then mixed with sodium stearyl fumarate and compressed to tablets.

	mg/tabl
Compound A	24
Microcrystalline cellulose (MCC pH 101)	140
Sodium starch glycollate	16
Mannitol	16
Polyvinylpyrrolidone K 90	15
Water	q.s.
Sodium stearyl fumarate	2
Punches:	9mm
Tablet weight:	213 mg
Hardness:	110N

The obtained tablets were analysed with regard to dissolution of Compound A using a USP dissolution apparatus No. 2 (paddle), 100 rpm, 500 ml. The dissolution medium used had a temperature of 37°C. Two different dissolution medium were used, 0.1 M HCl pH 1 and phosphate buffer pH 6.8 (ionic strength 0.1). The amount of Compound A released was determined by UV-spectrometry.

Results are shown in Figure 1. After 30 minutes the amount of Compound A dissolved was 94 % (average n=3) in 0.1 M HCl and 94 % (average n=3) in phosphate buffer pH 6.8.

Example 1b Drug dissolution from tablets according to the invention

IR tablets of thrombin inhibitor, Compound A were prepared by mixing Compound A, microcrystalline cellulose and maize starch and the mixture was moistured with a suitable amount of maize starch (paste). After drying the granulate was milled and then mixed with polyvinylpyrrolidone crosslinked. Finally the sodium stearyl fumarate was admixed and the granulate was compressed into tablets.

	mg/tabl
Compound A	30
Microcrystalline cellulose	115
Maize starch	55
Maize starch (paste)	6
Water	q.s.
Polyvinylpyrrolidone crosslinked	10
Sodium stearyl fumarate	2.2
Punches:	8.5 mm
Tablet weight:	219 mg
Hardness:	110 N

The obtained tablets were analysed for dissolution of Compound A according to the method described in Example 1. Results are shown in Figure 2. After 30 minutes the amount of Compound A dissolved was 100 % (average n=3) in 0.1 M HCl and 97 % (average n=3) in phosphate buffer pH 6.8.

Example 2 Drug dissolution from tablets according to the reference

Lachman ((The theory and practice of industrial pharmacy 1986,343,appA) describes another composition and manufacturing of a"standard" granulate for an IR tablet. IR tablets of the thrombin inhibitor, Compound A were prepared according to this method by mixing Compound A, tricalcium phosphate and the mixture was moistured with pre-gelatinated maize starch dissolved in water. After drying the granulate was milled and then mixed with talc Finally, the mineral oil was admixed and the granulate was compressed to tablets.

Compound A	24
Tricalcium phosphate	100
Pregelatinized starch	15
Water	q.s.
Talc	60
Mineral oil, light	4
Punches:	9 mm
Tablet weight:	198 mg
Hardness:	12 N

The obtained tablets were analysed for dissolution of Compound A according to the method described in Example 1. Results are shown in Figure 2. After 30 minutes the amount of Compound A dissolved was 40 % (average n=3) in 0.1 M HCl and 5 % (average n=3) in phosphate buffer pH 6.8.

Example 3 · Drug dissolution from tablets according to the reference

Lachman (The theory and practice of industrial pharmacy 1986,343,appA) describes composition and manufacturing of a another "standard" granulate for an IR tablet. IR tablets of thrombin inhibitor, Compound A were prepared according to this method by mixing Compound A, lactose and the mixture was moistured with starch dissolved in water.

After drying the granulate was milled and then mixed with dry starch and talc. Finally the mineral oil was admixed and the granulate was compressed to tablets.

Compound A	24
Lactose	110
Starch(paste)	5
Starch	28
Talc	28
Mineral oil 50 cps	11
Punches:	9mm
Tablet weight	206 mg
Hardness:	13 N

The obtained tablets were analysed for dissolution of Compound A according to the method described in Example 1. Results are shown in Figure 3. After 30 minutes the amount of Compound A dissolved was 100 % (average n=3) in 0.1 M HCl and 74 % (average n=3) in phosphate buffer pH 6.8.

Short description of the Figures

Figure 1: Dissolution of the thrombin inhibitor Compound A from tablets according to the invention as described in Example 1. (No figure is given for example 1b).

Figure 2: Dissolution of the thrombin inhibitor Compound A from tablets according to the reference as described in Example 2

Figure 3: Dissolution of the thrombin inhibitor Compound A from tablets according to the reference as described in Example 3

Conclusion (Examples)

From the Examples it is obvious that a sufficient quality of the product is not achieved when using a "standard" granulate. Either the technical properties are bad [Example 2 and 3,] and/or the dissolution in phosphate buffer pH 6.8 does not meet the definition of a rapidly dissolving drug product in Guidance for Industry. Waiver of in Vivo Bioavailability and Bioequivalens Studies for Immediate Release Solids Dosage Forms Containing Certain Active Moieties/Active Ingredients Based on Biopharmaceutics Classification System. With the formulation according to the invention the dissolution is fast in both medias and the technical properties are excellent.

What is claimed is:

1. An oral immediate release formulation in solid form, comprising (a) a low molecular weight peptide thrombin inhibitor having pH dependent solubility and having a particle size of less than 300 μm, and (b) a combination of microcrystalline cellulose and sodium starch glycollate in an amount higher than 35% w/w of the formulation.

2. The oral formulation according to claim 1, wherein the formulation optionally contains a sugar, a disintegrant, a binder and/or a lubricant.

3. The oral formulation according to claim 1 or 2, further comprising comprises mannitol.

4. The oral formulation according to claim 3, wherein mannitol constitutes up to 15% (w/w) of the formulation.

5. The oral formulation according to claim 1, wherein the thrombin inhibitor is glycine, N-[1-cyclohexyl-2-[2-[[[[4-[(hydroxyimino)aminomethyl]-phenyl]methyl]amino]carbonyl]-1-azetidinyl]-2-oxoethyl]-, ethyl ester, [S-(R*, S*)]-).

6. A process for preparing an oral immediate release formulation according to claim 1 or 2, comprising mixing the low molecular weight peptide thrombin inhibitor with the microcrystalline cellulose and sodium starch glycollate.

7. A process for the preparation of an oral intermediate release formulation according to claim 1, comprising preparing said formulation by direct compression or by wet granulation techniques.

8. The process according to claim 6, comprising adding to the mixture at least one ingredient selected from the group consisting of a sugar, a disintegrant, a binder, and a lubricant.

9. The oral formulation according to claim 1 or 2, wherein the thrombin inhibitor has a particle size of less than 150 μm.

10. The oral formulation according to claim 1 or 2, wherein the thrombin inhibitor has a mean particle size less than 80 μm.

11. The process according to claim 9, further comprising the steps of adding a lubricant to the mixture and compressing the mixture to form tablets.

12. A process for preparing an oral immediate release formulation according to claim 1 or 2, comprising:

mixing the low molecular weight thrombin inhibitor, microcrystalline cellulose and sodium starch glycollate to form a mixture;

moisturizing the mixture with a binder;

drying the mixture to form a granulate;

milling the granulate;

mixing the granulate with a lubricant; and

compressing the granulate with the lubricant to form tablets.

13. The process according to claim 12, comprising adding to the mixture at least one ingredient selected from the group consisting of a sugar and a disintegrant.

14. The oral formulation according to claim 1, wherein the peptide thrombin inhibitor is selected from the group consisting of inogatran, melagatran and glycine, N-[1-cyclohexyl-2[2-[[[[4-[(hydroxyimino)aminomethyl]-phenyl]methyl]amino] carbonyl]-1-azetidinyl]-2-oxoethyl]-, ethyl ester, [S-(R*, S*)]-).

15. The oral formulation of claim 1 or 2, wherein microcrystalline cellulose constitutes 50-90% (w/w) of the formulation.

16. The oral formulation of claim 1 or 2, wherein sodium starch glycollate constitutes 3-20% (w/w) of the formulation.

17. The oral formulation of claim 1 or 2, wherein the thrombin inhibitor constitutes 1-35% (w/w) of the formulation.

18. The oral formulation of claim 1 or 2, which comprises:
thrombin inhibitor 1-35% (w/w);
microcrystalline cellulose 50-90% (w/w);
sodium starch glycollate 3-20% (w/w);
mizuitol 0-15% (w/w);
polyvinylpyrrolidone K 90 3-15% (w/w); and,
sodium stearyl fumarate 0.5-1.5% (w/w).

19. The oral formulation of claim 18, wherein the thrombin inhibitor is glycine, N-[1-cyclohexyl-2-[2-[[[[4-[(hydroxyimino)aminomethyl]phenyl]-methyl]amino]carbonyl]-1-azetidinyl]-2-oxoethyl]-, ethyl ester, [S-(R*, S*)]-).

20. The oral formulation of claim 1, wherein the formulation contains a binder.

21. The oral formulation of claim 20, wherein the binder constitutes up to 15% (w/w) of the formulation.

22. The oral formulation of claim 20 or 21, wherein the binder is a polyvinylpyrrolidone.