2-[4-(METHYLAMINOMETHYL)PHENYL]-5-FLUORO-BENZOFURAN-7-CARBOXAMIDE HYDROCHLORIDE POLYMORPH, PREPARATION METHOD THEREFOR AND APPLICATION THEREOF

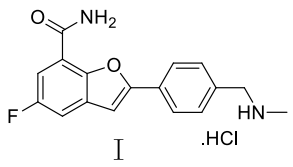
TECHNICAL FIELD

The present invention belongs to the category of medicinal chemistry, and specifically relates to polymorphs of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride and a preparation method and use thereof in the preparation of a medicine.

BACKGROUND ART

Different crystal forms of a compound may have different properties, such as solubility, dissolution rate, suspension stability, stability during milling, vapor pressure, optical and mechanical properties, hygroscopicity, crystal size, filtration performance, drying, density, melting point, degradation stability, stability to prevent phase change to other crystal forms, color and even chemical reactivity, etc. More importantly, the different crystal forms of a small molecule compound may change its dissolution, dissolution performance, pharmacokinetics and bioavailability, which will affect the efficacy and safety performance of a drug. Therefore, the polymorph of small-molecule drugs should be fully considered during the development process. Therefore, research and control on crystal form has become one of the important research contents in the process of small molecule drug development.

WO2013117120 disclosed a PARP selective inhibitor with pharmaceutical value, in which an example of a series of specifically described inhibitors (see Example 21 on page 37) is 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride (hereinafter referred to as mefurapine hydrochloride), with a structure as shown in Formula I:



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According to the method disclosed in WO2013117120, the compound was characterized by ^{1}HMR analysis and/or measurement of melting point. In the prior art, different crystal forms of mefurapine hydrochloride were not described, and any characterization of a specific crystal form and the preparation method used to obtain a specific crystal form have not been described. Different crystal forms of mefurapine hydrochloride may change its dissolution,

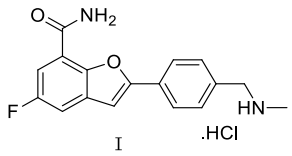
dissolution performance, pharmacokinetics and bioavailability, and then affect the efficacy and safety of the drug. Therefore, for the large-scale preparation of mefurapine hydrochloride, it is important to know if there are different crystal forms of this compound (also often referred to as polymorphs, or pseudopolymorphs in the case of solvent encapsulation), how to obtain them, and how its characteristic performance is.

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

SUMMARY OF THE INVENTION

In view of the above background, the present invention discloses various crystal forms of mefurapine hydrochloride, and characterization, preparation method as well as use thereof. Therefore, the technical problem to be solved by the present invention is to provide a polymorph of mefurapine hydrochloride, which provides technical support for further development of mefurapine hydrochloride.

Disclosed is a polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride as shown in Formula I.



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In an aspect of the invention, the polymorph is 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form A, and the powder diffraction pattern thereof comprises 3 or more 2θ values selected from the group consisting of: 6.49±0.1°, 12.625±0.1°, 15.271±0.1°, 20.727±0.1°, 22.933±0.1°, 23.913±0.1°, 25.139±0.1°, 25.618±0.1°, 26.082±0.1°, 27.084±0.1°, 27.406±0.1°, and 28.828±0.1°.

In another preferred embodiment, the crystal form a further has one or more characteristics selected from the group consisting of:

(1) the crystal form A has a DSC spectrum substantially as shown in Figure 1b;

(2) the crystal form A has an infrared spectrum substantially as shown in Figure 1c;

(3) the crystal form A has a TG spectrum substantially as shown in Figure 1d; and

(4) the crystal form A has a Raman spectrum substantially as shown in Figure 1e.

In an aspect of the invention, the polymorph is 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form B, and the powder diffraction

pattern thereof comprises 3 or more 2θ values selected from the group consisting of: 6.145±0.1°, 10.318±0.1°, 12.459±0.1°, 14.914±0.1°, 20.806±0.1°, 22.832±0.1°, 23.295±0.1°, 24.996± 0.1°, 25.198±0.1°, 25.481±0.1°, 26.787±0.1°, 27.285±0.1°, 28.003±0.1°, and 29.59±0.1°.

In another preferred embodiment, the crystal form B further has one or more characteristics selected from the group consisting of:

(1) the crystal form B has a DSC pattern substantially as shown in Figure 2b;

(2) the crystal form B has an infrared spectrum substantially as shown in Figure 2c;

(3) the crystal form B has a TG pattern substantially as shown in Figure 2d; and

(4) the crystal form B has a Raman spectrum substantially as shown in Figure 2e.

In an aspect of the invention, the polymorph is 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form C, and the powder diffraction pattern thereof comprises 3 or more 2θ values selected from the group consisting of: 10.306±0.1°, 12.666±0.1°, 15.312± 0.1°, 17.436±0.1°, 18.918±0.1°, 20.748±0.1°, 22.974±0.1°, 24.553±0.1°, 25.238±0.1°, 26.241±0.1°, 29.336±0.1°, 32.739±0.1°, 33.738±0.1°, 34.118±0.1°, 35.204.

In another preferred embodiment, the crystal form C further has one or more characteristics selected from the group consisting of:

(1) the crystal form C has a DSC pattern substantially as shown in Figure 3b;

(2) the crystal form C has an infrared spectrum substantially as shown in Figure 3c;

(3) the crystal form C has a TG pattern substantially as shown in Figure 3d; and

(4) the crystal form C has a Raman spectrum substantially as shown in Figure 3e.

In the second aspect of the present invention, it provides a method for preparing the polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to the first aspect of the present invention, comprising the steps:

(i) dissolving 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form A in an alcohol at 0°C to 80°C to form an alcohol solution containing 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride;

(ii) adding an organic solvent dropwise to the alcohol solution of step i), stirring, standing, and precipitating crystals; and

(iii) isolating and drying the precipitated crystals to obtain 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form B;

wherein said alcohol is selected from the group consisting of: methanol, ethanol, propanol, tert-butanol, butanol, octanol, pentanol, hexanol, heptanol, decanol, or a combination thereof; the organic solvent is selected from the group consisting of: butanone, methyl tert-butyl ether, isopropyl acetate, or a combination thereof;

or the preparation method includes the steps of:

(a) dissolving 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form A in an alcohol or an alcohol-water system at 0°C to 80°C to form an alcohol solution or an alcohol-water solution containing 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride;

(b) adjusting the pH of the alcohol solution or the alcohol-water solution of step a) to be acidic with hydrochloric acid, stirring at room temperature, standing, and precipitating crystals; and

(c) separating and drying the precipitated crystals to obtain 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form C;

wherein said alcohol-water system is selected from the group consisting of methanol-water, ethanol-water, propanol-water, tert-butanol-water, butanol-water, octanol-water, pentanol-water, hexanol-water, heptanol-water or decanol-water.

In another preferred embodiment, the alcohol is methanol or ethanol, preferably ethanol.

In another preferred embodiment, the organic solvent is butanone or methyl tert-butyl ether, preferably butanone.

In another preferred embodiment, the alcohol-water system is methanol-water or ethanol-water, and preferably ethanol-water.

In another preferred embodiment, the pH of the alcohol or the alcohol-water solution of step a) is adjusted by hydrochloric acid to be 1 to 5, preferably the pH is 2 to 4, and more preferably the pH is 2.

In another preferred embodiment, the precipitated crystals are dried at 25°C to 100°C.

In the third aspect of the present invention, it provides a pharmaceutical composition comprising a pharmaceutically effective dose of the polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to the first aspect of the present invention, and a pharmaceutically acceptable excipient or carrier.

In the fourth aspect of the present invention, it provides the use of the polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to the first aspect of the present invention or the composition according to the third

aspect of the present invention for preparing a drug for treating and/or preventing diseases related to poly (ADP-ribose polymerase) (PARP).

In another preferred embodiment, the diseases include: tumor, inflammation, cardiovascular disease, diabetes, rheumatoid arthritis, endotoxic shock, and stroke.

In another preferred embodiment, the tumor includes: a tumor in which BRCA1 or BRCA2 is deleted or mutated.

In another preferred embodiment, the tumor includes: ovarian cancer, breast cancer, prostate cancer, gastric cancer, pancreatic cancer, cervical cancer, glioma, and Ewing's sarcoma.

In another preferred embodiment, the drugs include antitumor drugs and/or anti-inflammatory drugs.

It should be understood that in the present invention, any of the technical features specifically described above and below (such as in the Examples) can be combined with each other, which will not redundantly be described one by one herein.

Unless the context clearly requires otherwise, throughout the description and the claims, the words “comprise”, “comprising”, and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of “including, but not limited to”.

DESCRIPTION OF FIGURES

Figure 1a is an X-ray powder diffraction (XRPD) pattern of mefurapine hydrochloride crystal form A;

Figure 1b is a DSC spectrum of mefurapine hydrochloride crystal form A;

Figure 1c is an infrared (IR) spectrum of mefurapine hydrochloride crystal form A;

Figure 1d is a TG spectrum of mefurapine hydrochloride crystal form A;

Figure 1e is a Raman spectrum of mefurapine hydrochloride crystal form A;

Figure 2a is an X-ray powder diffraction (XRD) pattern of mefurapine hydrochloride crystal form B;

Figure 2b is a DSC spectrum of mefurapine hydrochloride crystal form B;

Figure 2c is an infrared (IR) spectrum of mefurapine hydrochloride crystal form B;

Figure 2d is a TG spectrum of mefurapine hydrochloride crystal form B;

Figure 2e is a Raman spectrum of mefurapine hydrochloride crystal form B;

Figure 3a is an X-ray powder diffraction (XRPD) pattern of mefurapine hydrochloride crystal form C;

Figure 3b is a DSC spectrum of mefurapine hydrochloride crystal form C;

Figure 3c is an infrared (IR) spectrum of mefurapine hydrochloride crystal form C;

Figure 3d is a TG spectrum of mefurapine hydrochloride crystal form C;

Figure 3e is a Raman spectrum of mefurapine hydrochloride crystal form C.

DETAILED DESCRIPTION OF THE INVENTION

After extensive and in-depth research, the present inventors have unexpectedly discovered three new polymorphs of mefurapine hydrochloride, and the preparation process is simple, efficient, and repeatable, and can realize large-scale industrial production. On above basis, the present invention has been completed.

TERMS

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.

As used herein, when used in reference to a particular recited value, the term "about" means that the value can vary by no more than 1% from the recited value. For example, as used herein, the expression "about 100" includes all values between 99 and 101(e.g., 99.1, 99.2, 99.3, 99.4, etc.).

For a characteristic diffraction peak represented by a 2θ angle, the term "about" means that the listed value varies by no more than 0.2°, for example, about X°, it means X±0.2°, preferably X±0.1°.

As used herein, the terms "contain" or "includes (comprises)" may be open ended, semi-close ended and close ended. In other words, the terms also include "consisting essentially of" or "consisting of".

As used herein, the term "room temperature" generally refers to 4-30°C, preferably 20±5°C.

As used herein, the term "pharmaceutically acceptable ingredient" refers to a substance that is suitable for use in humans and/or animals without excessive adverse side effects (such as toxicity, irritation, and allergies), that is, with a reasonable benefit/risk ratio.

As used herein, the term "effective amount" refers to an amount of a therapeutic agent to treat, alleviate or prevent a target disease or condition, or an amount that exhibits a detectable therapeutic or preventive effect. The exact effective amount for a subject depends on the subject's size and health, the nature and extent of the condition, and the chosen therapeutic agent and/or combination of therapeutic agents. Therefore, it is not useful to specify an accurate

effective amount in advance. However, for a given condition, a routine experiment can be used to determine the effective amount, which can be judged by the clinician.

CRYSTALLIZATION

A solution can be manipulated so that the solubility limit of a compound of interest can be exceeded, thereby completing crystallization on a production scale. This can be done in a number of ways, for example by dissolving the compound at a relatively high temperature and then cooling the solution below the saturation limit, or reducing the volume of the liquid by boiling, atmospheric evaporation, vacuum drying, or some other methods. The solubility of a compound of interest can be reduced by adding an anti-solvent or a solvent in which the compound has a low solubility, or a mixture of such solvents. Another option is to adjust the pH to reduce solubility. For a detailed description of crystallization, see Crystallization, 3rd Edition, J W Mullens, Butterworth-Heineman Ltd., 1993, ISBN 0750611294.

If it is desired that the salt formation and crystallization occur at the same time, and if the salt is less soluble in the reaction medium than the starting material, then the addition of a suitable acid or base can result in direct crystallization of the desired salt. Also, in a medium where the final desired form is less soluble than the reactants, the completion of the synthetic reaction allows the final product to crystallize directly.

Optimization of the crystallization may include seeding the crystals in the desired form as crystal seed in the crystallization medium. In addition, a combination of the above strategies is adopted in many crystallization methods. One example is to dissolve the compound of interest in a solvent at a high temperature, and then an appropriate volume of anti-solvent is added in a controlled manner so that the system is just below the saturation level. At this point, a crystal seed in the desired form can be added (and the integrity of the crystal seed is maintained) and the system is cooled to complete the crystallization.

POLYMORPHS OF THE INVENTION

The polymorph of mefurapine hydrochloride according to the present invention includes three crystal forms: crystal form A, crystal form B, and crystal form C.

Crystal Form A

The powder X-ray diffraction pattern of the mefurapine hydrochloride crystal form A of the present invention has obvious characteristic absorption peaks at diffraction angles (2θ)

of approximately 6.49, 12.625, 15.271, 20.727, 22.933, 23.913, 25.139, 25.618, 26.082, 27.084, 27.406, 28.828.

The X-ray powder diffraction pattern of the mefurapine hydrochloride crystal form A is substantially consistent with Figure 1a; the DSC spectrum, and the infrared spectrum, the TG spectrum, and the Raman spectrum are substantially consistent with Figure 1b, 1c, 1d, and 1e.

It can be seen from Figure 1b that the crystal form A has a characteristic endothermic peak in the range of about 280-300°C.

It can be seen from Figure 1c that, in the infrared spectrum of the crystal form A, there are characteristic peaks at least at 3486 cm^{-1}, 3172 cm^{-1}, 2923 cm^{-1}, 2709 cm^{-1}, 2476 cm^{-1}, 1666 cm^{-1}, 1608 cm^{-1}, 1592 cm^{-1}, 1469 cm^{-1}, 1428 cm^{-1}, 1378 cm^{-1}, 1,338 cm^{-1}, 1189 cm^{-1}, 1114 cm^{-1}, 946 cm^{-1}, 779 cm^{-1}, and 470 cm^{-1}, and the error range is ±2 cm^{-1}.

It can be concluded from Figure 1d that the crystal form A begins to decompose at 250 ±20°C according to the thermogravimetric analysis.

Crystal Form B

The powder X-ray diffraction pattern of the mefurapine hydrochloride crystal form B of the present invention has obvious characteristic absorption peaks at diffraction angles (2θ) of approximately 6.145, 10.318, 12.459, 14.914, 20.806, 22.832, 23.295, 24.996, 25.198, 25.481, 26.787, 27.285, 28.003 and 29.59.

The X-ray powder diffraction pattern of the mefurapine hydrochloride crystal form B is substantially consistent with Figure 2a; and the DSC spectrum, the infrared spectrum, the TG spectrum, and the Raman spectrum are substantially consistent with Figure 2b, 2c, 2d, and 2e.

It can be seen from Figure 2b that the crystal form B has a characteristic endothermic peak in the range of about 280-300°C.

It can be seen from Figure 2c that, in the infrared spectrum of the crystal form B, there are characteristic peaks at least at 3469 cm^{-1}, 3164 cm^{-1}, 2923 cm^{-1}, 2701 cm^{-1}, 2470 cm^{-1}, 1654 cm^{-1}, 1606 cm^{-1}, 1589 cm^{-1}, 1428 cm^{-1}, 1469 cm^{-1}, 1428 cm^{-1}, 1378 cm^{-1}, 1338 cm^{-1}, 1189 cm^{-1}, 1172 cm^{-1}, 1103 cm^{-1}, and 779 cm^{-1}, and the error range is ±2 cm^{-1}.

It can be concluded from Figure 2d that the crystal form B begins to decompose at 250 ±20°C according to the thermogravimetric analysis.

Crystal Form C

The powder X-ray diffraction pattern of the mefurapine hydrochloride crystal form C of the present invention has obvious characteristic absorption peaks at diffraction angles (2θ) of approximately 10.306, 12.666, 15.312, 17.436, 18.918, 20.748, 22.974, 24.553, 25.238, 26.241, 29.336, 32.739, 33.738, 34.118, and 35.204.

The X-ray powder diffraction pattern of the mefurapine hydrochloride crystal form C is substantially consistent with Figure 3a; and the DSC spectrum, the infrared spectrum, the TG spectrum, and the Raman spectrum are substantially consistent with Figure 3b, 3c, 3d, and 3e.

It can be seen from Figure 3b that the crystal form C has a characteristic endothermic peak in the range of about 270-300°C.

It can be seen from Figure 3c that, in the infrared spectrum of the crystal form C, there are characteristic peaks at least at 3485 cm^{-1}, 3227 cm^{-1}, 3170 cm^{-1}, 3047 cm^{-1}, 2747 cm^{-1}, 2709 cm^{-1}, 2475 cm^{-1}, 1665 cm^{-1}, 1609 cm^{-1}, 1468 cm^{-1}, 1428 cm^{-1}, 1377 cm^{-1}, 1338 cm^{-1}, 1190 cm^{-1}, 1173 cm^{-1}, 1114 cm^{-1}, 947 cm^{-1}, 838 cm^{-1}, and 779 cm^{-1}, and the error range is ±2 cm^{-1}.

It can be concluded from Figure 3d that the crystal form C begins to decompose at 250±20°C according to the thermogravimetric analysis.

From the above experimental results, it can be seen that the crystal forms A, B and C of the present invention have high crystallinity and good thermal stability.

PREPARATION METHOD OF THE POLYMORPH

The invention also provides a method for preparing the three mefurapine hydrochloride crystal forms A, B and C, and the specific steps are as follows.

Preparation of Mefurapine Hydrochloride Crystal Form A

Mefurapine in free form is dissolved in an organic solvent, HCl/organic solvent is slowly added dropwise at an equivalent ratio, stirred to precipitate solids, which are filtered and dried to obtain mefurapine hydrochloride crystal form A; wherein the organic solvent may be one or more of methanol, ethanol, dichloromethane, ethyl acetate, tetrahydrofuran, and acetone.

Preparation of Mefurapine Hydrochloride Crystal Form B

Mefurapine hydrochloride crystal form A is dissolved in methanol or ethanol, an organic solvent that is highly insoluble to the raw materials is slowly added dropwise, stirred and left to stand. The solution is filtered, and the solid part is dried at 25 degrees to obtain mefurapine hydrochloride crystal form B.

The organic solvent that is highly insoluble to the raw materials is any one or a combination of two or more of butanone, methyl tert-butyl ether, and isopropyl acetate, and preferably butanone or methyl tert-butyl ether, more preferably butanone.

Preparation of Mefurapine Hydrochloride Crystal Form C

Mefurapine hydrochloride crystal form A is completely dissolved in an alcohol or an alcohol-water system, the pH is adjusted to be acidic with hydrochloric acid, and the mixture is stirred at room temperature, and filtered to obtain white solids of mefurapine hydrochloride crystal form C, wherein the alcohol is methanol , ethanol, propanol, tert-butanol, butanol, octanol, pentanol, hexanol, heptanol, decanol, etc., preferably methanol or ethanol, more preferably ethanol.

The alcohol-water system is methanol-water, ethanol-water, propanol-water, tert-butanol-water, butanol-water, octanol-water, pentanol-water, hexanol-water, heptanol-water or decanol-water, etc., preferably methanol-water or ethanol-water system, more preferably ethanol-water system;

The pH is adjusted to 1 to 5, preferably the pH is 2 to 4, more preferably the pH is 2.

PHARMACEUTICAL COMPOSITION

The pharmaceutical composition of the present invention contains mefurapine hydrochloride polymorphs in a safe and effective amount range, that is, crystal form A, crystal form B and crystal form C, and pharmacologically acceptable salts thereof and pharmacologically acceptable excipients or carriers, in which, "safe and effective amount" means that the amount of the compound is sufficient to significantly improve the condition without causing serious side effects.

"Pharmaceutically acceptable carrier" means one or more compatible solid or liquid fillers or gelatinous materials which are suitable for human use and should be of sufficient purity and sufficiently low toxicity. "Compatible" means that each component in the composition can be admixed with the polymorph of the present invention and with each other without significantly reducing the efficacy of the compounds. Some examples of pharmaceutically acceptable carriers include cellulose and the derivatives thereof (such as sodium carboxymethyl cellulose, sodium ethyl cellulose, cellulose acetate, etc.), gelatin, talc, solid lubricants (such as stearic acid, magnesium stearate), calcium sulfate, vegetable oils (such as soybean oil, sesame oil, peanut oil, olive oil, etc.), polyols (such as propylene glycol, glycerol, mannitol, sorbitol, etc.), emulsifiers (such as Tween®), wetting agent (such as sodium

dodecyl sulfate), coloring agents, flavoring agents, stabilizers, antioxidants, preservatives, pyrogen-free water, etc..

The polymorphs of the invention are usually mixed with at least one conventional inert excipient (or carrier), such as sodium citrate or dicalcium phosphate, or mixed with any of the following components: (a) fillers or compatibilizer, for example, starch, lactose, sucrose, glucose, mannitol and silicic acid; (b) binders, for example, hydroxymethyl cellulose, alginate, gelatin, polyvinylpyrrolidone, sucrose and arabic gum; (c) humectants, such as, glycerol; (d) disintegrating agents such as agar, calcium carbonate, potato starch or tapioca starch, alginic acid, certain composite silicates, and sodium carbonate; (e) dissolution-retarding agents, such as paraffin; (f) absorption accelerators, for example, quaternary ammonium compounds; (g) wetting agents, such as cetyl alcohol and glyceryl monostearate; (h) adsorbents, for example, kaolin; and (i) lubricants such as talc, calcium stearate, magnesium stearate, solid polyethylene glycol, sodium lauryl sulfate, or the mixture thereof. In capsules, tablets and pills, the dosage forms may also contain buffering agents.

Preferably, the excipient includes one or more of a filler, a disintegrant, a binder, and a lubricant.

Preferably, the filler is any one or a combination of starch, lactose, microcrystalline cellulose, dextrin, mannitol, oxidase, and calcium sulfate.

Preferably, the disintegrant includes any one or several of carboxymethylcellulose and salts thereof, crosslinked carboxymethylcellulose and salts thereof, crosslinked povidone, sodium carboxymethyl starch, low substituted hydroxypropylcellulose.

Preferably, the binder includes any one or more of povidone, hydroxypropylmethyl cellulose, starch slurry, and pregelatinized starch.

Preferably, the lubricant includes any one or more of sodium stearyl fumarate, magnesium stearate, and calcium stearate.

APPLICATION

The polymorph of mefurapine hydrochloride according to the present invention is used for preparing a medicament for preventing and/or treating a disease related to poly ADP-ribose polymerase (PARP). It can also be used for preparing a medicament for preventing and/or treating tumors. It can also be used to prepare anti-inflammatory drugs.

Diseases associated with poly ADP-ribose polymerase (PARP) include tumors, inflammation, and topical ischemia-reperfusion-associated diseases such as cardiovascular disease, diabetes, rheumatoid arthritis, endotoxin shock, stroke, and the like. The tumor is a

tumor with homologous recombination repair deficiency, that is, a tumor in which BRCA1 or BRCA2 is deleted or mutated, such as ovarian cancer, breast cancer, prostate cancer, gastric cancer, pancreatic cancer, cervical cancer, glioma, Ewing's sarcoma, and the like.

Main advantages of the invention include:

Compared with the prior art, the main advantages of the present invention are:

1. The present invention provides different crystal forms of mefurapine hydrochloride, which can be converted into three crystal forms A, B, and C respectively in different crystalline forms of solvent ratio. The three polymorphs can be readily prepared, and the product has high crystal purity and good stability and is easy to be stored.

2. The preparation method of the three polymorphs of the present invention has advantages of simple preparation process, easy operation, good process repeatability, and high purity of the obtained product crystal form.

In order to make the objectives, technical solutions, and advantages of the present invention clearer, the present invention is further described in detail below with reference to the accompanying drawings and embodiments. It should be understood that the specific embodiments described herein are only used to explain the present invention and are not intended to limit the present invention. The experimental methods with no specific conditions described in the following examples are generally performed under the conventional conditions, or according to the manufacturer’s instructions. Unless otherwise stated, percentages and parts are percentages by weight and parts by weight.

The experimental materials and reagents used in the following examples can be obtained from commercial sources unless otherwise specified.

EXPERIMENTAL CONDITIONS

1) XRPD Method

Instrument model: Bruker D8 advance, target: Cu Kα (40kV, 40mA), sample distance to the detector is 30 cm, scanning range is 3° -40° (2 theta value), scanning step: 0.1. It should be noted that, in the powder sample X-ray diffraction pattern, the crystal form with the specific diffraction pattern obtained from the crystalline compound is often characteristic, and the relative intensity of the band (especially at low angles) may change due to dominant orientation effects caused by differences of crystallization conditions, particle size, relative content of the mixture, and other test conditions. Therefore, the relative intensity of the diffraction peaks is not characteristic for the crystals. Whether a crystal form is the same as a

known crystal form, it is more important to pay attention to the position of the peaks rather than their relative intensity. In addition, to judge whether the crystal forms are the same, we should pay attention to maintaining the overall concept, because not one diffraction line represents one phase, but a specific set of "d-1 / 11" data represents a certain phase. It should also be noted that in the identification of mixtures, due to factors such as reduced content, some of the diffraction lines will be missing. At this time, there is no need to rely on the safety band observed in the high-purity sample, and even a band may be characteristic for certain crystals.

2) DSC method

Instrument model: Perkin Elmer DSC 8500, temperature range is 50-280°C, scan rate is 10°C/min, and nitrogen flow rate is 50ml/min.

3) IR method

Nicolot-Magna FT-IR750 infrared spectrometer from Nicol Corporation US is used to detect at room temperature, and the detection range is 4000-350 cm-1 wave number.

4) TGA

method Instrument model: Netzsch TG 209F3, temperature range 30-400°C, scan rate 10K/min, purge gas flow rate 25 mL/min, shielding gas flow rate 15 mL/min.

5) Raman Method

Instrument Model: Thermo Scientific, DXR Raman Microscope; Laser power level: 150.0 mW, Filter: 780 nm, Spectrograph aperture: 25 slit-25, Exposure time: 1.00 sec, Number of exposures: 10, Number of background exposures: 32).

6) DVS method

Instrument model: SMS DVS Intrinsic, 0 ~ 95% RH, temperature: 25°C.

EXAMPLES

Example 1

Preparation method of crystal form A:

Free mefurapine hydrochloride (59.6g, 199.9mmol, purity greater than 97%) was added to methanol/dichloromethane (v/v = 1: 1, 2000 mL) and stirred vigorously. The solid was not completely dissolved to make the system be a suspension system, cooled to 0°C, and 8N hydrochloric acid in ethyl acetate (250 mL) was slowly added dropwise, and the system was completely dissolved. Upon dropwise addition, the reaction system was continuously stirred at 0°C to 10°C for 12 hours, and a large amount of solids precipitated, and filtered to

obtain a filter cake. The filter cake was dried under vacuum at 50°C to 55°C to constant weight to obtain crystal form A.

The X-ray powder diffraction measurement showed that the obtained crystal form was mefurapine hydrochloride crystal form A. The specific peak positions are shown in Table 1 (see Figure 1a):

Table 1: X-Ray Powder Diffraction (XRPD) Data of mefurapine hydrochloride crystal form A

2θ angle/°	d/A	intensity%
6.49	13.6084	15.8
10.339	8.5491	9.4
12.625	7.0059	11
15.271	5.7972	100
17.395	5.094	2.8
18.121	4.8914	7.8
18.844	4.7053	6.5
19.482	4.5526	8
20.727	4.2819	34.8
21.448	4.1396	6.6
22.933	3.8748	11.4
23.133	3.8418	8.7
23.913	3.7181	21.3
24.5	3.6304	4.2
25.139	3.5395	24.3
25.618	3.4743	11.6
26.082	3.4137	26.2
27.084	3.2896	12.1
27.406	3.2517	20.8
28.828	3.0944	11.3
29.31	3.0446	3.5
29.891	2.9867	9.2
30.591	2.9199	3.3
30.789	2.9016	3.8
32.717	2.7349	5
33.681	2.6588	5.1
35.163	2.5501	3
35.441	2.5307	2.1
35.964	2.4951	2.9
36.688	2.4475	3.5
37.048	2.4245	5
38.132	2.3581	1.3
39.375	2.2865	3.6
40.075	2.2481	1.8
40.68	2.216	2.7

43.606	2.0739	1.4
43.926	2.0596	1.4

Other tests were performed on the obtained samples, and the obtained DSC spectrum, infrared spectrum, TG spectrum, and Raman spectrum were substantially consistent with Figure 1b, 1c, 1d, and 1e.

Example 2

Preparation method of crystal form A:

About 25 mg of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride of Example 1 was taken, and stirred with 1 ml of methanol at 25°C for at least 24 h. Then, the solution was filtered, and the solid part was dried in air for 10 min, and then XRPD detection was performed. The results of the X-ray powder diffraction data are shown in Table 1.

Example 3

Preparation method of crystal form A:

The difference from Example 2 is that the solvent was replaced with ethanol, and the results of the X-ray powder diffraction data are shown in Table 1.

Example 4

Preparation method of crystal form A:

The difference from Example 2 is that the solvent was replaced with isopropyl alcohol, and the results of the X-ray powder diffraction data are shown in Table 1.

Example 5

Preparation method of crystal form A:

The difference from Example 2 is that the solvent was replaced with ethyl acetate, and the results of the X-ray powder diffraction data are shown in Table 1.

Example 6

Preparation method of crystal form A:

The difference from Example 2 is that the solvent was replaced with a methanol-water system having a volume ratio of 1: 1, and the results of the X-ray powder diffraction data are shown in Table 1.

Example 7

Preparation method of crystal form A

The difference from Example 2 is that the temperature was adjusted to 50°C, and the results of the X-ray powder diffraction data are shown in Table 1.

Example 9

Preparation method of crystal form B:

About 25 mg of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride of Example 1 was taken, and methanol (3 mL) was added at 25°C until the raw materials were completely dissolved, and then butanone(12 mL) was slowly added dropwise. Upon dropwise addition, the mixture was stirred at this temperature for 12 hours, and filtered. The filter cake was dried under vacuum at 50 °C to 55 °C to constant weight to obtain crystal form B.

The X-ray powder diffraction measurement showed that the obtained crystal form was mefurapine hydrochloride crystal form B. The specific peak positions are shown in Table 2 (see Figure 2a).

Table 2: X-Ray Powder Diffraction (XRPD) Data of mefurapine hydrochloride crystal form B

2θ angle/°	d/A	intensity%
6.145	14.37	18.6
10.318	8.566	16.5
12.459	7.0985	12.8
14.914	5.9353	100
15.154	5.8418	8.5
17.204	5.15	3.5
17.6	5.0349	5.4
18.643	4.7557	6.3
19.082	4.6472	6.6
19.965	4.4436	3.6
20.806	4.2659	51.1
22.832	3.8917	10.7
23.295	3.8153	10.9
23.933	3.7151	4.6
24.996	3.5595	30.1
25.198	3.5313	42.1
25.481	3.4928	11
25.778	3.4532	2.5

26.787	3.3254	10.8
27.285	3.2658	10.4
28.003	3.1836	19.8
29.59	3.0165	18.2
31.374	2.8488	2.7
32.012	2.7935	2.1
32.536	2.7497	2.4
32.9	2.7202	6.3
33.519	2.6713	3.2
33.722	2.6556	3.6
35.065	2.557	2.6
35.724	2.5113	9.8
36.046	2.4896	5.4
36.767	2.4424	3.5
39.012	2.3069	6
39.426	2.2836	1.7

Other tests were performed on the obtained samples, and the obtained DSC spectrum, infrared spectrum, TG spectrum, and Raman spectrum were substantially consistent with Figure 2b, 2c, 2d, and 2e.

Example 10

Preparation method of crystal form B:

About 25 mg of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride of Example 1 was taken, and methanol (1.8 mL) was added at 50°C until the raw materials were completely dissolved, and then butanone(6 mL) was slowly added dropwise. Upon dropwise addition, the mixture was stirred at this temperature for 12 hours, and filtered. The filter cake was dried under vacuum at 50 °C to 55 °C to constant weight to obtain crystal form B. The results of the X-ray powder diffraction data are shown in Table 2.

Example 11

Preparation method of crystal form C:

About 100 mg of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride of Example 1 was taken and added to 4 ml of anhydrous ethanol, the temperature was raised to 50 ^{o} C with stirring, and then pure water was added and stirred until the raw materials were completely dissolved. The mixture was stirred at this temperature for 30 min, then concentrated hydrochloric acid was added dropwise to adjust the pH to about 2. The mixture was naturally cooled to room temperature, stirred for about 12 hours, and

filtered to obtain white solids. The filter cake was rinsed with anhydrous ethanol, suction-filtered, and dried at 50 °C ~ 55 °C under vacuum to constant weight to obtain crystal form C.

The X-ray powder diffraction measurement showed that the obtained crystal form was mefurapine hydrochloride crystal form C. The specific peak positions are shown in Table 3 (see Figure 3a).

Table 3: X-Ray powder diffraction (XRPD) data of mefurapine hydrochloride crystal form C

2θ angle/°	d/A	intensity%
10.306	8.5765	19.2
12.666	6.9831	17.9
15.312	5.7817	100.0
17.436	5.0820	23.3
18.918	4.6870	33.8
20.748	4.2776	90.0
22.974	3.8679	37.1
24.553	3.6226	27.1
25.238	3.5259	16.7
26.241	3.3934	52.1
29.336	3.0419	27.1
32.739	2.7331	45.0
33.738	2.6544	20.4
34.118	2.6257	18.8
35.204	2.5472	26.7

Other tests were performed on the obtained samples, and the obtained DSC spectrum, infrared spectrum, TG spectrum, and Raman spectrum were substantially consistent with Figure 3b, 3c, 3d, and 3e.

Example 12

Preparation method of crystal form C:

The difference from Example 10 is that the organic solvent is methanol, and its X-ray powder diffraction data is shown in Table 3.

Example 13

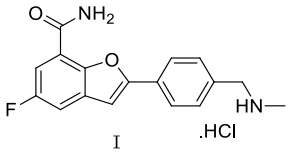
Preparation method of crystal form C:

The difference from Example 10 is that the reaction temperature is 78 ^{o} C, and its X-ray powder diffraction data is shown in Table 3.

All literatures mentioned in the present invention are incorporated by reference herein, as though individually incorporated by reference. Additionally, it should be understood that after reading the above teaching, many variations and modifications may be made by the skilled in the art, and these equivalents also fall within the scope as defined by the appended claims.

CLAIMS

1. A polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride as shown in Formula I, the polymorph is



I

2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form A, 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form B or 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form C, wherein

the powder diffraction pattern of crystal form A comprises 310 or more 2θ values selected from the group consisting of: 6.49 ± 0.1 °, 12.625 ± 0.1 °, 15.271 ± 0.1 °, 20.727 ± 0.1 °, 22.933 ± 0.1 °, 23.913 ± 0.1 °, 25.139 ± 0.1 °, 25.618 ± 0.1 °, 26.082 ± 0.1 °, 27.084 ± 0.1 °, 27.406 ± 0.1 °, and 28.828 ± 0.1 °;

the powder diffraction pattern of crystal form B comprises 310 or more 2θ values selected from the group consisting of: 6.145 ± 0.1 °, 10.318 ± 0.1 °, 12.459 ± 0.1 °, 14.914 ± 0.1 °, 20.806 ± 0.1 °, 22.832 ± 0.1 °, 23.295 ± 0.1 °, 24.996 ± 0.1 °, 25.198 ± 0.1 °, 25.481 ± 0.1 °, 26.787 ± 0.1 °, 27.285 ± 0.1 °, 28.003 ± 0.1 °, and 29.59 ± 0.1 °;

the powder diffraction pattern of crystal form C comprises 310 or more 2θ values selected from the group consisting of: 10.306 ± 0.1 °, 12.666 ± 0.1 °, 15.312 ± 0.1 °, 17.436 ± 0.1 °, 18.918 ± 0.1 °, 20.748 ± 0.1 °, 22.974 ± 0.1 °, 24.553 ± 0.1 °, 25.238 ± 0.1 °, 26.241 ± 0.1 °, 29.336 ± 0.1 °, 32.739 ± 0.1 °, 33.738 ± 0.1 °, 34.118 ± 0.1 °, 35.204.

2. The polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to claim 1, wherein the crystal form A further has one or more characteristics selected from the group consisting of:

(1) the crystal form A has a DSC spectrum substantially as shown in Figure 1b;
(2) the crystal form A has an infrared spectrum substantially as shown in Figure 1c;
(3) the crystal form A has a TG spectrum substantially as shown in Figure 1d; and
(4) the crystal form A has a Raman spectrum substantially as shown in Figure 1e.

3. The polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to claim 1, wherein the crystal form B further has one or more characteristics selected from the group consisting of:

(1) the crystal form B has a DSC pattern substantially as shown in Figure 2b;

(2) the crystal form B has an infrared spectrum substantially as shown in Figure 2c;

(3) the crystal form B has a TG pattern substantially as shown in Figure 2d; and

(4) the crystal form B has a Raman spectrum substantially as shown in Figure 2e.

4. The polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to claim 1, wherein the crystal form C further has one or more characteristics selected from the group consisting of:

(1) the crystal form C has a DSC pattern substantially as shown in Figure 3b;

(2) the crystal form C has an infrared spectrum substantially as shown in Figure 3c;

(3) the crystal form C has a TG pattern substantially as shown in Figure 3d; and

(4) the crystal form C has a Raman spectrum substantially as shown in Figure 3e.

5. A method for preparing the polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to claim 1, comprising the steps of:

(i) dissolving 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form A in an alcohol at 0°C to 80°C to form an alcohol solution containing 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride;

(ii) adding an organic solvent dropwise to the alcohol solution of step i), stirring, standing, and precipitating crystals; and

(iii) isolating and drying the precipitated crystals to obtain 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form B;

wherein said alcohol is selected from the group consisting of: methanol, ethanol, propanol, tert-butanol, butanol, octanol, pentanol, hexanol, heptanol, decanol, or a combination thereof ; the organic solvent is selected from the group consisting of: butanone, methyl tert-butyl ether, isopropyl acetate, or a combination thereof;

or the preparation method includes the steps of:

(a) dissolving 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form A in an alcohol or an alcohol-water system at 0°C to 80°C to form an alcohol solution or an alcohol-water solution containing 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride;

(b) adjusting the pH of the alcohol solution or the alcohol-water solution of step a) to be acidic with hydrochloric acid, stirring at room temperature, standing, and precipitating crystals; and

(c) separating and drying the precipitated crystals to obtain 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride crystal form C;

wherein said alcohol-water system is selected from the group consisting of methanol-water, ethanol-water, propanol-water, tert-butanol-water, butanol-water, octanol-water, pentanol-water, hexanol-water, heptanol-water or decanol-water.

6. A pharmaceutical composition, characterized in that the composition comprises a pharmaceutically effective dose of the polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to any one of claims 1 to 4, and a pharmaceutically acceptable excipient or carrier.

7. The polymorph of 2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride according to any one of claims 1 to 4 or the composition according to claim 6 for use in the treatment or prevention of diseases related to poly (ADP-ribose polymerase) (PARP).

8. Use of a polymorph of (2-[4-(methylaminomethyl)phenyl]-5-fluoro-benzofuran-7-carboxamide hydrochloride in the manufacture of a medicament for the treatment of a disease related to poly (ADP-ribose polymerase) (PARP), wherein the medicament is to be administered.