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(54) **Titre : FORME CRISTALLINE DE SEL (6S)-5-METHYLTETRAHYDROFOLATE ET PROCEDE POUR SA PREPARATION**
(54) **Title: CRYSTAL FORM OF (6S)-5-METHYLTETRAHYDROFOLATE SALT AND METHOD FOR PREPARING SAME**

(57) **Abrégé/Abstract:**
Disclosed are a crystal form of (6S)-5-methyltetrahydrofolate salt and a method for preparing the same. The crystal form is: Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.3±0.2 and 19.2±0.2; or the crystal form of (6S)-5-methyltetrahydrofolate strontium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.5±0.2 and 22.0±0.2. The crystal form of (6S)-5-methyltetrahydrofolate salt of the present invention has the advantages of excellent physicochemical properties, good stability, high purity, good reproducibility, and being more suitable for production on an industrial scale.

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ABSTRACT

Disclosed are a crystal form of (6S)-5-methyltetrahydrofolate salt and a method for preparing the same. The crystal form is: Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.3±0.2 and 19.2±0.2; or the crystal form of (6S)-5-methyltetrahydrofolate strontium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.5±0.2 and 22.0±0.2. The crystal form of (6S)-5-methyltetrahydrofolate salt of the present invention has the advantages of excellent physicochemical properties, good stability, high purity, good reproducibility, and being more suitable for production on an industrial scale.

CRYSTAL FORM OF (6S)-5-METHYLTETRAHYDROFOLATE SALT AND METHOD FOR PREPARING SAME

BACKGROUND

Technical Field

The present invention belongs to the field of crystal forms of compounds, and specifically relates to a crystal form of (6S)-5-methyltetrahydrofolate salt and methods for preparing the same and uses of the same.

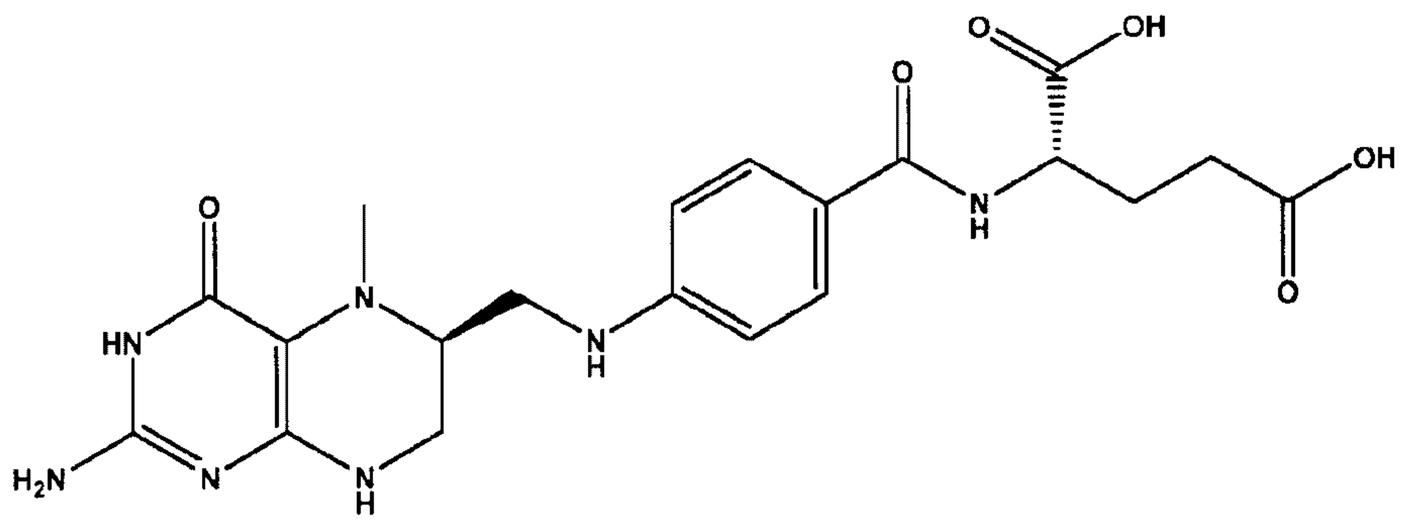
Related Art

The crystal forms of active pharmaceutical ingredients are closely associated with the biological activity, bioavailability, dissolution, stability, and shelf life thereof. Therefore, during the research and development of new drugs, screening of crystal form is one of the most important tasks. Even if the drug has been on the market for many years, seeking more effective crystal forms of the drug is still the goal intensely pursued by pharmaceutical companies.

5-methyltetrahydrofolic acid was first separated from a horse liver in the form of barium salt by Donaldson et al. in 1959 and was named as Prefolic-A™, and was synthesized by a chemical method in 1961 (K.O. Donaldson et al., Fed.Proc, (1961), 20, 453).

The 5-methyltetrahydrofolic acid molecule has two chiral carbon atoms, where the configuration of the chiral carbon atom at the glutamic acid site is certain, while the chiral carbon atom at Site 6 has two configurations R and S, and therefore, 5-methyltetrahydrofolic acid has been used in the form of a diastereomeric mixture. It is reported that, the two isomers have different effects with in vivo enzymes, where the compound with S configuration of the carbon atom at site 6 exhibits good efficacy, while the compound with R configuration of the carbon atom at site 6 almost has no efficacy in comparison.

The chemical name of (6S)-5-methyltetrahydrofolic acid is (6S)-N[4-[[(2-amino-1,4,5,6,7,8-hexahydro-4-oxo-5-methyl-6-pteridinyl)methyl]amino]benzoyl]-L-glutamic acid, referred to as (6S)-5-MTHF for short hereinafter. The structural formula is shown in Formula 1:



Formula I

(6S)-5-MTHF and salts thereof are very unstable and easily degraded, and especially are highly sensitive to oxygen and moisture (A. L. Fitzhugh, Pteridines 1993, 4(4), 187-191). In the air, (6S)-5-MTHF and salts thereof are easily oxidized into 5-methyldihydrofolic acid and/or folic acid and the like. Therefore, it is difficult to prepare high-purity and high-stability bulk pharmaceutical chemicals or food additives, to meet the quality standards.

Due to the physical and chemical properties of (6S)-5-MTHF, it is difficult to prepare a stable crystal form of (6S)-5-MTHF by a conventional crystallization process. In the past few decades of production of (6S)-5-MTHF and preparation of formulations thereof, a reducing agent, for example, Vitamin C or 2-mercaptoethanol, is often added to achieve the purpose of anti-oxidation.

Patent Document US5223500 reports a process for preparing a stable crystal form of (6S)-5-MTHF calcium salt. The process includes the following steps: first, preparing amorphous (6S)-5-MTHF calcium salt, then transferring into boiling water of 100°C to form a solution, cooling and standing overnight at room temperature. The collected solid is called to be a stable crystal product. However, relevant crystal parameters are not reported in this patent.

Patent Document US6441168 discloses a crystal form of (6S)-5-MTHF calcium salt with extremely high stability and a method for preparing the same. (6S)-5-MTHF sodium salt and calcium chloride are subjected to heat treatment in a polar solvent at about 90°C to obtain four stable crystal forms of (6S)-5-MTHF calcium salt, which are respectively Form I having 2θ values of 6.3, 13.3, 16.8, and 20.1, Form II having 2θ values of 5.3, 6.9, 5.7, and 21.1, Form III having 2θ values of 6.8, 10.2, 15.4, and 22.5, and Form IV having 2θ values of 6.6, 15.9, 20.2, and 22.5.

Patent Document WO2008144953 discloses a process for preparing a stable amorphous (6S)-5-MTHF calcium salt, in which a crystal form of (6S)-5-MTHF is used as a raw material, calcium chloride is added for slow crystallization. The whole crystallization process in this patent is very complex, and the crystallization time is 16 to 18 hours, thereby reducing the production capacity in the product procedure.

SUMMARY

Surprisingly, it has been found now that by using ultrasonic waves to assist crystallization during the formation of a salt, a crystal form of (6S)-5-methyltetrahydrofolate salt with high stability and good chemical and optical purity can be obtained.

In order to overcome the disadvantages in the prior art, an objective of the present invention is to provide a novel crystal form of (6S)-5-methyltetrahydrofolate salt with good stability, high purity, and good reproducibility.

Preferably, the present invention sets forth Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.3±0.2 and 19.2±0.2.

Preferably, the present invention sets forth a crystal form of (6S)-5-methyltetrahydrofolate strontium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.5±0.2 and 22.0±0.2.

Preferably, the X-ray diffraction pattern of the Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt has diffraction peaks at the 2θ angles of 3.2±0.2, 6.3±0.2, 13.2±0.2, 14.6±0.2, 19.2±0.2, and 32.6±0.2.

Preferably, the X-ray diffraction pattern of the crystal form of (6S)-5-methyltetrahydrofolate strontium salt has diffraction peaks at the 2θ angles of 6.5±0.2, 10.0±0.2, 13.7±0.2, 16.8±0.2, 17.1±0.2, 22.0±0.2, and 24.9±0.2.

Preferably, the X-ray diffraction pattern of the Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt has diffraction peaks at the 2θ angles of 3.2±0.1, 6.3±0.1, 13.2±0.1, 14.6±0.1, 19.2±0.1, and 32.6±0.1; or, preferably, the X-ray diffraction pattern of the crystal form of (6S)-5-methyltetrahydrofolate strontium salt has diffraction peaks at the 2θ angles of 6.5±0.1, 10.0±0.1, 13.7±0.1, 16.8±0.1, 17.1±0.1, 22.0±0.1, and 24.9±0.1.

Another objective of the present invention is to provide methods for preparing the crystal form of (6S)-5-methyltetrahydrofolate salt.

The third objective of the present invention is to provide pharmaceutical compositions of the crystal form of (6S)-5-methyltetrahydrofolate salt.

The fourth objective of the present invention is to provide uses of the crystal form of (6S)-5-methyltetrahydrofolate salt.

The objectives of the present invention can be achieved according to the following ways:

A crystal form of (6S)-5-methyltetrahydrofolate salt is provided, where the crystal form is Form C of the crystal form of (6S)-5-methyltetrahydrofolic acid calcium salt or a crystal form of (6S)-5-methyltetrahydrofolate strontium salt.

In an aspect, the present invention provides Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt, where by using Cu-Ka radiation, the X-ray diffraction pattern has diffraction peaks at 2θ of 6.3±0.2 and 19.2±0.2 in degree, especially has one or more diffraction peaks at 2θ of 3.2±0.2, 6.3±0.2, 13.2±0.2, 14.6±0.2, 19.2±0.2, and

32.6±0.2, and preferably has one or more diffraction peaks at 2θ of 3.2±0.1, 6.3±0.1, 13.2±0.1, 14.6±0.1, 19.2±0.1, and 32.6±0.1. The X-ray diffraction pattern of the Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt exhibits strong diffraction peaks and low background spectrum, indicating high crystallinity.

The further X-ray diffraction pattern of the Form C (6S)-5-methyltetrahydrofolic acid calcium salt is essentially shown in FIG. 1. The chemical purity of the Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt is further greater than 99.0%.

In another aspect, the present invention provides a crystal form of (6S)-5-methyltetrahydrofolate strontium salt, where by using Cu-Ka radiation, the X-ray diffraction pattern has diffraction peaks at 2θ of 6.5±0.2 and 22.0±0.2 in degree, especially has one or more diffraction peaks at 2θ of 6.5±0.2, 10.0±0.2, 13.7±0.2, 16.8±0.2, 17.1±0.2, 22.0±0.2, and 24.9±0.2, and preferably has one or more diffraction peaks at 2θ of 6.5±0.1, 10.0±0.1, 13.7±0.1, 16.8±0.1, 17.1±0.1, 22.0±0.1, and 24.9±0.1. The X-ray diffraction pattern of the crystal form of (6S)-5-methyltetrahydrofolate strontium salt exhibits strong diffraction peaks and low background spectrum, indicating high crystallinity.

The further X-ray diffraction pattern of the (6S)-5-methyltetrahydrofolate strontium salt is essentially shown in FIG. 2.

In the present invention, the moisture content of the crystal form of (6S)-5-methyltetrahydrofolate salt is 10% to 18%, and further is 15% to 17%.

In still another aspect, the present invention provides a method for preparing a (6S)-5-methyltetrahydrofolate salt, where the method includes crystallizing (6S)-5-methyltetrahydrofolate salt from a polar medium through ultrasonic assistance.

In yet another aspect, the present invention provides a method for preparing a (6S)-5-methyltetrahydrofolate salt, specifically including the following steps:

(1) Neutralization of (6S)-5-methyltetrahydrofolic acid with a base in a polar medium to full dissolution; the polar medium may be water, deionized water, or a solution formed by

water and an organic solvent capable of being mixed uniformly with water, and may also be a salt; a preferred polar medium is water and deionized water. The base is an inorganic base or organic base capable of forming a salt with (6S)-5-methyltetrahydrofolic acid, the inorganic base is selected from alkali metal bases or alkaline earth metal bases, carbonates and bicarbonates; the organic base is selected from ammonia, amines, pyridines or piperazines, where potassium hydroxide, sodium hydroxide, calcium hydroxide, potassium carbonate, sodium carbonate, potassium bicarbonate, sodium bicarbonate, ammonia, methylamine, 4-dimethyl-pyridine or piperazine are preferred.

(2) Addition of an alkaline earth metal salt or an alkaline earth metal salt solution; the alkaline earth metal salt refers to an inorganic salt or organic salt that is soluble or partially solution in the polar medium, for example, calcium salt, magnesium salt, strontium salt, barium salt, and calcium chloride, hexahydrate calcium chloride and strontium chloride are preferred.

(3) Heating to a temperature higher than 30°C, especially to a temperature of 30°C to 60°C or 60°C to 100°C.

(4) Introduction of ultrasonic waves and crystallization, and isolation of (6S)-5-methyltetrahydrofolate salt crystal.

Ultrasonic technology is a simple, inexpensive technique, and is safe and convenient in use. On one hand, ultrasonic wave can strength the nucleation and growth of crystals. In the crystallization process, the introduction of ultrasonic waves may cause cavitation phenomenon, when cavitation bubbles burst, a certain micro-jet is produced, the micro-jet crushes crystal grains having a certain size, and a part of the crushed crystals serve as seed for crystal growth, thereby promoting the growth of crystals. On the other hand, in the crystallization process, ultrasonic waves are equivalent to a catalyst, and excite the molecular motion through translation, rotation and reversal, thereby increasing the crystallization rate of the entire system, and shortening the crystallization time. The ultrasonic waves can also improve the particle size distribution of the product, and with the increase of the ultrasonic power, the crystal particles show a tendency of decrease. Since no other reagents are added

and no contaminants are introduced in the crystallization process, the ultrasonic waves can be used to prepare very pure crystalline materials, and this is very important for some materials with very strict requirements for purity, especially pharmaceutical products and foods. Compared with other crystallization starting methods such as stimulation crystallization starting method and seed charging crystallization starting method, the degree of supersaturation required by ultrasonic crystallization is low, the growth speed is fast, the resulting crystal is uniform, complete and clean, the crystal size distribution range is small, and the coefficient of variation is low.

Ultrasonic waves have been used in crystalline area since 1927. In recent years, the utilization of ultrasonic waves in pharmaceutical and fine chemical industries is further promoted. Ishtiaq et al. reviewed the application of ultrasonic waves in the pharmaceutical field (World Applied sciences Journal (2009), 6(7), 856-893). However, so far, in the pharmaceutical industry, merely several papers and patents disclose and apply the ultrasonic crystallization technique, for example, paroxetine, aspartame, adipic acid, fenoterol hydrobromide (Organic Process Research & Development 2005, 9, 923-932).

The inventors apply ultrasonic waves in the field of crystallization of 5-methyltetrahydrofolic acid and salts thereof for the first time. We have found in experiments that when the ultrasonic power is 0.01 W/ml to 1.0 W/ml, the resulting crystal is uniform, complete, and clean, the crystal size distribution range is small, and the purity is high and is up to above 99.0%. Preferably, the ultrasonic power is 0.04 W/ml to 0.60 W/ml.

Neutralization with a base in Step (1) generally refers to neutralization to a pH value of about 7.0, generally neutralization to a pH value of 6.5 to 8.5, preferably neutralization to a pH value of 7.0 to 7.5, and most preferably neutralization to a pH value of 7.0. The base may be directly added, and may also be added in the form of a solution (for example, aqueous solution). This method has not specific requirements on the amount of the polar medium, and an amount for a general reaction or a crystallization medium is suitable.

When an alkaline earth metal salt solution is used in Step (2), generally a 5% to 50% aqueous solution of an alkaline earth metal salt, preferably a 25% to 50% aqueous solution of

an alkaline earth metal salt, is used.

The heating temperature in Step (3) is 30°C to 60°C or 60°C to 100°C, preferably 40°C to 80°C, and more preferably 65°C to 70°C.

In Step (4), after ultrasonic crystallization and isolation the crystal, a step of washing with water and drying (drying in vacuum at a temperature of 20°C to 40°C).

Preparation of the crystal form of (6S)-5-methyltetrahydrofolate salt by using ultrasonic waves can be carried out naturally or be carried out by introducing a corresponding (6S)-5-methyltetrahydrofolate salt seed.

In another aspect, the present invention relates to a composition containing at least one (6S)-5-methyltetrahydrofolate salt described above, since persons skilled in the art can understand based on the knowledge in the art that the composition of the present invention may further contain a pharmaceutically acceptable excipient or carrier. The carrier includes a diluent, a binder, a disintegrant, a lubricant, and an anti-oxidant, and these excipients are existing conventional excipients. The preparation form of the composition is an oral solid preparation or injection, for example, tablets, capsules, orally disintegrating tablets, lozenge, sustained-release preparations, injections, and lyophilized powder, prepared by adopting methods for corresponding formulations.

A preparation is provided, which contains an effective amount of the crystal form of (6S)-5-methyltetrahydrofolate salt.

In another aspect, the present invention discloses a use of the at least one (6S)-5-methyltetrahydrofolate salt and/or composition defined above in preparation of pharmaceuticals, food additives or nutritional supplements, where the pharmaceuticals, food additives, or nutritional supplements are used for preventing and/or treating defects or diseases positively impacted by administration of 5-methyltetrahydrofolate salt.

Merely for example, the (6S)-5-methyltetrahydrofolate salt and/or composition of the present invention defined above may be used in preparation of pharmaceuticals, food

additives, or nutritional supplements. The pharmaceuticals, food additives, or nutritional supplements are used for preventing and/or treating neurological diseases such as subacute encephali associated with dementia and vacuolar myelopathy; physiological and pathological vascular and cardiovascular disorders such as premature occlusive arterial diseases, severe vascular diseases in infancy and childhood, progressive arterial stenosis, intermittent claudication, renal vascular hypertension, ischemic cerebrovascular diseases, premature occlusive retinal artery and retinal vein, crebral occlusive arterial diseases, occlusive peripheral arterial diseases, and premature death caused by thromboembolic diseases and/or ischemic heart diseases; autoimmune diseases such as psoriasis, celiac disease, arthritis and inflammatory conditions; megaloblastic anemia caused by folate inficiency, intestinal malabsorption, used as antidote for folic acid antagonists (for example, methotrexate, pyrimethamine or trimethoprim); used for preventing serious toxic effects caused by methotrexate overdose or high-dose therapy, reducing risks of woman miscarriage and/or production of fetuses with neural tube defects, cleft defects and/or palate defects, keeping and/or normalizing homocysteine levels and/or metabolism; changes synthesis of and/or functions and/or variations in DNA and RNA and changes in synthesis of cells; and depression.

The (6S)-5-methyltetrahydrofolate salt of the present invention exhibits long-term persistent chemical stability, and after long-term exposure in the air at a temperature of 40°C and relative humidity of 60%, and the color of the crystal form has no significant changes, which is very important for application of the (6S)-5-methyltetrahydrofolate salt in pharmaceutical preparations.

In addition to the rare high chemical stability, it may also be noted that, the (6S)-5-methyltetrahydrofolate salt of the present invention has good dissolution rate, and in water at a temperature of 25°C, the saturated state can be quickly reached within 1 min. The high dissolution rate can not only improve the producibility of preparations for parenteral administration such as injections, thereby facilitating industrial production, and can also be made into oral preparations, thereby having important biopharmaceutical advantages in oral administration of pharmaceuticals, because the high dissolution rate of the active

pharmaceuticals improves the absorption rate of the active pharmaceuticals through the gastrointestinal wall. Additionally, the crystal form of the present invention further has the advantages of high crystallinity, uniform particle distribution, smooth surface, and high chemical purity of up to above 99.0%.

The method for preparing the crystal form of (6S)-5-methyltetrahydrofolate salt of the present invention has the advantages that the reaction steps are simple, no pollution occurs, the obtained novel crystal form of (6S)-5-methyltetrahydrofolic acid calcium salt has high chemical stability, high purity, high dissolution rate, and high bioavailability, thereby providing a novel way for preparing (6S)-5-methyl-tetrahydrofolate crystalline salt.

The crystal form of (6S)-5-methyltetrahydrofolate salt of the present invention has the advantages of excellent physicochemical properties, good stability, high purity, good reproducibility, and being more suitable for production on an industrial scale.

BRIEF DESCRIPTION OF DRAWINGS

The disclosure will become more fully understood from the detailed description given herein below for illustration only, and thus are not limitative of the disclosure, and wherein:

FIG. 1 shows an X-ray diffraction pattern of Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt;

FIG. 2 shows an X-ray diffraction pattern of the crystal form of (6S)-5-methyltetrahydrofolate strontium salt; and

FIG. 3 shows the particle diameter distribution of Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt obtained through the preparation method of the present invention.

DETAILED DESCRIPTION

Without further description, by means of the previous description, persons skilled in the art can implement the present invention to the maximum. The following preferred specific

embodiments are just examples, and in no way limit the disclosure of the present invention.

Embodiment 1

15.0 g (6S)-5-MTHF was added to 325 ml deionized water, and 10% NaOH solution was added with stirring for neutralization to a pH value of 7.8 till (6S)-5-MTHF was fully dissolved. Next, 37.5 g calcium chloride solution (containing 9.0 g calcium chloride) was added, the resulting reaction solution was transferred into an ultrasonic reactor having a power density of 0.04 W/ml at a temperature of 72°C, and after 40 min-ultrasonic reaction, the reaction solution was filtered, and washed with water, ethanol and acetone respectively. After drying in vacuum at 25°C, 13.5 g white Form C of (6S)-5-MTHF calcium salt was obtained. The chemical purity is 99.25% (detected by HPLC), and the moisture content is 10.67%.

Embodiment 2

10.0 g (6S)-5-MTHF was added to 250 ml water, and 10% NaOH solution was added with stirring for neutralization to a pH value of 7.4 till (6S)-5-MTHF was fully dissolved. Next, 25 g calcium chloride solution (containing 6.0 g calcium chloride) was added, the resulting reaction solution was transferred into an ultrasonic reactor having a power density of 0.03 W/ml at a temperature of 60°C, and after 40 min-ultrasonic reaction, the reaction solution was filtered, and washed with water and acetone. After drying in vacuum at 30°C, 9.2 g white Form C of (6S)-5-MTHF calcium salt was obtained. The chemical purity is 99.01% (detected by HPLC), and the moisture content is 15.8%.

Embodiment 3

10.0 g (6S)-5-MTHF was added to 150 ml water, and ammonia was added with stirring for neutralization to a pH value of 7.4 till (6S)-5-MTHF was fully dissolved. Next, 12 g calcium chloride solution (containing 3.0 g calcium chloride) was added, the resulting reaction solution was transferred into an ultrasonic reactor having a power density of 0.05 W/ml at a temperature of 40°C, and after 100 min-ultrasonic reaction, the reaction solution was filtered, and washed with water and acetone. After drying in vacuum at 25°C, 9.0 g white

Form C of (6S)-5-MTHF calcium salt was obtained. The chemical purity is 99.60% (detected by HPLC), and the moisture content is 17.76%.

Embodiment 4

40.0 g (6S)-5-MTHF was added to 1,000 ml water, and 10% NaOH solution was added with stirring for neutralization to a pH value of 7.8 till (6S)-5-MTHF was fully dissolved. Next, 96 g calcium chloride solution (containing 24 g calcium chloride) was added, the resulting reaction solution was transferred into an ultrasonic reactor having a power density of 0.56 W/ml at a temperature of 90°C, and after 30 min-ultrasonic reaction, the reaction solution was filtered, and washed with water and acetone. After drying in vacuum at 25°C, 36.0 g white Form C of (6S)-5-MTHF calcium salt was obtained. The chemical purity is 99.77% (detected by HPLC), and the moisture content is 16.39%.

Embodiment 5: Strontium salt

6.0 g (6S)-5-MTHF was added to 150 ml water, and 10% NaOH solution was added with stirring for neutralization to a pH value of 7.3 till (6S)-5-MTHF was fully dissolved. Next, 7.29 g strontium chloride solution (containing 1.8 g strontium chloride) was added, the resulting reaction solution was transferred into an ultrasonic reactor having a power density of 0.30 W/ml at a temperature of 70°C, and after 20 min-ultrasonic reaction, the reaction solution was filtered, and washed with water and acetone. After drying in vacuum at 25°C, 4.2 g white (6S)-5-MTHF strontium salt was obtained. The chemical purity is 97.57% (detected by HPLC), and the moisture content is 15.02%.

Embodiment 6

9.0 g (6S)-5-MTHF was added to 225 ml water, and 10% NaOH solution was added with stirring for neutralization to a pH value of 7.1 till (6S)-5-MTHF was fully dissolved. Next, 10.2 g calcium chloride solution (containing 2.7 g calcium chloride) was added, the resulting reaction solution was transferred into an ultrasonic reactor having a power density of 0.20 W/ml at a temperature of 70°C, and after 20 min-ultrasonic reaction, the reaction solution was filtered, and washed with water and acetone. After drying in vacuum at 25°C, 6.1 g white

Form C of (6S)-5-MTHF calcium salt was obtained. The chemical purity is 99.08% (detected by HPLC), and the moisture content is 15.20%.

Embodiment 7

18.0 g (6S)-5-MTHF was added to 450 ml water, and 10% NaOH solution was added with stirring for neutralization to a pH value of 7.3 till (6S)-5-MTHF was fully dissolved. Next, 21.6 g calcium chloride solution (containing 5.4 g calcium chloride) was added, the resulting reaction solution was transferred into an ultrasonic reactor having a power density of 0.04 W/ml at a temperature of 70°C, and after 30 min-ultrasonic reaction, the reaction solution was filtered, and washed with water and acetone. After drying in vacuum at 25°C, 13.9 g white Form C of (6S)-5-MTHF calcium salt was obtained. The chemical purity is 99.53% (detected by HPLC), and the moisture content is 16.4%.

Embodiment 8

2.0 g (6S)-5-MTHF was added to 50 ml water, and sodium hydroxide was added with stirring for neutralization to a pH value of 7.2 till (6S)-5-MTHF was fully dissolved. Next, 2 g calcium chloride solution (containing 0.5 g calcium chloride) was added, the resulting reaction solution was transferred into an ultrasonic reactor having a power density of 0.05 W/ml at a temperature of 50°C, and after 60 min-ultrasonic reaction, the reaction solution was filtered, and washed with water and acetone. After drying in vacuum at 40°C, 1.0 g white Form C of (6S)-5-MTHF calcium salt was obtained. The chemical purity is 99.01% (detected by HPLC), and the moisture content is 15.6%.

Although the above specific embodiments merely disclose the preparation methods of the (6S)-5-methyltetrahydrofolic acid calcium salt crystal and the (6S)-5-methyltetrahydrofolate strontium salt crystal, persons skilled in the art can prepare other types of (6S)-5-methyltetrahydrofolate salt crystals according to the teaching of the preparation methods, particularly the (6S)-5-methyltetrahydrofolic acid alkaline earth metal salt crystals.

Embodiment 9: Stability study

In order to determine the stability of the novel crystal form of the Form C of (6S)-5-MTHF calcium salt, the crystal form was placed in the air at a temperature of 40°C and a relative humidity of 60%, and the content of remained (6S)-5-MTHF calcium salt was periodically measured.

Crystal Form	Storage Days	Appearance	Content
Form C	0	White crystal	99.5%
	3	White crystal	99.1%
	6	White crystal	99.1%
	9	White crystal	98.4%

The results show that the Form C of (6S)-5-MTHF calcium salt has good stability, which is beneficial to the production and storage of pharmaceutical preparations.

Embodiment 10: Particle diameter distribution of the Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt

FIG. 3 shows the particle diameter distribution of the Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt obtained through the preparation method of the present invention. It can be seen from FIG. 3 that, the particle size is in normal distribution, indicating that the crystal treated by ultrasonic waves has a relatively uniform particle size.

Embodiment 11: Conditions and data of the X-ray diffraction pattern of the Crystal form

Instrument: Bruker DS™ advance XRD

Diffraction ray: CuKα (40 kV, 40 mA)

Scanning rate: 80°/min (2θ value)

Scanning range: 2° to 45° (2θ value)

Peak Search Report (37 Peaks, Max P/N=46.1)

PEAK: 35-pts/Parabolic Filter, Threshold=3.0, Cutoff=0.1%, BG=3/1.0,

Peak-Top=Summit

#	2-Theta	d(A)	BG	Height	I%	Area	I%	FWHM
1	3.151	28.0163	612	8740	89.06	165950	100.00	0.343
2	6.309	13.9974	689	9814	100.00	155754	93.86	0.286
3	9.447	9.3545	681	1601	16.31	16953	10.22	0.309
4	13.199	6.7022	913	4338	44.20	46545	28.05	0.228
5	13.612	6.4999	1029	2121	21.61	14775	8.90	0.227
6	14.166	6.2469	1072	1514	15.43	12344	7.44	0.441
7	14.639	6.0462	1057	4630	47.18	52370	31.56	0.246
8	15.329	5.7755	1055	1310	13.35	2233	1.35	0.147
9	16.001	5.5343	1133	2147	21.88	18187	10.96	0.301
10	16.534	5.3572	958	1409	14.36	15394	9.28	0.539
11	17.046	5.1973	1089	2406	24.52	14700	8.86	0.187
12	18.824	4.7103	1017	3484	35.50	74762	45.05	0.479
13	19.158	4.6288	1118	3998	40.74	84209	50.74	0.491
14	20.125	4.4085	1295	3176	32.36	30820	18.57	0.275
15	20.976	4.2316	1169	2397	24.42	22579	13.61	0.308
16	21.411	4.1466	1068	1503	15.31	5525	3.33	0.213
17	22.614	3.9287	863	1716	17.49	13799	8.32	0.271
18	24.073	3.6937	857	1619	16.50	9785	5.90	0.215
19	24.785	3.5892	884	1719	17.52	26584	16.02	0.503
20	25.022	3.5558	898	1971	20.08	26647	16.06	0.417
21	25.914	3.4354	884	1390	14.16	7075	4.26	0.235
22	26.858	3.3168	846	1262	12.86	10476	6.31	0.423
23	27.334	3.2601	852	1244	12.68	8923	5.38	0.359
24	27.674	3.2207	901	1048	10.68	1050	0.63	0.113
25	28.358	3.1446	915	1606	16.36	15814	9.53	0.384
26	28.908	3.0860	913	1339	13.64	16265	9.80	0.641
27	29.444	3.0310	977	1419	14.46	9424	5.68	0.358
28	30.251	2.9520	921	1248	12.72	3742	2.25	0.192
29	30.769	2.9035	880	1518	15.47	9728	5.86	0.256
30	31.537	2.8345	836	1196	12.19	4349	2.62	0.203
31	32.602	2.7443	813	1863	18.98	21721	13.09	0.347
32	35.722	2.5115	617	929	9.47	4980	3.00	0.268
33	37.675	2.3856	659	1229	12.52	10784	6.50	0.317
34	38.819	2.3179	633	884	9.01	5939	3.58	0.397
35	40.263	2.2381	607	776	7.91	4592	2.77	0.429
36	42.037	2.1476	580	988	10.07	14181	8.55	0.583
37	43.615	2.0735	563	841	8.57	6633	4.00	0.400

Embodiment 12: Conditions and data of the X-ray diffraction pattern of the crystal form of strontium salt

Instrument model: Bruker D8™ advance XRD

Diffraction ray: CuKα (40 kv, 40 mA)

Scanning rate: 8°/min (2θ value)

Scanning range: 5° to 45° (2θ value)

Peak Search Report (36 Peaks, Max P/N=20.9)

PEAK: 29-pts/Parabolic Filter, Threshold=3.0, Cutoff=0.1%, BG=3/1.0, Peak-Top=Summit

#	2-Theta	d(A)	BG	Height	I%	Area	I%	FWHM
1	6.54	13.503	581	2213	100	46131	100	0.354
2	7.496	11.7831	565	96	4.3	1563	3.4	0.277
3	8.38	10.5426	570	136	6.1	2418	5.2	0.302
4	9.96	8.8736	610	1379	62.3	35198	76.3	0.434
5	12.339	7.1672	647	292	13.2	5831	12.6	0.339
6	13.66	6.4772	902	604	27.3	20626	44.7	0.581
7	14.22	6.2232	826	413	18.7	26525	57.5	1.092
8	14.741	6.0044	940	355	16	5431	11.8	0.26
9	15.58	5.6828	842	199	9	3770	8.2	0.322
10	16.279	5.4403	1049	239	10.8	2625	5.7	0.187
11	16.8	5.2729	815	533	24.1	28957	62.8	0.924
12	17.14	5.169	898	672	30.4	16152	35	0.409
13	18.28	4.8492	796	664	30	16290	35.3	0.417
14	19.54	4.5393	819	598	27	15788	34.2	0.449
15	20.3	4.371	779	328	14.8	5046	10.9	0.262
16	22.02	4.0334	699	1281	57.9	31787	68.9	0.422
17	23.259	3.8211	764	131	5.9	2094	4.5	0.272
18	24.399	3.6451	944	589	26.6	22484	48.7	0.649
19	24.92	3.5702	911	788	35.6	34957	75.8	0.754
20	26.42	3.3707	830	673	30.4	12784	27.7	0.323
21	27.999	3.1841	838	310	14	5810	12.6	0.319
22	28.961	3.0805	851	249	11.3	4360	9.5	0.298
23	29.881	2.9877	723	138	6.2	2168	4.7	0.267
24	30.84	2.897	679	190	8.6	3775	8.2	0.338
25	32.04	2.7912	678	220	9.9	7951	17.2	0.614
26	32.44	2.7577	683	157	7.1	7115	15.4	0.77
27	33.12	2.7026	662	190	8.6	2851	6.2	0.255
28	34.12	2.6256	655	149	6.7	4534	9.8	0.517
29	35.041	2.5587	674	88	4	2007	4.4	0.388
30	37.179	2.4163	663	223	10.1	8948	19.4	0.682
31	37.723	2.3827	689	142	6.4	7683	16.7	0.92
32	39.78	2.2641	592	373	16.9	9421	20.4	0.429
33	41.019	2.1985	577	122	5.5	3827	8.3	0.533
34	42.84	2.1092	648	445	20.1	17304	37.5	0.661
35	43.298	2.0879	726	211	9.5	10128	22	0.816
36	44.321	2.0421	683	153	6.9	4026	8.7	0.447

Therefore, the present invention relates to the crystal form of (6S)-5-methyltetrahydrofolate salt prepared by the above method.

The crystal form of (6S)-5-methyltetrahydrofolate salt is:

(a) Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.3±0.2 and 19.2±0.2; or

(b) Crystal form of (6S)-5-methyltetrahydrofolate strontium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.5±0.2 and 22.0±0.2.

Preferably, the crystal form of (6S)-5-methyltetrahydrofolate salt is:

(a) Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 3.2±0.2, 6.3±0.2, 13.2±0.2, 14.6±0.2, 19.2±0.2 and 32.6±0.2; or

(b) the crystal form of (6S)-5-methyltetrahydrofolate strontium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.5±0.2, 10.0±0.2, 13.7±0.2, 16.8±0.2, 17.1±0.2, 22.0±0.2 and 24.9±0.2.

Preferably, the crystal form of (6S)-5-methyltetrahydrofolate salt is:

(a) Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 3.2±0.1, 6.3±0.1, 13.2±0.1, 14.6±0.1, 19.2±0.1 and 32.6±0.1; or

(b) the crystal form of (6S)-5-methyltetrahydrofolate strontium salt, where the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 6.5±0.1, 10.0±0.1, 13.7±0.1, 16.8±0.1, 17.1±0.1, 22.0±0.1 and 24.9±0.1.

Specifically, the crystal form of (6S)-5-methyltetrahydrofolate salt is:

(a) X-ray diffraction pattern of the Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt is essentially shown in FIG. 1; or

(b) X-ray diffraction pattern of the crystal form of (6S)-5-methyltetrahydrofolate strontium salt is essentially shown in FIG. 2.

The preferred or specific embodiments of the present invention are described above in detail. It should be understood that persons skilled in the art can make various modifications and variations according to the design concept of the present invention without any creative work. Therefore, all technical solutions that can be obtained by persons skilled in the art through logical analysis, reasoning or limited experiments based on the prior art according to the design concept of the present invention shall fall within the scope of the present invention and/or the protection scope defined by the claims.

CLAIMS:

1. A crystal form of (6S)-5-methyltetrahydrofolate salt, wherein the crystal form is:

(a) Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt, wherein the X-ray diffraction pattern has diffraction peaks at the 2θ angles of 3.2 ±0.2, 6.3±0.2, 13.2±0.2, 14.6±0.2, 19.2±0.2 and 32.6±0.2.

2. A method for preparing Form C of the crystal form of (6S)-5-methyltetrahydrofolate calcium salt having diffraction peaks at the 2θ angles of 3.2±0.2, 6.3±0.2, 13.2±0.2, 14.6±0.2, 19.2±0.2 and 32.6±0.2, wherein the Form C of (6S)-5-methyltetrahydrofolate calcium salt is crystallized from a polar medium, wherein the crystallization process comprises:

a) adding (6S)-5-methyltetrahydrofolic acid to a polar medium and neutralizing with a base;

b) adding a calcium salt or a solution of a calcium salt;

c) heating to a temperature in the range of 30°C. to 60°C. or 60°C. to 100°C.; and

d) introducing ultrasonic waves for crystallization, and

e) isolating the Form C of (6S)-5-methyltetrahydrofolate calcium salt,

wherein the polar medium in Step a) is water, deionized water or a solution formed by water and an organic solvent capable of being mixed uniformly with water,

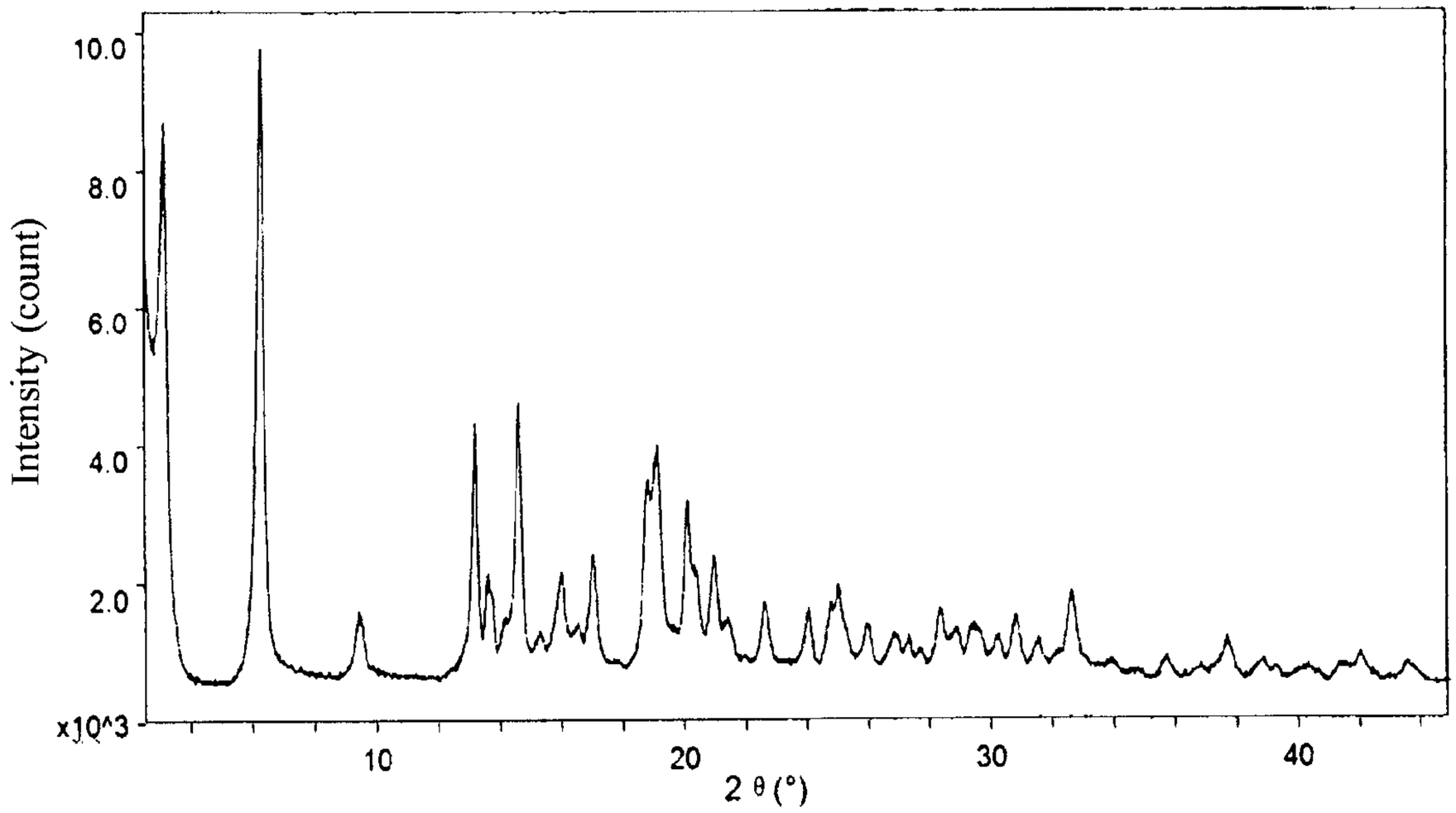
wherein the base in Step a) is selected from potassium hydroxide, sodium hydroxide, calcium hydroxide, potassium carbonate, sodium carbonate, potassium bicarbonate, sodium bicarbonate, ammonia, methylamine, 4-dimethyl-pyridine or piperazine,

wherein the ultrasonic power density is 0.01 w/ml to 1.0 w/ml.

3. The method according to claim 2, wherein the crystallization process is carried out at a temperature in the range of 30°C. to 60°C. or 60°C. to 100°C.

4. The method according to claim 2, wherein the ultrasonic power density is 0.04 w/ml to 0.60 w/ml.

5. A pharmaceutical composition, comprising the Form C crystal form of (6S)-5-methyltetrahydrofolate calcium salt according to claim 1 and at least a pharmaceutically acceptable excipient.


Intensity (count)
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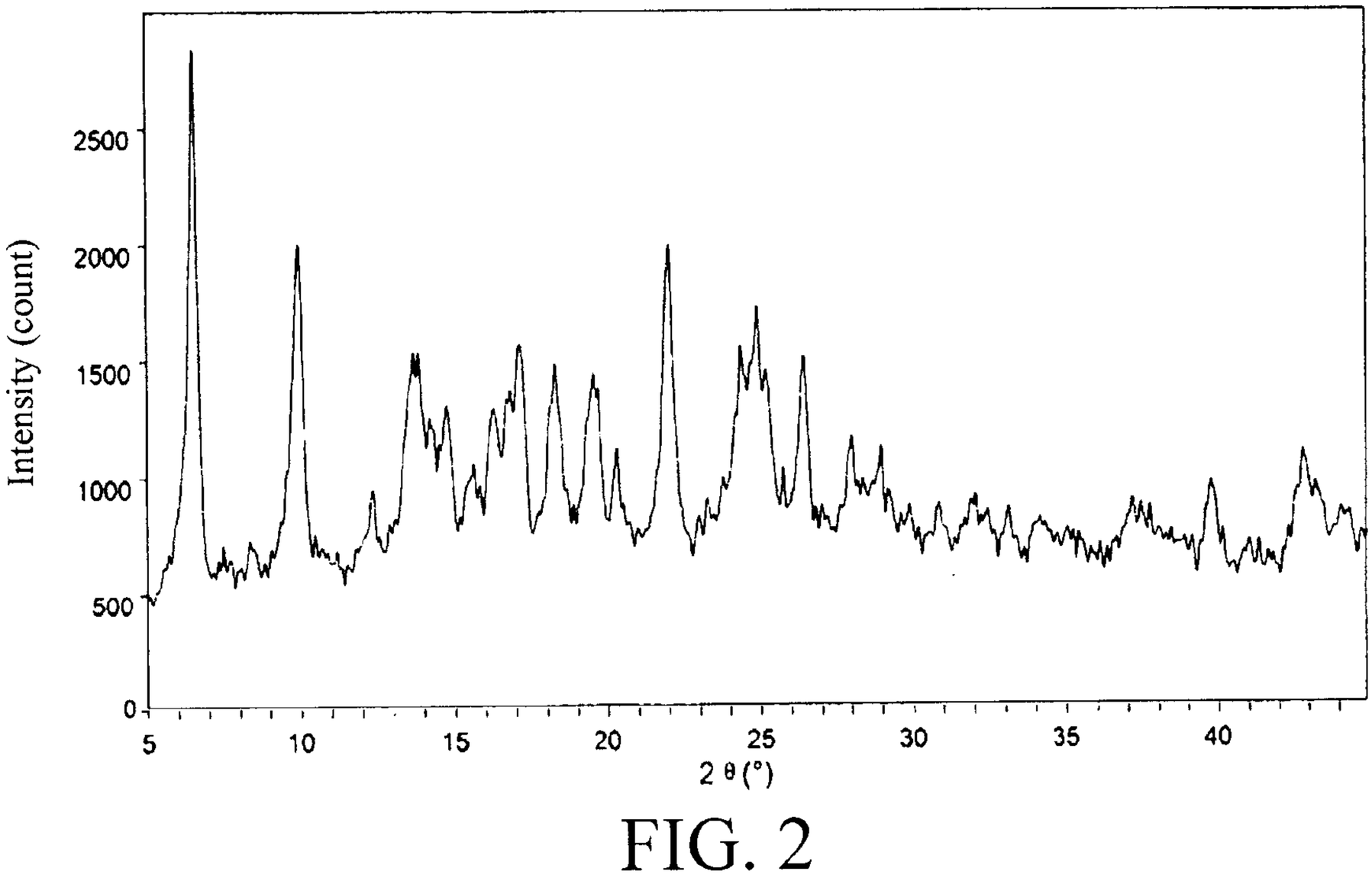
6.0
4.0
2.0
x10^3
10
20
30
40
2 θ (°)

FIG. 1


Intensity (count)
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2000
1500
1000
500
0
5
10
15
20
25
30
35
40
2 θ (°)

FIG. 2

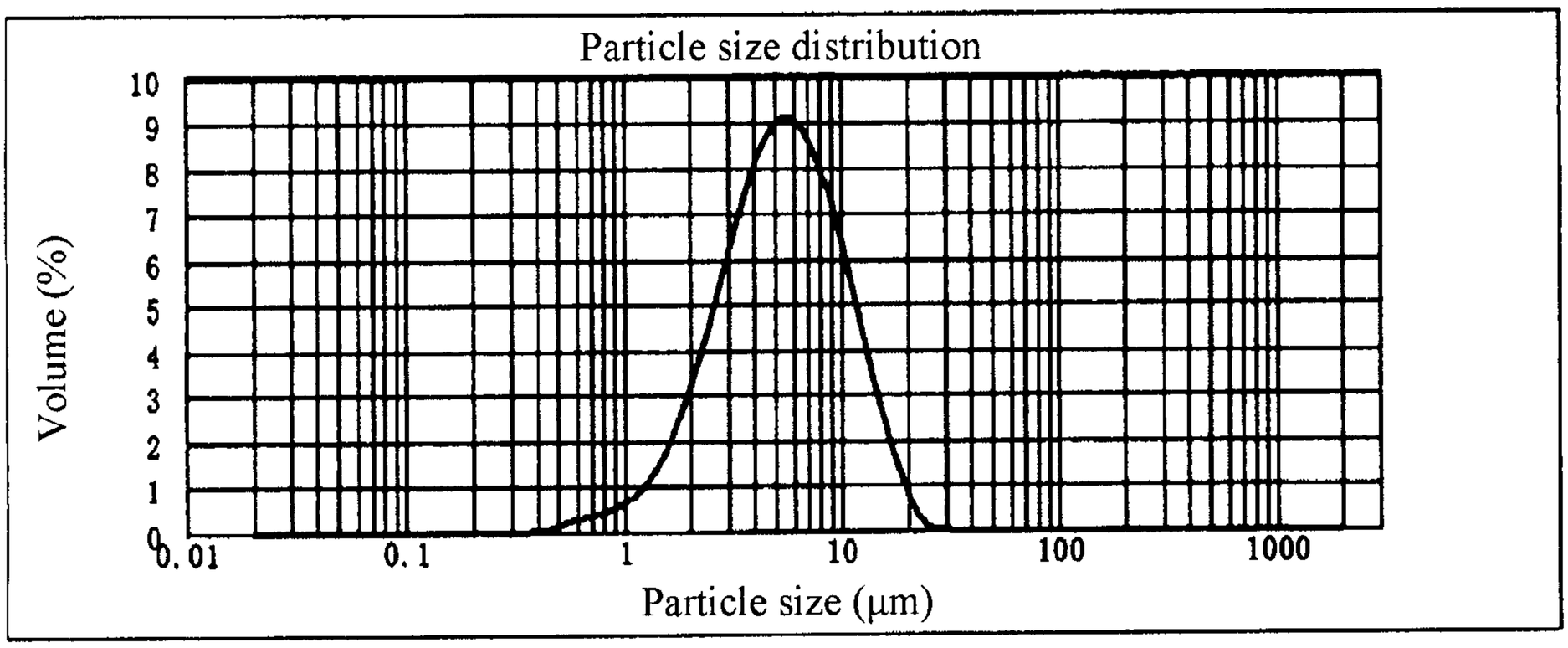
Particle size distribution
Volume (%)
10
9
8
7
6
5
4
3
2
1
0
0.01
0.1
1
10
100
1000
Particle size (μm)

FIG. 3