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(54) Titre : UN HYDRATE CRISTALLIN VARIABLE DE 6-[4-[2-[[3-(9H-CARBAZOL-4-YLOXY)-2-HYDROXYPROPYL]AMINO]-2-METHYLPROPYL]PHENOXY]-HEMI-SUCCINATE DE (S)-(PYRIDINE-3-CARBOXAMIDE

(54) Title: A CRYSTALLINE VARIABLE HYDRATE OF (S)-(3-PYRIDINECARBOXAMIDE,6-[4-[2-[[3-(9H-CARBAZOL-4-YLOXY)-2-HYDROXYPROPYL]AMINO]-2-METHYLPROPYL]PHENOXY]- HEMI-SUCCINATE SALT

(57) **Abrégé/Abstract:**

The present invention relates to a crystalline variable hydrate of (S)-(3- pyridinecarboxamide,6-[4-[2-[[3-(9H-carbazol-4-yloxy)-2-hydroxypropyl]amino]-2-methylpropyl]phenoxy])-hemi-succinate, a pharmaceutical formulation containing said salt and to methods for treating obesity and/or Type 2 diabetes using said salt.

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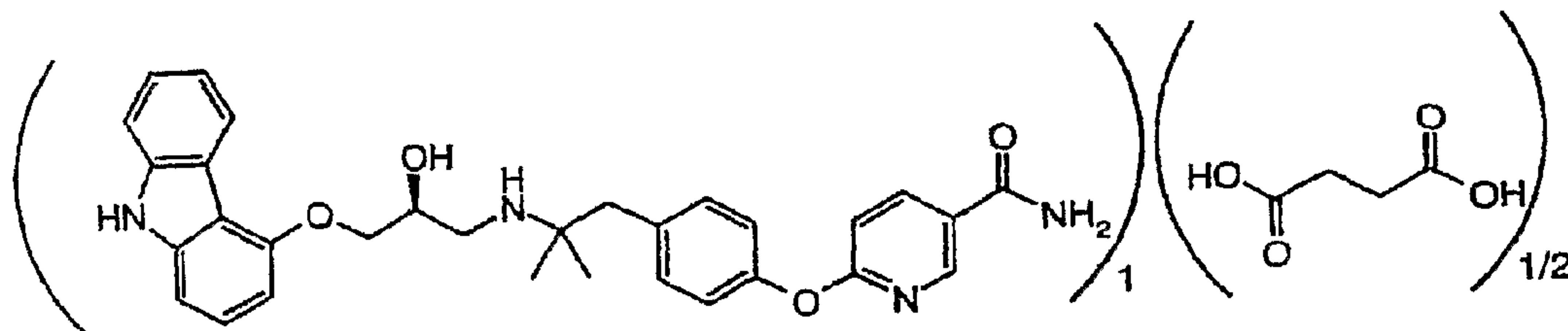
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(57) Abstract: The present invention relates to a crystalline variable hydrate of (S)-(3-pyridinecarboxamide,6-[4-[2-[[3-(9H-carbazol-4-yloxy)-2-hydroxypropyl]amino]-2-methylpropyl]phenoxy])-hemi-succinate, a pharmaceutical formulation containing said salt and to methods for treating obesity and/or Type 2 diabetes using said salt.



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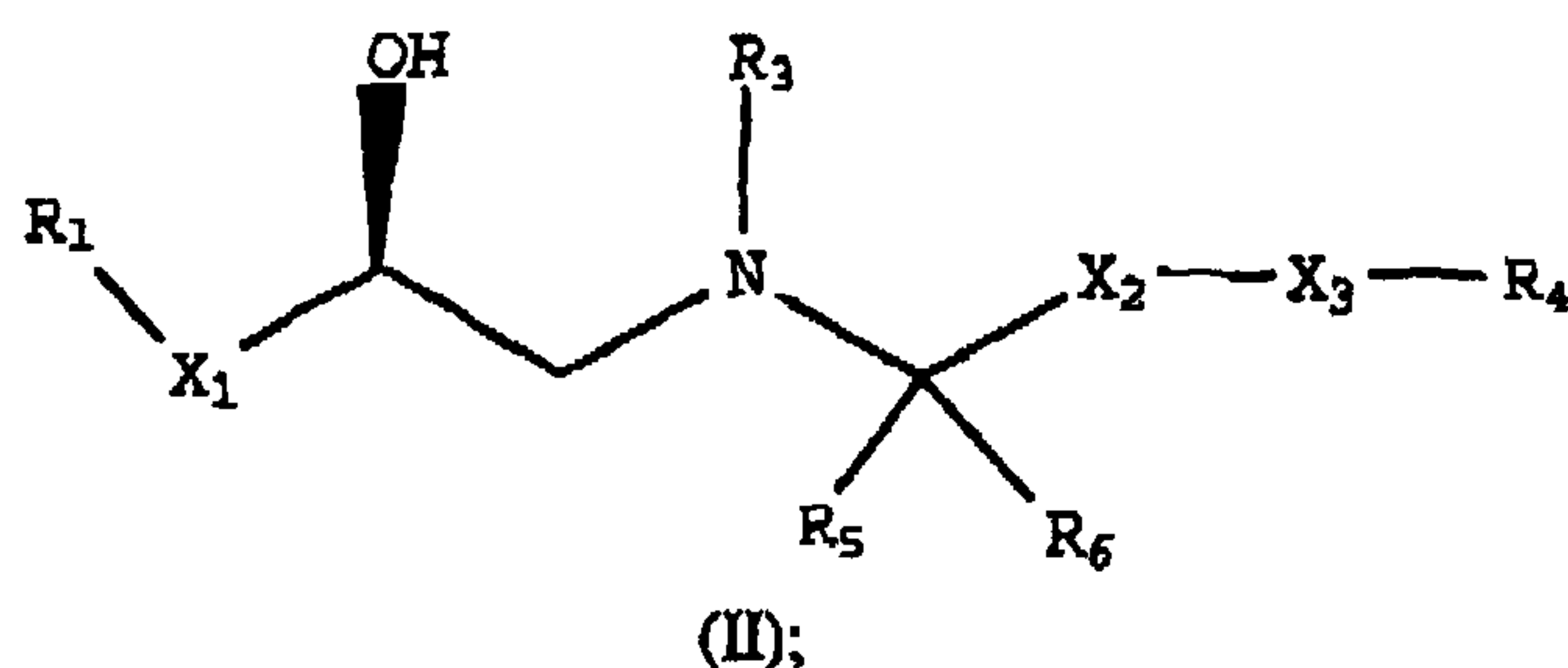
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A Crystalline Variable Hydrate of (S)-(3-Pyridinecarboxamide,6-[4-[2-[[3-(9H-carbazol-4-yloxy)-2-hydroxypropyl]amino]-2-methylpropyl]phenoxy]- Hemi-Succinate Salt

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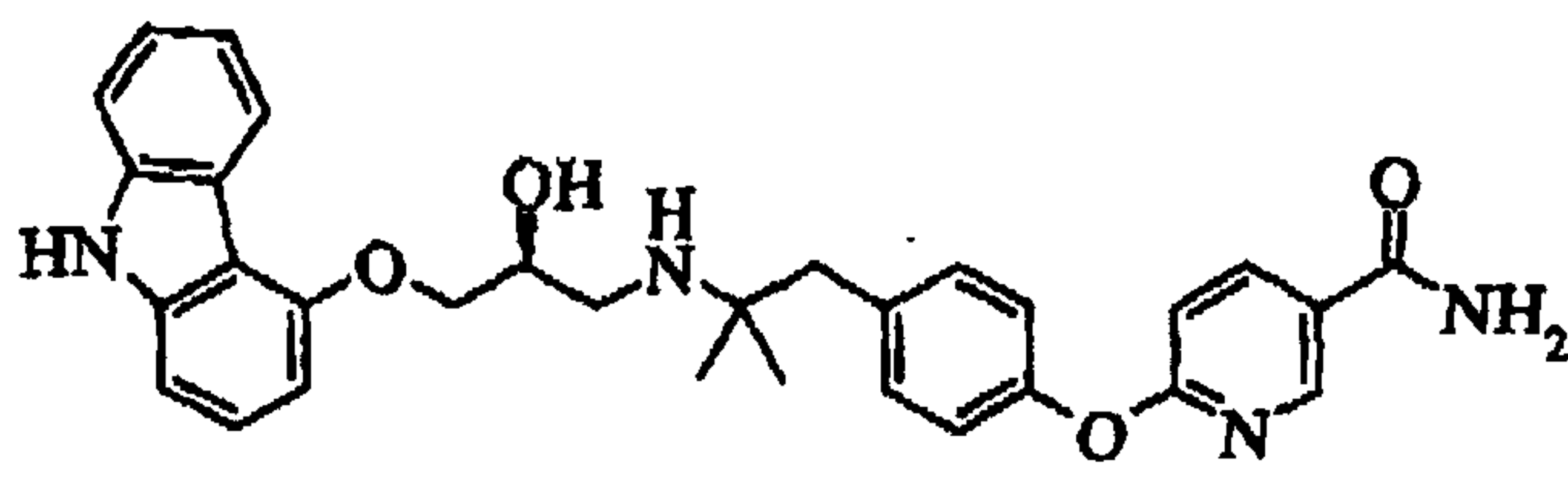
Background of the Invention

Compounds of formula II:



10 and pharmaceutically acceptable salts thereof, useful as selective β_3 receptor agonists, were disclosed by Crowell, et al., in European Patent Publication No. 827,746 (Crowell).

Example 126 from Crowell disclosed the synthesis of a hemi-succinate salt of a formula II compound having the structure:



15 hereafter referred to as "SAM Classic".

Said synthetic procedures described the production of an "amorphous form" of SAM Classic "containing only trace residual ethanol". Crowell described the production of the amorphous SAM Classic by solvent exchange of the ethanol in the crystalline ethanolic solvate of SAM Classic with water. In particular, Crowell taught that "The mixture (from the water slurry) was vacuum filtered, and the filter cake was washed with water (3x100 ml). The solid was air dried under vacuum for approximately 2 hours then in a vacuum oven (65°C) overnight. This gave (amorphous) product as an off white solid." Thus, Crowell discloses that in the process of drying the wet cake material, the crystal structure of the initially isolated material (present as a wet cake) collapsed to form the amorphous SAM Classic.

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Poorly crystalline materials, in particular amorphous materials, are typically less desirable than highly crystalline materials for formulation processing. In addition, it is generally not desirable to formulate pharmaceuticals containing substantial amounts of organic solvent due to potential solvent toxicity to the recipient thereof and changes in potency of the pharmaceutical as a function of the solvent. Although the amorphous SAM Classic prepared by the procedures taught in EP 827 746 could be used as a pharmaceutical, it would be highly desired and advantageous to find a stable crystalline form of SAM Classic that did not contain substantial amounts of organic solvent within its crystal structure which could be reproducibly and efficiently prepared on a commercial scale.

Surprisingly, and in accordance with the invention, it has now been discovered that a crystalline hydrate of SAM Classic is capable of reproducible production, isolation and formulation on a commercial scale, is sufficiently stable for use in oral formulations, and can be produced and isolated in a highly crystalline state.

15

Brief Summary of the Invention

The present invention relates to a crystalline variable hydrate of (S)-(3-pyridinecarboxamide,6-[4-[2-[[3-(9H-carbazol-4-yloxy)-2-hydroxypropyl]amino]-2-methylpropyl]phenoxy]))-hemi-succinate salt wherein the water content of said hydrate by weight is between 6 and 11% when measured at $22 \pm 5^\circ\text{C}$ and between 10-80% relative humidity. This crystalline material is hereafter referred to "SAM Classic Hydrate".

The present invention further relates to SAM Classic Hydrate having an X-ray diffraction pattern which comprises the following peaks: 7.6 ± 0.1 and $8.8 \pm 0.1^\circ$ in 2θ ; when the pattern is obtained at $20-25^\circ\text{C}$ and 25-30% relative humidity (RH) using a copper radiation source ($\text{CuK}\alpha$; $\lambda = 1.54056 \text{ \AA}$).

In another embodiment, the present invention relates to a pharmaceutical composition containing SAM Classic Hydrate and a pharmaceutical carrier. In still another embodiment, the pharmaceutical compositions of the present invention may be adapted for use in treating obesity and/or Type II diabetes.

Moreover, the present invention relates to methods for treating obesity and/or Type II diabetes which comprise administering to a patient in need thereof an effective amount of SAM Classic Hydrate.

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In addition, the present invention is related to SAM Classic Hydrate for treating obesity and/or Type II diabetes. In yet another embodiment, the present invention relates to the use of SAM Classic Hydrate for the manufacture of a medicament for the treatment of obesity and/or Type II diabetes.

5

Brief Description of the Figures

Figure 1 is a representative XRD pattern for SAM Classic Hydrate.

Detailed Description of the Invention

10 For the purposes of the present invention, as claimed herein, the following terms are defined below.

The term "pharmaceutical" when used herein as an adjective means substantially non-deleterious.

15 The term "patient" as used herein refers to humans and non-human animals such as companion animals (dogs, cats, horses and the like). A preferred patient is a human.

The terms "treating" and "treat" as used herein means alleviating, ameliorating, preventing, prohibiting, restraining, slowing, stopping, or reversing the progression or severity of a pathological condition, or sequela thereof, described herein.

20 The term "a patient in need thereof" is a patient suffering from the claimed pathological condition or sequela thereof as determined by medical diagnosis, i.e., as determined by the attending physician.

As used herein, the term "effective amount" means an amount of SAM Classic Hydrate that is capable of treating the conditions described herein.

25 According to Crowell, removal of the water from the wet cake precursor to the amorphous SAM Classic described therein via air drying under vacuum for approximately 2 hours then in a vacuum oven at 65°C overnight caused the crystal structure of this precursor to collapse. Thus, Crowell suggests that the crystal structure of SAM Classic Hydrate is not stable when prepared using the standard laboratory/manufacturing
30 techniques described therein and, therefore, not suitable for development as the active pharmaceutical ingredient (API). As described herein, Applicants have found commercially relevant methods for the preparation and isolation of SAM Classic Hydrate.

Characterization of SAM Classic Hydrate

Various methods, including moisture sorption analysis, Karl Fischer analysis, X-ray powder diffraction (XRD) and ^{13}C solid-state nuclear magnetic resonance (SSNMR),
5 are used to characterize SAM Classic Hydrate.

The moisture sorption profile for SAM Classic Hydrate reveals that it is a non-stoichiometric hydrate. The SAM Classic Hydrate crystal structure retains approximately 6-11% water between 10 and 80% relative humidity. The hydrate rapidly equilibrates with the atmosphere, such that the water content observed by analytical techniques is a
10 function of the relative humidity at which the sample was equilibrated.

The water content of SAM Classic Hydrate may be determined by volumetric Karl Fischer titration employing a suitable Karl Fischer (KF) titration system, *e.g.*, a Metrohm® system. Water content, via KF, is determined via the quantitative reaction of water with iodine and sulfur dioxide while in the presence of alcohol and an organic base
15 such as pyridine. The amount of water is quantitated by end-point determination using an appropriately calibrated titrant. Method Conditions: Standard - Purified water; Titer - Hydranal* Composite 2K Pyridine-Free reagent, or AquaStar*Comp2 Pyridine-Free reagent or equivalent (2 mg/mL); Volumetric Flow Rate - 5 ml/min; Agitator Speed - the maximum speed at which air bubbles are not being created in the titration vessel.
20 Procedure: Transfer an aliquot of sample (200 mg or more) to the titration vessel. Completely dissolve the sample in anhydrous methanol prior to analysis. Perform first titration. Perform a second titration using approximately the same amount of SAM Classic Hydrate employed in the first run. Calculate the average of the two results.

Calculations:

$$25 \quad \% \text{Water} = [(T) \times V_{\text{titer}}] / W_{\text{t sample}} \times 100\%$$

$[T]$ = Titer concentration

V_{titer} = Volume of titer used in the titration

$W_{\text{t Sample}}$ = Weight of sample in mg

30 The X-ray powder diffraction patterns are obtained on a Siemens D5000 X-ray powder diffractometer which is equipped with a $\text{CuK}\alpha$ source ($\lambda = 1.54056 \text{ \AA}$) operated at 50 kV and 40 mA with a Kevex solid state Si(Li) detector. The samples are scanned from

* Trade-mark

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4 to 40° in 2 θ at 3.0 seconds per step size of 0.02 ° with 1 mm divergence and receiving slits and a 0.1 mm detector slit. The dry powder is dusted onto a low background sample holder for analysis at 20-25°C and 25-30% relative humidity (RH).

A representative XRD trace of SAM Classic Hydrate is shown in Figure 1. The XRD pattern features sharp peaks and a flat baseline, indicative of highly crystalline material. The angular peak positions in 2 θ and corresponding I/I₀ data for all peaks with intensities equal to or greater than 10% of the largest peak are tabulated in Table 1. All data in Table 1 is expressed with an accuracy of $\pm 0.1^\circ$ in 2 θ .

Table 1

Angle 2 θ	I/I ₀ (%)	Angle 2 θ	I/I ₀ (%)
7.5	34.9	17.8	19.2
7.6	64.7	18.3	17.3
8.0	14.4	18.9	15.7
8.8	100.0	20.7	18.3
11.0	18.1	21.2	19.9
13.1	34.3	21.5	10.1
13.3	18.9	22.2	20.0
13.8	17.1	23.0	15.7
15.3	19.9	23.8	12.8
15.5	25.9		
17.3	15.1		

It is well known in the crystallography art that, for any given crystal form, the relative intensities of the diffraction peaks may vary due to preferred orientation resulting from factors such as crystal morphology. Where the effects of preferred orientation are present, peak intensities are altered, but the characteristic peak positions of the polymorph are unchanged. See, *e.g.*, The United States Pharmacopeia #23, National Formulary #18, pages 1843-1844, 1995. Furthermore, it is also well known in the crystallography art that, for any given crystal form, the angular peak positions may vary slightly. For example, peak positions can shift due to a variation in the temperature or humidity at which a sample is analyzed or sample displacement. In the present case, a peak position

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variability of $\pm 0.1^\circ$ in 2θ will take into account these potential variations without hindering the unequivocal identification of SAM Classic Hydrate.

Based on peak intensities as well as peak positions, SAM Classic Hydrate may be identified by the presence of peaks at 7.6 ± 0.1 and $8.8 \pm 0.1^\circ$ in 2θ ; when the pattern is obtained at 20-25°C and 25-30% relative humidity (RH) using a copper radiation source (CuK α ; $\lambda = 1.54056 \text{ \AA}$). The presence of the SAM Classic Hydrate may be further verified by peaks at 13.1 ± 0.1 and $15.5 \pm 0.1^\circ$ in 2θ ; when the pattern is obtained as described above and even further verified by the presence of peaks at 8.0 ± 0.1 , 11.0 ± 0.1 , 13.3 ± 0.1 , 13.8 ± 0.1 , and $15.3 \pm 0.1^\circ$ in 2θ ; when the pattern is obtained as described above.

^{13}C SSNMR analysis is performed with a Varian Unity Inova 400 MHz spectrometer operating at a carbon frequency of 100.578 MHz, using high-power proton decoupling, cross polarization (CP) and magic angle spinning (MAS) at 7.0 kHz. Acquisition parameters are as follows: 90° proton r.f. pulse width 4.0 μs , contact time 1.5 ms, pulse repetition time 5 s, spectral width 50 kHz, and acquisition time 50 ms. Chemical shifts, expressed as parts per million, are referenced to the methyl group of hexamethylbenzene ($\delta = 17.3 \text{ ppm}$) by sample replacement. The magic angle is adjusted by optimizing the sidebands of the ^{79}Br signal of KBr as described by Frye and Maciel (Frye J. S. and Maciel G. E., *J. Magn. Reson.*, **1982**, 48, 125).

SAM Classic Hydrate may be identified by the presence of isotropic peaks at: 59.8 ± 0.1 , 111.4 ± 0.1 and $151.4 \pm 0.1 \text{ ppm}$ when the sample has been equilibrated at 33% R.H. prior to data collection. SAM Classic Hydrate is further characterized by solid-state ^{13}C NMR resonances at 99.2 ± 0.1 , 102.4 ± 0.1 , 134.9 ± 0.1 , 146.9 ± 0.1 and $149.2 \pm 0.1 \text{ ppm}$ when the sample has been equilibrated at 33% R.H. prior to data collection.

The amount (weight percentage) of solvent, such as methanol, ethanol or ethyl acetate, present in the crystalline material may be determined by headspace gas chromatography with flame ionization detection. A sample of the crystalline solid (50 mg) is weighed in a headspace vial and dissolved in 2 mL of dimethylsulfoxide. The vial is incubated at 80°C for 5 minutes and then analyzed using a DB624 column (30 meter, 0.53 mm i.d., 3 micron film thickness). The column temperature is held at 40°C for 10 minutes to elute the solvents of interest, then the oven temperature is increased to 240°C to elute the sample solvent peak. The GC utilizes helium as a carrier gas at a flow of approximately 5 ml/minute. The inlet temperature is set to 220°C with a split ratio of 1:5

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and injection volume of 1 mL. The detector temperature is 250°C. The amount of solvent is determined by comparison to solvent standards prepared at known concentrations. A linear least squares calibration curve is constructed using standard concentrations (in mg/mL) and standard peak areas. The solvent peak areas in the sample injections are compared to the calibration curve to determine the concentration of solvent in each of the sample injections. The percentage of solvent is calculated using the following formula:

$$\% \text{solvent} = \frac{(\text{amount solvent found in mg/mL})(2.0\text{mL})}{\text{mg sample}} \times 100$$

The amount (weight percentage) of chemical impurities present in the crystalline material may be determined using reversed-phase HPLC with UV detection. A sample of the crystalline solid (approximately 10 mg) is weighed into a 25-ml volumetric flask and diluted with 70/30 (v/v) mixture of methanol/water. An aliquot of this solution is assayed using a Zorbax SB-Phenyl column (25 cm X 4.6 mm I.D., 5 micron particles). The injection volume is 5 microliters with an autosampler temperature of 5°C. The detector wavelength is 240 nm and the column flow rate is 1.0 ml/minute. The following gradient solvent system is used:

Time (minute)	%A	%B
0	100	0
32	0	100
33	0	100
34	100	0
44	100	0

A: 50% Methanol : 50% Water : 0.1% Trifluoroacetic Acid
 B: 75% Methanol : 25% Water : 0.1% Trifluoroacetic Acid

The area percentage of the impurities is calculated using the following formula

$$\% \text{Total Impurities} = \frac{\text{Sum of the impurity peak areas}}{\text{Total of all peak areas}} \times 100$$

Synthesis

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The crystalline ethanol solvate of SAM Classic (719.35 g) is combined with 5.4 L of deionized water. The resulting slurry is stirred at ambient temperature for approximately 25 hours. The slurry is filtered using nitrogen pressure. The filter cake is rinsed with 2.165 L of water. The filter cake is dried at ambient temperature under a

5 purge of nitrogen that had been bubbled through a saturated solution of potassium acetate in water to maintain a constant humidity. The nitrogen going into the filter has a relative humidity of 22.9% and is at 15 PSI of pressure. The filter cake is dried until the % water is 8.5 to 11% as measured by KF analysis as described herein. After approximately 112 hours, the KF is 8.85% and 666.20 g of SAM Classic Hydrate is obtained.

10

Formulation

The SAM Classic Hydrate of the present invention is preferably formulated in a unit dosage form prior to administration to the recipient patient. SAM Classic Hydrate is preferably formulated employing a dry blend process. Although SAM Classic Hydrate on

15 its own has very poor flow that could have lead to flowability (cohesiveness of the powder) problems during filling (leading to poor control on weight uniformity) and/or homogeneity problems after mixing, the formulations described herein have acceptable mixing and uniformity attributes, even with the high strength.

20

Formulation Examples

Ingredient	Quantity (mg/capsule)
SAM Classic Hydrate	16.7 (15.0 free base)
Partially pregelatinized starch RLC	388.3
Starch flowable powder with 5% silicon	45.0

Ingredient	Quantity (mg/capsule)
SAM Classic Hydrate	55.6 (50.0 mg free base)
Partially pregelatinized starch RLC	349.4
Starch flowable powder with 5% silicon	45.0

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Ingredient	Quantity (mg/capsule)
SAM Classic Hydrate	111.3 (100 mg of free base)
Partially pregelatinized starch RLC	316.2
Starch flowable powder with 5% silicon	47.5

Sieve partially pregelatinized starch through a 10 mesh screen. Add the pregelatinized starch to a tumble bin. Add SAM Classic Hydrate (API) to tumble bin by layering API in between the starch. Mix for 15 minutes at 13 rpm. Pass the resultant mixture through a Comill (screen size: ~610 μ m). Transfer mixture back to tumble bin and mix for 30 minutes at 13 rpm. Sieve the starch flowable powder (5% silicon) through a 10 mesh screen and add to mixture in tumble bin. Mix for 15 minutes at 13 rpm. Fill into size 0 capsules. Refrigerate filled capsules in sealed foil bags at 2-8°C.

10 *Demonstration of Function*

SAM Classic free base was disclosed in WO 98/09625 (Example 87 therein). In the "Functional Agonist B3 assay", this free base material was described as having

15 at least 30% ... of isoproterenol's response at a single dose of 50 μ mol. Dose response titrations on the agonists described reveal EC₅₀ values <10 mM

20 When screened against the B₁ and B₂ receptors in the functional assay, dose titration experiments indicate that greatly reduced or no receptor stimulation is observed with the compounds of the invention.

Utilities

25 The diseases, disorders or conditions for which SAM Classic Hydrate is useful in treating include, but are not limited to, Type 2 diabetes mellitus and obesity. Human patients in need of obesity and/or Type 2 diabetes treatment are typically those with a body mass index (BMI) >30 or those with a BMI $\geq$ 27 when co-morbidities, e.g., hypertension, high cholesterol, heart disease or diabetes are present.

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Dose

The specific dose administered is determined by the particular circumstances surrounding each situation. These circumstances include: the route of administration (preferably oral), the prior medical history of the recipient, the pathological condition or symptom being treated, the severity of the condition/symptom being treated, and the age of the recipient. The recipient patient's physician should determine the therapeutic dose administered in light of the relevant circumstances. Generally, an effective minimum daily dose will be about 1 mg or more. Typically, an effective maximum daily dose will not exceed about 600 mg.

Combination Therapy

SAM Classic free base, or a pharmaceutical salt thereof (preferably the hemi-succinate salt of SAM Classic free base, more preferably SAM Classic Hydrate), may be used in combination with other drugs that are used in the treatment of the diseases or conditions for which the present salts are useful, e.g., treatment of obesity and/or type 2 diabetes. Such other drug(s) may be administered, by a route and in an amount commonly used therefore, contemporaneously or sequentially with the free base of SAM Classic (or salt thereof). When SAM Classic free base, or a salt thereof, is used contemporaneously with one or more other drugs, a pharmaceutical unit dosage form containing such other drugs in addition to SAM Classic free base (or salt thereof) may be preferred. Accordingly, the pharmaceutical compositions of the present invention include those that also contain one or more other active ingredients, in addition to SAM Classic free base (or salt thereof).

A preferred combination therapy for the treatment of obesity is the use of SAM Classic Hydrate in combination with Meridia® (sibutramine or active metabolites of sibutramine, e.g., desmethyl sibutramine and di-desmethyl sibutramine, preferably with sibutramine hydrochloride mono-hydrate) or with Xenical® (orlistat).

WE CLAIM:

1. A crystalline variable hydrate of (S)-(3-pyridinecarboxamide,6-[4-[2-[[3-(9H-carbazol-4-yloxy)-2-hydroxypropyl]amino]-2-methylpropyl]phenoxy]])-hemi-succinate salt wherein the water content of said hydrate by weight is between 6 and 11% when measured at $22 \pm 5^\circ\text{C}$ and between 10-80% relative humidity; ethanol is present at $\leq 1\%$ weight; and having an X-ray diffraction pattern which comprises the following peaks: 7.6 ± 0.1 , 8.0 ± 0.1 , 8.8 ± 0.1 , 11.0 ± 0.1 , 13.1 ± 0.1 , 13.3 ± 0.1 , 13.8 ± 0.1 , 15.3 ± 0.1 and $15.5 \pm 0.1^\circ$ in 2θ ; when the pattern is obtained at $20-25^\circ\text{C}$ and 25-30% relative humidity (RH) using a copper radiation source ($\text{CuK}\alpha$; $\lambda = 1.54056 \text{ \AA}$).
5
2. The hydrate of claim 1 wherein the water content is between 7.5 and 11%.
3. The hydrate of claim 1 having a solid-state ^{13}C nuclear magnetic resonance spectrum which comprises peaks at the following chemical shifts: 59.8 ± 0.1 , 111.4 ± 0.1 and 151.4 ± 0.1 ppm when the hydrate has been equilibrated at 33% R.H. prior to data collection.
15
4. The hydrate of claim 3 having a solid-state ^{13}C nuclear magnetic resonance spectrum which further comprises peaks at the following chemical shifts: 99.2 ± 0.1 , 102.4 ± 0.1 , 134.9 ± 0.1 , 146.9 ± 0.1 and 149.2 ± 0.1 ppm.
20
5. The hydrate of any one of claims 1-4 wherein the amount of chemical impurities present by weight is $< 2\%$.
25
6. A pharmaceutical composition comprising an effective amount of the hydrate of any one of claims 1-5 and a pharmaceutically acceptable carrier, for treatment of obesity or Type 2 diabetes.
7. The pharmaceutical composition of claim 6 that contains between 1 and 600 mg of the hydrate.
30

- 5 8. The use of a hydrate of any one of claims 1-5 or a composition of claim 6 or 7
for the manufacture of a medicament for the treatment of obesity or Type 2
diabetes.
- 10 9. The use of a hydrate of any one of claims 1-5 or a composition of claim 6 or 7
for the manufacture of a medicament for the treatment of obesity.
10. The use of a hydrate of any one of claims 1-5 or a composition of claim 6 or 7
for the treatment of obesity or Type 2 diabetes.
- 15 11. The use of a hydrate of any one of claims 1-5 or a composition of claim 6 or 7
for the treatment of obesity.

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