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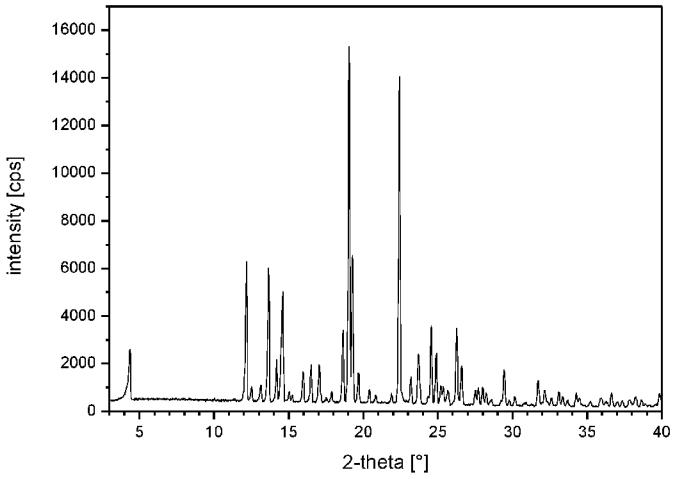
(54) **Title**: (4-((3*R*,4*R*)-3-METHOXYTETRAHYDRO-PYRAN-4-YLAMINO)PIPERIDIN-1-YL)(5-METHYL-6-(((2*R*,6S)-6-(P-TOLYL)TETRAHYDRO-2H-PYRAN-2-YL)METHYLAMINO)PYRIMIDIN-4YL)METHANONE CITRATE

FIGURE 2



(57) **Abstract**: The invention provides a salt of a tetrahydropyranylmethylaminopyrimidine amide, such as the citrate salt of (4-((3*R*,4*R*)-3-methoxytetrahydropyran-4-ylamino)piperidin-l-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone, pharmaceutical compositions containing the same, processes for preparing the same, and methods of medical treatment using the same.

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(4-((3*R*,4*R*)-3-METHOXYTETRAHYDRO-PYRAN-4-YLAMINO)PIPERIDIN-1-YL)(5-METHYL-6-(((2*R*,6*S*)-6-(P-TOLYL)TETRAHYDRO-2H-PYRAN-2-YL)METHYLAMINO)PYRIMIDIN-4-YL)METHANONE CITRATE

CROSS REFERENCE TO RELATED APPLICATIONS

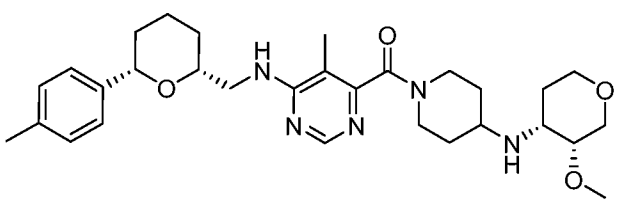
[0001] This application claims the benefit of and priority to European Patent Application serial number 15175066.8, filed July 2, 2015, the contents of which are hereby incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention provides the citrate salt of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone and to a process for manufacturing it. The present invention also provides the same citrate salt for use in the treatment of medical conditions, such as acute and chronic mild to moderate musculoskeletal pain, low back pain, chronic low back pain, pain related to rheumatoid arthritis, shoulder pain, dental pain, signs and symptoms of osteoarthritis, osteoarthritis of the knee, osteoarthritis of the hip, osteoarthritis of the hand, pain associated with osteoarthritis, cancer pain, diabetic polyneuropathy, visceral pain, acute pain, diabetic nephropathy, neuropathic pain, as well as to a pharmaceutical composition comprising the same salt.

BACKGROUND

[0003] WO 2011/073154 discloses a number of tetrahydropyranyl-methyl-amino-(hetero)aryl-amides without disclosing any specific salt or crystal form of the compounds exemplified therein. Among others, WO 2011/073154 discloses compound **I**



I.

[0004] Compounds disclosed in WO 2011/073154 are potent CCR2 antagonists. However, in order to prove to be developable for use as a medicament in a human, a drug substance and its solid form must, in addition to *in vitro* and *in vivo* pharmacokinetic and pharmacological properties and safety profile, fulfil a series of criteria with regard to the requirements of chemistry, manufacturing and controls (CMC) such as solid form characteristics, purity, drying times, filterability, stability, thermal stability, hygroscopicity, reproducibility and further physicochemical properties including solubility and intrinsic dissolution rate.

[0005] One of the biggest challenges in the course of the development of a drug product for medical use in humans is to identify a drug substance which is potent, efficacious, fulfils safety requirements and simultaneously has a solid form suitable for human drug development, i.e., fulfilling all the above mentioned criteria cumulatively. This is because each and every solid form, salt and polymorphic form thereof has physicochemical and pharmacokinetic properties which are just as unforeseeable as unexpected.

[0006] Furthermore, due to the unpredictable and unexpected nature of the solid, salt and polymorphic forms, there is neither generic nor specific guidance for the skilled person how to design a solid form with the desired characteristics. Therefore, extensive and creative research and experimentation is essential to arrive at the specific solid form of a selected drug substance that fulfils all requirements. Optimization of one crucial parameter often results in the deterioration of another or other parameter(s).

SUMMARY

[0007] The objective technical problem underlying the present invention is to provide a drug substance with CCR2 antagonistic activity which is developable for use as a medicament in humans, i.e., where:

a) the drug substance is characterised by high pharmacological potency, efficacy, *in vitro* and *in vivo* pharmacokinetics, and necessary safety properties; and
b) the drug substance and its solid form fulfil a series of criteria with regard to the requirements of chemistry, manufacturing and controls (CMC) such as solid form characteristics, purity, drying times, filterability, stability, thermal stability,

hygroscopicity, reproducibility and further physicochemical properties including solubility and intrinsic dissolution rate.

[0008] Compound **I** has surprisingly been found to fulfil the majority of the above mentioned criteria required for use as a medicament in humans as demonstrated (see biological data below). These parameters include plasma protein binding (relevant for pharmacokinetics and pharmacodynamics), *in vitro* metabolic stability (relevant for pharmacokinetics), pharmacokinetics and safety properties (hERG, relevant for cardiovascular safety, and drug-induced phospholipidosis).

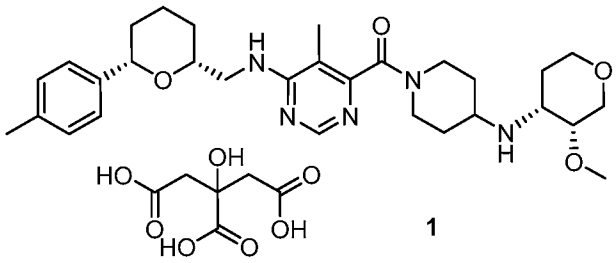
[0009] However, the free base of compound **I** however turned out to be an amorphous material which was in a metastable state and thus subject to metamorphosis. It was not suitable as a drug substance for development because it did not fulfil the requirement of being able to be reproducibly manufactured.

[0010] Attempts to obtain compound **I** in crystalline form from solutions in all commonly used solvents such as ethanol, ethanol / water, 2-propanol, 2-propanol / water, acetone, ethyl acetate, 2-butanone or tetrahydrofuran failed. Such attempts to obtain compound **I** in crystalline form from solutions in all commonly used solvents such as ethanol, ethanol / water, 2-propanol, 2-propanol / water, acetone, ethyl acetate, 2-butanone or tetrahydrofuran yielded only amorphous material. Due to these failures, salt forms of compound **I** with various acids were investigated.

[0011] To ensure reproducibility of the physicochemical properties in the pharmaceutical manufacturing process, the drug substance must invariably be obtained in a well-defined crystalline modification. When a crystalline form of a drug substance or its salt exists in different polymorphic modifications (polymorphism), spontaneous conversion of one polymorphic form into another one may occur. Such a spontaneous interconversion cannot be tolerated and should be avoided by all means. Therefore, it is essential for securing the reproducibility of the pharmaceutical manufacturing process to identify a salt of a drug substance that exists either in one crystalline form only, or that at least is characterized by a reduced tendency towards polymorphism.

[0012] According to the present invention, the technical problem outlined above has been solved by experimentation and innovation that resulted in the identification of the specific compound (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-

(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone citrate salt **1**



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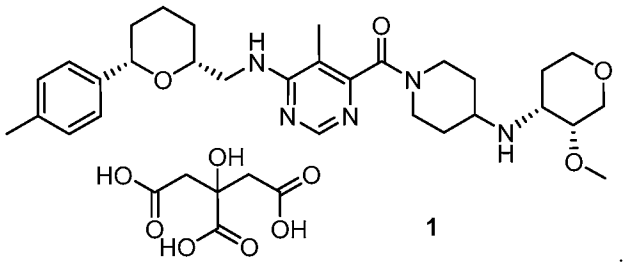
The citrate salt **1** is crystalline, i.e., defined by a specific crystal modification, thus allowing to obtain the drug substance in high purity and reproducibly high stability.

[0013] Various salt forms of compound **I** where prepared and analysed. For instance, crystalline forms of the citrate, hydrobromide, hydrochloride, esilate and methanesulfonate salt of compound **I** were obtained by crystallization. Analysis of these salt forms unexpectedly revealed that the citrate, esilate and methanesulfonate salts of compound **I** exhibited only one polymorphic form. This stands in contrast to the hydrobromide and hydrochloride salts of compound **I**, which were obtained in different polymorphic modifications.

[0014] Another key parameter of a drug substance is hygroscopicity. Water uptake of a salt of a drug substance by sorption during manufacture leads to a reduced amount of the drug substance in the drug product and therefore to reduced efficacy. In addition, water uptake of a salt of a drug substance or a drug product may lead to decomposition of the drug substance. Therefore, it is essential to identify a drug substance or salt thereof that is not hydroscopic, or has only very little hygroscopic character.

[0015] Unexpectedly, the crystalline form of the citrate salt **1** of compound **I** is characterized by low and reversible water uptake at a relative humidity of up to 90% (2.6% water uptake at 80% relative humidity and 3.4% water uptake at 90% relative humidity). On the contrary, the crystalline forms of the corresponding hydrobromide, hydrochloride, esilate and methanesulfonate of compound **I** readily absorb significant amounts of water at a relative humidity of as low as 80% and become irreversibly deliquescent.

[0016] Accordingly, one aspect of the invention provides the compound having the following formula **1**:



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In certain embodiments, the compound is provided in crystalline form.

[0017] Another aspect of the invention provides a pharmaceutical composition comprising (i) a compound described herein such as citrate salt **1** and (ii) one or more carriers and/or diluents. In certain embodiments, the pharmaceutical composition is formulated for oral administration.

[0018] Another aspect of the invention provides the citrate salt **1** or a pharmaceutical composition comprising said citrate salt **1** for use in treating a medical condition. Exemplary medical conditions include, for example, treatment of pain (e.g., inflammatory pain or neuropathic pain) and osteoarthritis.

[0019] Another aspect of the invention provides a method of treating a medical condition in a patient, where the method comprises administering to a patient in need thereof a therapeutically effective amount of a compound described herein, such as citrate salt **1**, in order to treat the medical condition. Exemplary medical conditions include, for example, pain (e.g., inflammatory pain or neuropathic pain) and osteoarthritis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] **Figure 1** shows the X-ray powder diffractogram of the **amorphous** base of the compound (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone.

[0021] **Figure 2** shows the X-ray powder diffractogram of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **citrate**.

[0022] **Figure 3** shows the thermoanalysis and determination of the melting point (DSC/TG) of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **citrate**.

[0023] **Figure 4** shows the sorption isotherms of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **citrate**.

[0024] **Figure 5** shows the X-ray powder diffractogram of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **hydrobromide**.

[0025] **Figure 6** shows the thermoanalysis and determination of the melting point (DSC/TG) of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **hydrobromide**.

[0026] **Figure 7** shows the sorption isotherms of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **hydrobromide**.

[0027] **Figure 8** shows the X-ray powder diffractogram of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **hydrochloride**.

[0028] **Figure 9** shows the thermoanalysis and determination of the melting point (DSC/TG) of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **hydrochloride**.

[0029] **Figure 10** shows the sorption isotherms of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **hydrochloride**.

[0030] **Figure 11** shows the X-ray powder diffractogram of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **esilate**.

[0031] **Figure 12** shows the thermoanalysis and determination of the melting point (DSC/TG) of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **esilate**.

[0032] **Figure 13** shows the sorption isotherms of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **esilate**.

[0033] **Figure 14** shows the X-ray powder diffractogram of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **methanesulfonate**.

[0034] **Figure 15** shows the thermoanalysis and determination of the melting point (DSC/TG) of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **methanesulfonate**.

[0035] **Figure 16** shows the sorption isotherms of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **methanesulfonate**.

[0036] **Figure 17** shows the FT-RAMAN spectrum of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **citrate**.

[0037] **Figure 18** shows the FT-RAMAN spectrum of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone **esilate**.

DETAILED DESCRIPTION

[0038] The invention provides salt forms of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone, pharmaceutical compositions containing such salt forms, methods for preparing salt forms, and therapeutic methods for using such salt forms, such as in the treatment of pain and other medical conditions. As described herein, the citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-

(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone was surprisingly discovered to provide multiple unexpected benefits over other salt forms of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone. For example, the citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone was found to exhibit low and reversible water uptake at a relative humidity up to 90%, which stands in contrast to salt forms of the corresponding hydrobromide, hydrochloride, esilate, and methanesulfonate that readily absorb significant amounts of water at a relative humidity of as low as 80% and become irreversibly deliquescent. Further still, the citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone was unexpectedly found to exhibit only one polymorphic crystalline form, which stands in contrast to the corresponding crystalline salts formed from hydrobromic acid and hydrochloric acid that exhibited different polymorphic modifications. Accordingly, the citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone is surprisingly superior for development as a pharmaceutical due to the multiple unexpected properties that are beneficial.

[0010] Various aspects and embodiments of the invention are further described below in sections. Aspects and embodiments of the invention described in one particular section are not to be limited to any particular section.

[0011] To facilitate an understanding of the present invention, a number of terms and phrases are defined below.

[0012] The terms "subject" and "patient" refer to organisms to be treated by the methods of the present invention. Such organisms include mammals (*e.g.*, murines, simians, equines, bovines, porcines, canines, felines, and the like), and most preferably is humans.

[0013] The term "effective amount" refers to the amount of a compound sufficient to effect beneficial or desired results. An effective amount can be administered in one or more administrations, applications or dosages and is not intended to be limited to a particular formulation or administration route.

[0014] The term "treating" includes any effect, *e.g.*, lessening, reducing, modulating, ameliorating or eliminating, that results in the improvement of the condition, disease, disorder, and the like, or ameliorating a symptom thereof.

[0015] Throughout the description, where compositions are described as having, including, or comprising specific components, or where processes and methods are described as having, including, or comprising specific steps, it is contemplated that, additionally, there are compositions of the present invention that consist essentially of, or consist of, the recited components, and that there are processes and methods according to the present invention that consist essentially of, or consist of, the recited processing steps.

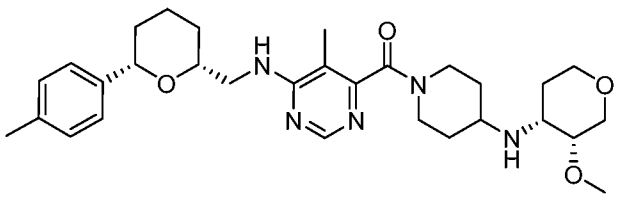
I. Salt Forms of 4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone

[0039] One aspect of the invention provides salt forms of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone. As described below and in the working examples, this disclosure describes salt forms of 4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone prepared by reacting 4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone with an acid selected from citric acid, hydrobromic acid, hydrochloric acid, ethanesulfonic acid, and methanesulfonic acid.

[0040] The citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone was surprisingly discovered to provide multiple unexpected benefits over other salt forms of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone. For example, the citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone was found to exhibit low and reversible water uptake at a relative humidity up to 90%, which stands in contrast to salt forms of the corresponding hydrobromide, hydrochloride,

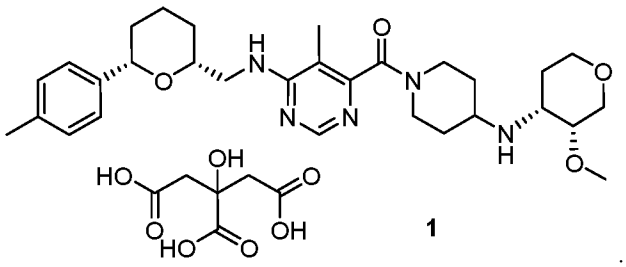
esilate, and methanesulfonate that readily absorb significant amounts of water at a relative humidity of as low as 80% and become irreversibly deliquescent. Further still, the citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone was unexpectedly found to exhibit only one polymorphic crystalline form, which stands in contrast to the corresponding crystalline salts formed from hydrobromic acid and hydrochloric acid that exhibited different polymorphic modifications. Accordingly, the citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone is surprisingly superior for development as a pharmaceutical due to the multiple unexpected properties that are beneficial.

[0041] Accordingly, one aspect of the invention provides the citrate salt of compound **I**:



I

having the formula



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[0042] In certain embodiments, said citrate salt is in crystalline form.

[0043] In certain embodiments, the crystalline form is characterized by showing a X-ray powder diffraction pattern comprising peaks at the following 2-theta values measured using monochromatic CuKα1 radiation of λ = 1.54056 Å, 40kV, 40mA: 19.1° and 22.4°. In certain embodiments, the crystalline form is characterized in that the X-ray powder diffraction pattern further comprises a peak at 12.2°. In certain embodiments, the crystalline form is, characterized in that the X-ray powder diffraction pattern further comprises a peak at 13.7°. In certain embodiments, the crystalline form is characterized in that the X-ray powder diffraction

pattern further comprises a peak at 14.6°. In certain embodiments, the crystalline form is characterized in that the X-ray powder diffraction pattern further comprises a peak at 18.7°. In certain embodiments, the crystalline form is characterized in that the X-ray powder diffraction pattern further comprises a peak at 24.6°. In certain embodiments, the crystalline form is characterized in that X-ray powder diffraction pattern further comprises a peak at 26.3°.

[0044] In certain embodiments, the crystalline form exhibits a X-ray powder diffraction pattern comprising peaks at the following 2-theta values measured using monochromatic CuKα1 radiation of λ = 1.54056 Å, 40kV, 40mA: 12.2 ± 0.2, 13.7 ± 0.2, 14.6 ± 0.2, 19.1 ± 0.2, and 22.4 ± 0.2. In certain other embodiments, the crystalline form exhibits a X-ray powder diffraction pattern comprising peaks at the following 2-theta values measured using monochromatic CuKα1 radiation of λ = 1.54056 Å, 40kV, 40mA: 12.2 ± 0.2, 13.7 ± 0.2, 14.6 ± 0.2, 18.7 ± 0.2, 19.1 ± 0.2, 22.4 ± 0.2, 24.6 ± 0.2, and 26.3 ± 0.2.

[0045] In certain embodiments, the relative intensity of the peak at said diffraction angles 2-theta is at least 10%. In certain other embodiments, the relative intensity of the peak at said diffraction angles 2-theta is at least 15%.

[0046] In certain embodiments, the crystalline form has a X-ray powder diffraction pattern that is substantially as shown in Figure 2.

[0047] In certain embodiments, the crystalline form is characterized by the following X-ray powder diffraction pattern expressed in terms of diffraction angle 2θ, inter-planar distances d, and relative intensity (expressed as a percentage with respect to the most intense peak):

2-theta [°]	**d-value [Å]**	**Intensity I/I_0 [%]**
4.36	20.24	17
12.17	7.27	41
12.51	7.07	6
13.13	6.74	7
13.66	6.48	39
14.20	6.23	14
14.60	6.06	32
15.03	5.89	5
15.25	5.81	4

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
15.97	5.54	11
16.51	5.37	13
17.05	5.20	13
17.54	5.05	4
17.88	4.96	5
18.65	4.75	22
19.05	4.66	100
19.68	4.51	11
20.42	4.35	6
20.84	4.26	4
21.25	4.18	3
21.90	4.06	5
22.42	3.96	92
23.19	3.83	9
23.70	3.75	16
24.34	3.65	4
24.56	3.62	23
24.89	3.57	16
25.20	3.53	7
25.36	3.51	7
25.67	3.47	6
26.26	3.39	23
26.59	3.35	12
27.51	3.24	6
27.71	3.22	6
28.01	3.18	7
28.23	3.16	5
28.57	3.12	3
29.44	3.03	12
30.15	2.96	4

[0048] The crystalline form may be further characterized according to its Raman spectrum. Accordingly, in certain embodiments, the crystalline form has a Raman spectrum comprising peaks at any one or all of the following Raman shifts expressed in wavenumbers in cm^{-1} : 1718, 1242, 731, 662, 553.

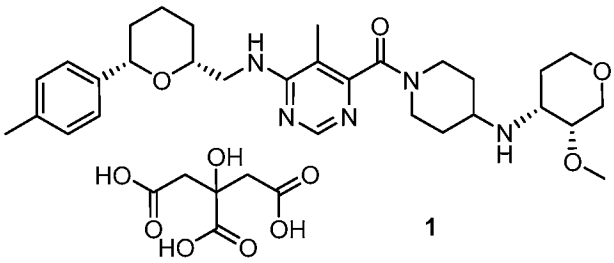
[0049] The crystalline form may be further characterized according to its melting point. Accordingly, in certain embodiments, the crystalline form has a melting point of 212 ± 5°C.

[0050] The crystalline form may be further characterized according to its differential scanning calorimetry curve. Accordingly, in certain embodiments, the crystalline form has a differential scanning calorimetry curve substantially the same as shown in Figure 3.

[0051] Desirably the molar ratio of citric acid to 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone is about 1:1 in a citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone. In certain embodiments, the molar ratio of citric acid to 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone is in the range of 1.2 : 1 to 1 : 1.2 in a citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone. In certain other embodiments, the molar ratio of citric acid to 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone is 1 : 1 in a citrate salt of 4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone.

[0052] The compound (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone (I) is specifically disclosed in WO 2011/073154, as well as a process for its preparation. For details on a process to manufacture this compound, reference is thus made to WO 2011/073154 (example 30, page 150).

[0053] Methods for preparing citrate salt **1** are also provided. For example, one aspect of the invention provides a method for preparing compound **1**



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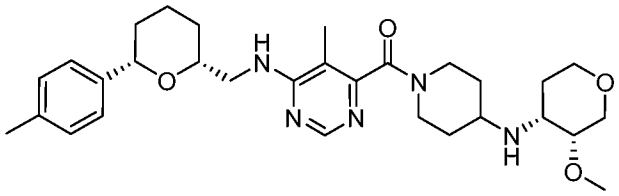
comprising the following steps:

a) addition of citric acid to a solution of compound **I**



in an organic solvent

b) isolation of the resulting salt **1** in pure form.

[0054] In certain embodiments, the method is further characterized in that the organic solvent in step a) is selected from the group consisting of ethyl acetate, isopropanol and a mixture of isopropanol and water.

II. Therapeutic Applications

[0055] Compounds such as those described in Section I (e.g., citrate salt **1**) and pharmaceutical compositions described herein are useful as a medicament. The medicament may be for treating a disorder in which inhibition of CCR2 activity provides a therapeutic benefit.

[0056] The Chemokine receptor CCR2 has been reported to be implicated as being an important mediator of inflammatory and immunoregulatory disorders and diseases as well as autoimmune pathologies such as rheumatoid arthritis and atherosclerosis. See, for example, WO 2010/070032. Thus, agents that modulate the chemokine receptor CCR2 are useful in treating such disorders and diseases.

[0057] More generally, it is widely accepted that numerous conditions and diseases involve inflammatory processes. Such inflammations are critically triggered and / or promoted by the activity of macrophages, which are formed by differentiation out of monocytes. It has further been found that monocytes are characterized by, e.g., a high expression of membrane-resident CCR2, whereas the CCR2 expression in macrophages is lower. CCR2 is a critical regulator of

monocytes trafficking, which can be described as the movement of the monocytes towards an inflammation along a gradient of monocyte chemoattractant proteins (MCP-1, MCP-2, MCP-3, MCP-4).

[0058] Therefore, in order to reduce macrophage-induced inflammation, it would be desirable to block the monocyte CCR2 by an antagonist, so that the monocytes can be less triggered to move towards an inflammation area for conversion into macrophages.

[0059] Accordingly, one aspect of the invention provides a method of treating a CCR2-related condition in a patient, where the method comprises administering to a patient in need thereof a therapeutically effective amount of a compound described herein (e.g., the citrate salt **1** or a crystalline form thereof) to treat the condition. In certain embodiments, the CCR2-related condition is a MCP-1 related condition.

[0060] In certain embodiments, the CCR2-related condition is pain. Exemplary types of pain contemplated for treatment, include, for example, inflammatory pain, neuropathic pain, and visceral pain. In certain embodiments, the pain is chronic pain. In certain embodiments, the pain is pain due to osteoarthritis. Other exemplary types of pain contemplated for treatment include, for example, low back pain, hip pain, leg pain, non-herpetic neuralgia, post herpetic neuralgia, diabetic neuropathy, nerve injury-induced pain, acquired immune deficiency syndrome (AIDS) related neuropathic pain, head trauma, toxin and chemotherapy caused nerve injuries, phantom limb pain, painful traumatic mononeuropathy, painful polyneuropathy, thalamic pain syndrome, post-stroke pain, central nervous system injury, post surgical pain, carpal tunnel syndrome, trigeminal neuralgia, post mastectomy syndrome, postthoracotomy syndrome, stump pain, repetitive motion pain, neuropathic pain associated hyperalgesia and allodynia, alcoholism and other drug-induced pain.

[0061] In certain other embodiments, the CCR2-related condition is an immune related disease. Exemplary immune-related diseases include, for example, rheumatoid arthritis, juvenile rheumatoid arthritis, systemic onset juvenile rheumatoid arthritis, psoriatic arthritis, ankylosing spondilitis, gastric ulcer, seronegative arthropathies, osteoarthritis, inflammatory bowel disease, and ulcerative colitis.

[0062] In certain other embodiments, the CCR2-related condition is a fibrotic condition. Exemplary fibrotic conditions include, for example, liver fibrosis (including but not limited to alcohol-induced cirrhosis, viral-induced cirrhosis, autoirnrnune- induced hepatitis); lung

fibrosis (including but not limited to scleroderma, idiopathic pulmonary fibrosis); kidney fibrosis (including but not limited to scleroderma, diabetic nephritis, glomerular pehpritis, lupus nephritis); dermal fibrosis (including but not limited to scleroderma, hypertrophic and keloid scarring, burns); myelofibrosis; neurofibromatosis; fibroma; intestinal fibrosis; and fibrotic adhesions resulting from surgical procedures.

[0063] In certain other embodiments, the CCR2-related condition is an inflammatory disorder.

[0064] Another aspect of the invention provides a method of treating a condition selected from pain, osteroarthritis, diabetic nephropathy, and diabetic polyneuropathy, where the method comprises administering to a patient in need thereof a therapeutically effective amount of a compound described herein (e.g., the citrate salt **1** or a crystalline form thereof) to treat the condition.

[0065] In certain embodiments, the condition is pain. In certain embodiments, the condition is inflammatory pain. In certain embodiments, the condition is chronic pain. In certain embodiments, the condition is pain due to osteoarthritis. In certain embodiments, the condition is neuropathic pain or visceral pain.

[0066] In certain embodiments, the condition is selected from the group consisting of acute and chronic mild to moderate musculoskeletal pain, low back pain, chronic low back pain, pain related to rheumatoid arthritis, shoulder pain, dental pain, signs and symptoms of osteoarthritis, osteoarthritis of the knee, osteoarthritis of the hip, osteoarthritis of the hand, pain associated with osteoarthritis, cancer pain, diabetic polyneuropathy, visceral pain, acute pain, diabetic nephropathy, and neuropathic pain. In certain embodiments, the condition is pain selected from (a) trigeminal neuralgia and (b) pain due to chemotherapy caused nerve injury.

[0067] In certain embodiments, the condition is osteoarthritis.

[0068] In certain embodiments, the method comprises administering to the patient a therapeutically effective amount of citrate salt **1** to treat the condition.

[0069] In a more specific embodiment, the invention provides for using a compound described herein for the treatment of a disease in which inhibition of the CCR2 receptor is beneficial, such as: (i) acute and chronic mild to moderate musculoskeletal pain (low back pain, chronic low back pain, pain related to rheumatoid arthritis, shoulder pain, dental pain); (ii)

signs and symptoms of osteoarthritis (osteoarthritis of the knee and/or hip, osteoarthritis of the hand, pain associated with osteoarthritis); (iii) cancer pain; (iv) diabetic polyneuropathy; (v) visceral pain, (vi) acute pain, (vii) diabetic nephropathy; and (viii) neuropathic pain.

III. Pharmaceutical Compositions

[0070] Another aspect of the invention provides a pharmaceutical composition comprising a compound described herein (e.g., citrate salt **1**) together with one or more inert carriers and/or diluents. The pharmaceutical compositions may be formulated for administration via a particular route, such as oral administration.

[0071] More generally, suitable forms for administration are, for example, tablets, capsules, solutions, syrups, emulsions or inhalable powders or aerosols. The content of the pharmaceutically effective compound(s) in each case should be in the range from 0.1 to 90 wt.%, preferably 0.5 to 50 wt.% of the total composition, i.e., in amounts which are sufficient to achieve the dosage range specified hereinafter.

[0072] The preparations may be administered orally in the form of a tablet, as a powder, as a powder in a capsule (e.g. a hard gelatine capsule), as a solution or suspension. When administered by inhalation the active substance combination may be given as a powder, as an aqueous or aqueous-ethanolic solution or using a propellant gas formulation.

[0073] Suitable tablets may be obtained, for example, by mixing the active substance(s) with known excipients, for example inert diluents such as calcium carbonate, calcium phosphate or lactose, disintegrants such as corn starch or alginic acid, binders such as starch or gelatine, lubricants such as magnesium stearate or talc and/or agents for delaying release, such as carboxymethyl cellulose, cellulose acetate phthalate, or polyvinyl acetate. The tablets may also comprise several layers. Coated tablets may be prepared accordingly by coating cores produced analogously to the tablets with substances normally used for tablet coatings, for example collidone or shellac, gum arabic, talc, titanium dioxide or sugar. To achieve delayed release or prevent incompatibilities the core may also consist of a number of layers. Similarly the tablet coating may consist of a number of layers to achieve delayed release, possibly using the excipients mentioned above for the tablets.

[0074] Syrups containing the active substances or combinations thereof according to the invention may additionally contain a sweetener such as saccharine, cyclamate, glycerol or sugar and a flavour enhancer, e.g. a flavouring such as vanillin or orange extract. They may also

contain suspension adjuvants or thickeners such as sodium carboxymethyl cellulose, wetting agents such as, for example, condensation products of fatty alcohols with ethylene oxide, or preservatives such as *p*-hydroxybenzoates.

[0075] Capsules containing one or more active substances or combinations of active substances may for example be prepared by mixing the active substances with inert carriers such as lactose or sorbitol and packing them into gelatine capsules.

[0076] Suitable suppositories may be made for example by mixing with carriers provided for this purpose, such as neutral fats or polyethyleneglycol or the derivatives thereof.

[0077] Excipients which may be used include, for example, water, pharmaceutically acceptable organic solvents such as paraffins (e.g. petroleum fractions), vegetable oils (e.g. groundnut or sesame oil), mono- or polyfunctional alcohols (e.g. ethanol or glycerol), carriers such as e.g. natural mineral powders (e.g. kaolins, clays, talc, chalk), synthetic mineral powders (e.g. highly dispersed silicic acid and silicates), sugars (e.g. cane sugar, lactose and glucose), emulsifiers (e.g. lignin, spent sulphite liquors, methylcellulose, starch and polyvinylpyrrolidone) and lubricants (e.g. magnesium stearate, talc, stearic acid and sodium lauryl sulphate).

[0078] For oral administration, the tablets may, of course, contain, apart from the abovementioned carriers, additives such as sodium citrate, calcium carbonate and dicalcium phosphate together with various additives such as starch, preferably potato starch, gelatine and the like. Moreover, lubricants such as magnesium stearate, sodium lauryl sulphate and talc may be used at the same time for the tabletting process. In the case of aqueous suspensions the active substances may be combined with various flavour enhancers or colourings in addition to the excipients mentioned above.

IV. Kits for Use in Medical Applications

[0079] Another aspect of the invention provides a kit for treating a medical condition. The kit comprises: i) instructions for treating a medical condition, such as pain, osteroarthritis, diabetic nephropathy, or diabetic polyneuropathy (for example, pain such as selected from acute and chronic mild to moderate musculoskeletal pain, low back pain, chronic low back pain, pain related to rheumatoid arthritis, shoulder pain, dental pain, pain associated with osteoarthritis, cancer pain, visceral pain, acute pain, diabetic nephropathy, and neuropathic pain); and ii) a compound described herein, such as citrate salt **1**. The kit may comprise one or

more unit dosage forms containing an amount of citrate salt **1** that is effective for treating said medical condition, such as pain.

EXAMPLES

[0080] The invention now being generally described, will be more readily understood by reference to the following examples, which are included merely for purposes of illustration of certain aspects and embodiments of the present invention, and are not intended to limit the invention.

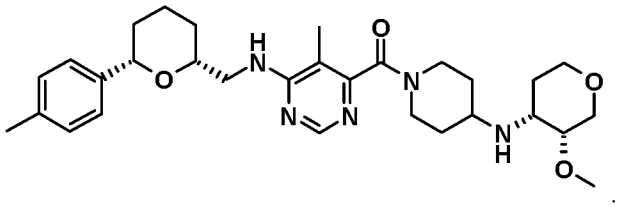
List of abbreviations

AUC	area under the plasma concentration-time curve
BR	hydrobromide (salt with hydrobromic acid)
BS	base (no salt defined)
C_{max}	peak concentration
CI	citrate (salt with citric acid)
CL	clearance
CL	hydrochloride (salt with hydrochloric acid)
ES	esilate (salt with one mol ethanesulfonic acid)
d.b.	(on) dry basis
DSC	Differential Scanning Calorimeter
DMSO	dimethyl sulfoxide
DMSO-d_6	deuterated DMSO
DVS	Dynamic vapour sorption
EDTA	Ethylenediaminetetraacetic acid
EGTA	ethylene glycol tetraacetic acid
ESI	electrospray ionization
f	female
F	oral bioavailability
FCS	fetal calf serum
HEPES	4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid
hERG	human ether-a-go-go-related gene
HR	high-resolution
IV, i.v.	intravenous
m	male

M	mol/L
McIlvaine buffer	citrate/phosphate buffer
MRT_{disp}	mean residence time following intravenous dosing
MRT_{tot}	mean residence time following oral dosing
MS	mass spectrometry
MS	methanesulfonate (salt with one mol methanesulfonic acid)
m/z	mass-to-charge ratio
NMR	nuclear magnetic resonance
PBS	phosphate buffered saline
PK	pharmacokinetics
PO, p.o.	peroral
r.h.	relative humidity
RT	room temperature
Sörensen buffer	NaOH/NaCL/Glycin-buffer
t_{max}	time of maximum plasma concentration
TG	ThermoGravimetry
V_{ss}	steady-state volume of distribution
VLE	very low endotoxin
XRPD	X-ray powder diffraction

EXAMPLE 1 -- Preparation and Physicochemical Characterization of Salts of Compound I

[0081] Multiple salts of compound **I** were prepared and characterized, including the citrate salt of compound **I**. Experimental procedures and results are provided below. Compound **I** has the following formula:



Part I: Description of Analytical Methods Used

[0082] Provided below is a description of analytical methods used to characterize salts of compound **I**.

ESI Mass Spectrometry (ESI+)

Instrument	QTOF 2 (Micromass, Manchester, UK)
Instrument control software	Masslynx 4.1
Ion source	ESI + (Lockspray source)
Lockspray/DXC	on/off
Calibration	0.1 % Phosphoric acid in acetonitrile/water (1:1), lockmass calibration
Resolution MS1(LM/HM)	5/5
Resolving power (FWHM)	16000 at m/z 491 (W mode)
MCP voltage	2200 V
Capillary voltage	+ 2.8 kV
Cone voltage	25 V
Collision energy	5 V
Collision gas	Argon
Source temperature	120 °C
Desolvation temperature	150 °C
Cone gas	nitrogen 75 L/h
Desolvation gas	nitrogen 450 L/h
Spray solvent	acetonitrile/water 9:1
Syringe pump	Harvard Apparatus 55-2222
Spray solvent flow rate	5 µL/min
Sample concentration	5 ng/µL spray solvent
Reagents	acetonitrile (ULC/MS, Biosolve) water (purified by Milli-Q-system)
Scan range	50 - 1000 u (TOF scan, profile data)
Scan time	2.9 s
No. of scans combined	20
Accurate mass determination	Center 5 points/80%, Np=0.35, lockmass: 588.8692
Data threshold	1.0 %

^{1}H NMR Spectroscopy

Instrument	Bruker DRX 400
Frequency	400.13 MHz
Software	TopSpin® version 1.3 PL8
Pulse program	zg30
Solvent	DMSO-d_6
Concentration	10.3 mg / 0.6 mL
Temperature	30 °C
Calibration	TMS (δ = 0.00 ppm)
Sweep width	8013 Hz
Size	64 K data points
Pulse width	30 degree
Relaxation delay	10 s
Number of scans	32
Dummy scans	8
Apodization	zerofilling to 128 K data points Gaussian multiplication (GB: 0.25, LB: -0.25 Hz)

^{13}C NMR Spectroscopy

Instrument	Bruker DRX 400
Frequency	100.61 MHz
Software	TopSpin® version 1.3 PL8
Pulse program	Zgpg
Solvent	DMSO-d_6
Concentration	10.3 mg / 0.6 ml
Temperature	30 °C
Calibration	DMSO-d_6 (δ = 39.5 ppm)
Sweep width	27778 Hz
Size	64 K data points
Pulse width	90 degree
Relaxation delay	4 s
Number of scans	4096

Dummy scans	32
Apodization	zerofilling to 128 K data points Exponential multiplication (LB: 2.5 Hz)

X-ray Powder (XRPD) Diagram

[0083] X-ray powder diagrams were generated using a STOE - STADI P-diffractometer in transmission mode fitted with a MYTHEN-detector and a Cu-anode as X-ray source with monochromatic CuKα1 radiation (λ = 1.54056 Å, 40kV, 40mA).

FT-RAMAN Spectroscopy

[0084] Samples have been measured in boiling point tubes using a Bruker RAM II FT-Raman Module instrument, resolution 2 cm^{-1}, 64 scans, laser power 500 mW (focussed laser). Analysis: scaling of vector in spectral range 3500 cm^{-1} – 50 cm^{-1}.

Differential Scanning Calorimetry – melting point

[0085] The compounds are characterised by a melting point determined by Differential Scanning Calorimetry (DSC), evaluated by the peak maximum or onset temperature. The heating rate of the experiment is 10°C/min. The values given were determined using a DSC instrument from the Q-series™ of TA Instruments.

ThermoGravimetry (TG)

[0086] Thermal gravimetry data were collected with a TG instrument from the Q-series of TA Instruments. This method measures weight changes in a material as a function of temperature under a controlled atmosphere.

Dynamic Vapour Sorption (DVS)

[0087] Sorption isotherms were generated using an IGAsorp water sorption monitor from Hiden Isochema. Adsorption and desorption isotherms were obtained at 25°C with 10 % r.h. step intervals ranging from 10 % r.h. to 90 % r.h.

[0088] For BR salt form only: Sorption isotherms were registered on a DVS-1 water sorption monitor from Surface Measurement Systems.

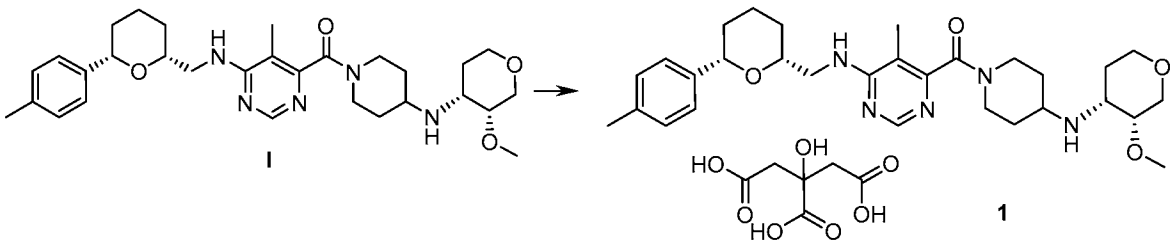
Solubility

[0089] Solubility was determined using an automated shake flask method (at room temperature) and quantitation of the dissolved drug substance was determined by UV-spectroscopy within this automated setup.

Part II: Preparation of (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone citrate (1)

[0090] Exemplary procedures for making the title compound are provided below, along with physical characterization data. The preparation procedures include two different routes for making the title compound.

Preparation Option a) Preparation of citrate salt starting from free base I:



I 1

[0091] To a solution of the free base **I** (200 mg, 0.372 mmol) in ethyl acetate (2 mL) is added citric acid mono hydrate (78.2 mg; 0.372 mmol). The solution is stirred overnight (18 h). The suspension is filtered and the product is dried at 40°C *in vacuo* to yield 140 mg 0.192 mmol (52%) colourless crystals. Physical characterization data for citrate salt **1** is provided below.

[0092] NMR (^{1}H, 400 MHz, DMSO-d_6): 11.7–8.5 (2H, broad), 8.34 (1H, s), 7.22 (2H, m), 7.12 (2H, m), 7.08 (1H, t), 4.49 (1H, m), 4.31 (1H, d), 4.09 (1H, m), 3.85 (1H, m), 3.74 (1H, m), 3.57–3.44 (2H, m), 3.48 (1H, m), 3.47 (1H, m), 3.35 (3H, s), 3.35 (1H, m), 3.33 (1H, m), 3.29 (1H, m), 3.27 (1H, m), 3.04 (1H, m), 2.84 (1H, m), 2.58 (2H, d), 2.50 (2H, d), 2.28 (3H, s), 2.12 (1H, m), 1.94 (1H, m), 1.91 (3H, s), 1.88 (1H, m), 1.78 (1H, m), 1.76 (1H, m), 1.70 (1H, m), 1.66 (1H, m), 1.63 (1H, m), 1.40 (1H, m), 1.40 (1H, m), 1.37 (1H, m), 1.24 (1H, m) (includes rotamers).

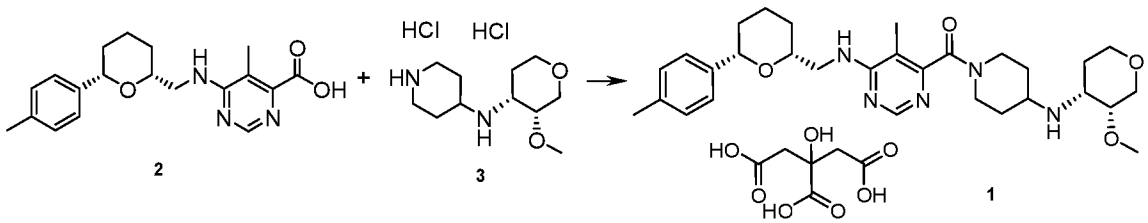
[0093] NMR (^{13}C, 100 MHz, DMSO-d_6): 176.6, 171, 165.4, 161.0, 156.6, 155.4, 140.3, 136.0, 128.5, 125.6, 109.3, 78.5, 75.4, 72.4, 72.2, 71.2, 64.8, 64.4, 64.4, 55.5, 55.5, 51.5, 51.4, 50.2, 45.6, 44.1, 44.1, 38.8, 33.3, 29.6, 28.7, 28.7, 25.1, 23.1, 20.6, 11.7 (includes rotamers).

[0094] HRMS (ESI): m/z 538.3400 ($[M + H]^+$; $C_{30}H_{44}N_5O_4$).

[0095] FT-RAMAN spectrum (characteristic bands) [cm^{-1}]: 1718, 1242, 731, 662, 553.

[0096] See table II below and Figures 2-4 and 17 for additional characterizing data.

Preparation *Option b) Amide coupling followed by preparation of citrate salt*:



[0097] 4.99 kg (30.75 mol) of 1,1'-carbonyldiimidazole are added to a suspension of 10.0 kg (29.29 mol) of **2** in 75 L of 2-methyltetrahydrofuran at 50 °C. The powder funnel is rinsed with 5 L 2-methyltetrahydrofuran. The reaction mixture is stirred for 70 min at 50 °C. Then, 8.83 kg (30.75 mol) of **3** are added to the reaction mixture and the funnel is rinsed with 5 L 2-methyltetrahydrofuran. Next, 7.41 kg (73.23 mol) of triethylamine and 10 L of 2-methyltetrahydrofuran are added and the reaction mixture is stirred for 1 h under reflux. Then, the mixture is cooled to 60 °C and a solution of 6.07 kg (43.94 mol) of potassium carbonate in 55 L water is added and the phases are separated at 55 °C. The organic layer is washed with 60 L water and 80 L of solvent are removed by distillation *in vacuo*. The resulting residue is diluted with 80 L of isopropyl alcohol and 55 L of solvent is removed by distillation *in vacuo*. The resulting residue is diluted with 40 L of isopropyl alcohol and 40 L of solvent is removed by distillation *in vacuo*. Next, 5.85 kg (27.83 mol) of citric acid monohydrate in 11 L of water are added and the dropping funnel is rinsed with 30 L of isopropyl alcohol. The reaction mixture is heated to 75 °C, stirred until a solution is formed, and then filtrated. The filter is rinsed with a mixture of 2 L of water and 20 L of isopropyl alcohol. Then, the filtrate is diluted with 30 L of isopropyl alcohol and seeded with 100 g of **1** as obtained in option a) at 65 °C. Next, the mixture is cooled to 55 °C within 30 minutes and then further stirred for 1 h at 55 °C. The resulting suspension is diluted with 60 L of isopropyl alcohol within 1 h at 55 °C and then cooled to 20 °C within 3 h. Then, the suspension is stirred for 17 h at 20 °C and

isolated by filtration. The filter cake is washed twice with a mixture of 19 L of isopropyl alcohol and 1 L of water, each. The product is dried at 50 °C *in vacuo* to yield 17.76 kg of compound (83 %). Physical characterization data for citrate salt **1** is provided below.

[0098] NMR (^{1}H, 400 MHz, DMSO-d_6): 11.7–8.5 (2H, broad), 8.34 (1H, s), 7.22 (2H, m), 7.12 (2H, m), 7.08 (1H, t), 4.49 (1H, m), 4.31 (1H, d), 4.09 (1H, m), 3.85 (1H, m), 3.74 (1H, m), 3.57–3.44 (2H, m), 3.48 (1H, m), 3.47 (1H, m), 3.35 (3H, s), 3.35 (1H, m), 3.33 (1H, m), 3.29 (1H, m), 3.27 (1H, m), 3.04 (1H, m), 2.84 (1H, m), 2.58 (2H, d), 2.50 (2H, d), 2.28 (3H, s), 2.12 (1H, m), 1.94 (1H, m), 1.91 (3H, s), 1.88 (1H, m), 1.78 (1H, m), 1.76 (1H, m), 1.70 (1H, m), 1.66 (1H, m), 1.63 (1H, m), 1.40 (1H, m), 1.40 (1H, m), 1.37 (1H, m), 1.24 (1H, m) (includes rotamers).

[0099] NMR (^{13}C, 100 MHz, DMSO-d_6): 176.6, 171, 165.4, 161.0, 156.6, 155.4, 140.3, 136.0, 128.5, 125.6, 109.3, 78.5, 75.4, 72.4, 72.2, 71.2, 64.8, 64.4, 64.4, 55.5, 55.5, 51.5, 51.4, 50.2, 45.6, 44.1, 44.1, 38.8, 33.3, 29.6, 28.7, 28.7, 25.1, 23.1, 20.6, 11.7 (includes rotamers).

[00100] HRMS (ESI): m/z 538.3400 ($[M + H]^+$; $C_{30}H_{44}N_5O_4$).

[00101] FT-RAMAN spectrum (characteristic bands) [cm^{-1}]: 1718, 1242, 731, 662, 553.

[00102] See table II below and Figures 2-4 and 17 for additional characterizing data.

Part III: Preparation of Additional Salts of (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone

[00103] Additional salts of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone were prepared and characterized as described below.

Preparation of (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone hydrobromide

[00104] 1.916 mL (0.1 M) of hydrobromic acid is added to a solution of 103 mg (0.1916 mmol) of (4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone in 2 mL of methanol and stirred for 2 h at 50 °C. Then, the solvent is removed in a vacuum dryer at 40 °C. Next, 4 mL of tetrahydrofuran is added to the residue. The mixture is sonicated, then

stirred for 2 h at 40 °C, and afterwards stored for 4 h at room temperature. Then, the solvent is removed in a vacuum dryer to yield the hydrobromide of (4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone.

[00105] See table III below and Figures 5-7 for characterizing data.

Preparation of (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone hydrochloride

[00106] 0.558 mL (0.1 M) of hydrochloric acid is added to a solution of 30 mg (0.0557 mmol) of (4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone in 1 mL of methanol and stirred for 2 h at 50 °C. Then, the solvent is removed in a vacuum dryer at 40 °C. Next, 1.2 mL of tetrahydrofuran is added to the residue. The mixture is sonicated, then stirred for 2 h at 40 °C, and afterwards stored for 4 h at room temperature. Then, the solvent is removed in a vacuum dryer to yield the hydrochloride of (4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone.

[00107] See table IV below and Figures 8-10 for characterizing data.

Preparation of (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone esilate

[00108] 1.860 mL (0.1 M) of ethanesulfonic acid is added to a solution of 100 mg (0.186 mmol) of (4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone in 2 mL of methanol and stirred for 2 h at 50 °C. Then, the solvent is removed in a vacuum dryer at 40 °C. Next, 4 mL of acetone is added to the residue. The mixture is sonicated, then stirred for 2 h at 40 °C, and afterwards stored for 4 h at room temperature. Then, the solvent is removed in a vacuum dryer to yield the esilate of (4-((3R,4R)-3-methoxytetrahydro-pyran-4-

ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone.

[00109] FT-RAMAN spectrum (characteristic bands) [cm^{-1}]: 1637, 1253, 1014, 740, 719, 534, 525, 219.

[00110] See table V below and Figures 11-13 and 18 for characterizing data.

Preparation of (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone methanesulfonate

[00111] 0.558 mL (0.1 M) of methanesulfonic acid is added to a solution of 30 mg (0.0557 mmol) of (4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone in 1 mL methanol and stirred for 2 h at 50 °C. Then, the solvent is removed in a vacuum dryer at 40 °C. Next, 1.2 mL toluene is added to the residue. The mixture is sonicated, then stirred for 2 h at 50 °C, and afterwards stored over night at room temperature. Then, the solvent is removed in a vacuum dryer to yield the methanesulfonate of (4-((3R,4R)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2R,6S)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone.

[00112] See table VI below and Figures 14-16 for characterizing data.

Part IV: Physical Characterization Data for Salts of (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone

[00113] Exemplary physical characterization data for salts of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone is provided below.

Solubility in Aqueous Media

[00114] Table I shows the solubility of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone citrate in different aqueous media at 2, 4 and 6 h.

Table I.

Medium	2 h [mg/ml]	4 h [mg/ml]	6 h [mg/ml]
Water	>1	>1	>1
0.1 N HCl	>1	>1	>1
0.01 N HCl	>1	>1	>1
McIlvaine buffer pH 2.2	>1	>1	>1
McIlvaine buffer pH 3.0	>1	>1	>1
McIlvaine buffer pH 4.0	>1	>1	>1
McIlvaine buffer pH 4.5	Not determined	>1	>1
McIlvaine buffer pH 5.0	>1	>1	>1
McIlvaine buffer pH 6.0	>1	>1	>1
McIlvaine buffer pH 6.8	>1	>1	>1
McIlvaine buffer pH 7.4	>1	>1	>1
KH_2PO_4-buffer pH 7.4	>1	>1	>1
Sörensen pH 10	>1	>1	>1
0.1 N NaOH	>1	>1	>1
EtOH	9.2	9.8	10

[00115] The data in table I demonstrate that (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone citrate is highly soluble in acidic, neutral and basic aqueous media.

Solid State Properties of Citrate Salt 1

[00116] Various solid state properties of citrate salt **1** are described below.

Appearance

[00117] In the solid state, (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone citrate is a white microcrystalline material.

Sorption Behaviour

[00118] Only (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone

citrate shows stability against relative humidity up to 80%. An uptake of 2.6% water is observed. The water uptake is reversible, and after the sorption experiment the compound still remains as solid material. All other salts turned into liquid phase at higher relative humidity (depending on the salt form starting at 60-70% relative humidity).

Crystallinity and Polymorphism

Citrate Salt 1

[00119] **Citrate salt 1** is highly crystalline as can be seen in the X-ray powder diffraction diagram in Figure 2. The X-ray powder reflection and intensities (standardised) are shown in Table II.

Table II.

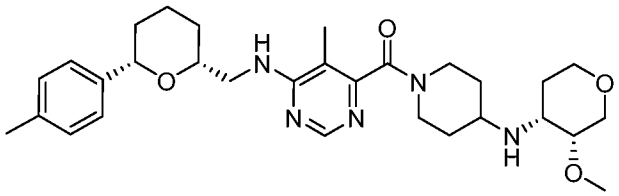
2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
4.36	20.24	17
12.17	7.27	41
12.51	7.07	6
13.13	6.74	7
13.66	6.48	39
14.20	6.23	14
14.60	6.06	32
15.03	5.89	5
15.25	5.81	4
15.97	5.54	11
16.51	5.37	13
17.05	5.20	13
17.54	5.05	4
17.88	4.96	5
18.65	4.75	22
19.05	4.66	100
19.68	4.51	11
20.42	4.35	6
20.84	4.26	4

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
21.25	4.18	3
21.90	4.06	5
22.42	3.96	92
23.19	3.83	9
23.70	3.75	16
24.34	3.65	4
24.56	3.62	23
24.89	3.57	16
25.20	3.53	7
25.36	3.51	7
25.67	3.47	6
26.26	3.39	23
26.59	3.35	12
27.51	3.24	6
27.71	3.22	6
28.01	3.18	7
28.23	3.16	5
28.57	3.12	3
29.44	3.03	12
30.15	2.96	4

[00120] In Table II above, the value "2-theta [°]" denotes the angle of diffraction in degrees and the d-value [Å] denotes the specified distances in Å between the lattice planes.

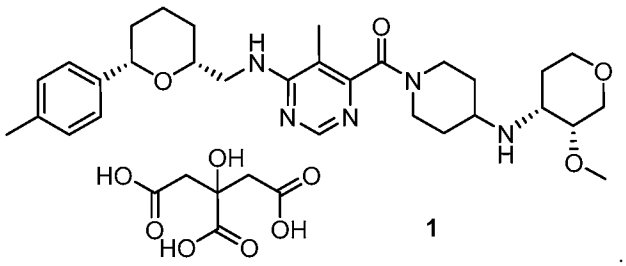
[00121] The crystalline citrate salt of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone is characterised in that the x-ray powder diagram has, inter alia, the characteristic values 2-theta = 19.1° (100% relative intensity), 22.4° (92% relative intensity), 12.2° (41% relative intensity), 13.7° (39% relative intensity), and 14.6° (32% relative intensity) (which are the most prominent peaks in the diagram of Figure 2, Table II).

[00122] Therefore, according to a first aspect, the invention provides a citrate salt of compound **I**



I

having the formula



1

[00123] In a second embodiment, salt **1** is in crystalline form.

[00124] In a third embodiment, according to any one of the preceding embodiments, the crystalline form of compound **1** shows a X-ray powder diffraction pattern comprising peaks at the following 2-theta values measured using monochromatic CuKα1 radiation of λ = 1.54056 Å, 40kV, 40mA: 19.1° and 22.4°.

[00125] In a further embodiment according to any one of the preceding embodiments, the crystalline form shows a X-ray powder diffraction pattern further comprising a peak at 12.2°.

[00126] In a further embodiment according to any one of the preceding embodiments, the crystalline form shows a X-ray powder diffraction pattern further comprising a peak at 13.7°.

[00127] In a further embodiment according to any one of the preceding embodiments, the crystalline form shows a X-ray powder diffraction pattern further comprising a peak at 14.6°.

[00128] In a further embodiment according to any one of the preceding embodiments, the crystalline form shows a X-ray powder diffraction pattern further comprising a peak at 18.7°.

[00129] In a further embodiment according to any one of the preceding embodiments, the crystalline form shows a X-ray powder diffraction pattern further comprising a peak at 24.6°.

[00130] In a further embodiment according to any one of the preceding embodiments, the crystalline form shows a X-ray powder diffraction pattern further comprising a peak at 26.3°.

[00131] In a further embodiment according to any one of the preceding embodiments, the crystalline form shows a Raman spectrum comprising peaks at any one or all of the following Raman shifts expressed in wavenumbers in cm^{-1} : 1718, 1242, 731, 662, 553.

[00132] In a further embodiment according to any one of the preceding embodiments, the crystalline form shows a melting point of 212 ± 5°C.

[00133] The citrate salt **1** may be provided in a pharmaceutical composition. Accordingly, another aspect of the present invention is a pharmaceutical composition containing the salt according to any one of the preceding embodiments optionally together with one or more inert carriers and/or diluents.

[00134] Only one crystalline form has been obtained from several experiments for (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone citrate.

Hydrobromide Salt of Compound of Formula (I)

[00135] The **hydrobromide salt** of compound of formula (I) is of medium crystallinity as demonstrated in the X-ray powder diffraction diagram in Figure 5. The X-ray powder reflection and intensities (standardised) are shown in Table III.

Table III.

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
4.73	18.67	100
7.60	11.62	37
9.48	9.32	15
12.74	6.94	34
14.46	6.12	78
15.25	5.81	62
17.38	5.10	56
18.16	4.88	17
19.36	4.58	62

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
20.39	4.35	83
22.01	4.03	17
22.72	3.91	25
24.05	3.70	37
24.94	3.57	26
25.23	3.53	41
25.65	3.47	27
26.35	3.38	19
27.25	3.27	19
28.00	3.18	15
28.92	3.08	21
29.49	3.02	15
29.59	3.02	16

[00136] In Table III above, the value "2-theta [°]" denotes the angle of diffraction in degrees and the d-value [Å] denotes the specified distances in Å between the lattice planes.

[00137] (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone hydrobromide is characterised in that the x-ray powder diagram has, inter alia, the characteristic values 2-theta = 4.7° (100% relative intensity), 20.4° (83% relative intensity), 14.5° (78% relative intensity), 15.3° (62% relative intensity), and 19.4° (62% relative intensity) (which are the most prominent peaks in the diagram of Figure 5, Table III).

[00138] Different polymorphic modifications of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone hydrobromide have been identified by X-ray powder diffraction.

Hydrochloride Salt of Compound of Formula (I)

[00139] The **hydrochloride salt** of compound of formula (I) is of medium crystallinity as can be seen in the X-ray powder diffraction diagram in Figure 8. The X-ray powder reflection and intensities (standardised) are shown in Table IV.

Table IV.

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
4.05	21.78	24
4.74	18.63	93
7.68	11.50	28
9.49	9.31	19
10.17	8.69	17
12.27	7.21	16
12.85	6.88	29
13.55	6.53	19
14.05	6.30	22
14.55	6.08	64
15.37	5.76	98
16.09	5.51	23
16.58	5.34	19
17.52	5.06	100
18.14	4.89	25
19.12	4.64	23
19.53	4.54	39
20.46	4.34	77
22.16	4.01	23
22.79	3.90	26
23.22	3.83	20
24.13	3.69	44
25.02	3.56	23
25.42	3.50	24
25.87	3.44	18
26.57	3.35	15
27.39	3.25	18
28.06	3.18	16
29.07	3.07	18
29.85	3.00	12

[00140] In Table IV above, the value "2-theta [°]" denotes the angle of diffraction in degrees and the d-value [Å] denotes the specified distances in Å between the lattice planes.

[00141] (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone hydrochloride is characterised in that the x-ray powder diagram has, inter alia, the characteristic values 2-theta = 17.5° (100% relative intensity), 15.4 (98% relative intensity), 4.7° (93% relative intensity), 20.5° (77% relative intensity), and 14.6° (64% relative intensity), (which are the most prominent peaks in the diagram of Figure 8, Table IV).

[00142] Different polymorphic modifications of (4-((3*R*,4*R*)-3-methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone hydrochloride have been identified by X-ray powder diffraction.

Esilate Salt of Compound of Formula (I)

[00143] The **esilate salt** of compound of formula (I) is of high crystallinity as can be seen in the X-ray powder diffraction diagram in Figure 11. The X-ray powder reflection and intensities (standardised) are shown in Table V.

Table V.

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
5.33	16.56	66
7.87	11.23	48
9.14	9.67	7
9.97	8.87	24
10.93	8.09	23
12.23	7.23	9
12.43	7.12	11
13.26	6.67	83
14.55	6.08	48
14.83	5.97	18
15.07	5.88	10

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
15.29	5.79	17
15.77	5.61	51
16.05	5.52	25
16.18	5.47	19
16.46	5.38	12
16.88	5.25	10
17.90	4.95	100
18.32	4.84	34
18.49	4.79	22
19.29	4.60	36
19.44	4.56	40
20.03	4.43	63
20.14	4.41	45
20.85	4.26	66
21.08	4.21	11
21.37	4.15	12
21.92	4.05	18
22.22	4.00	21
22.49	3.95	16
22.71	3.91	7
23.33	3.81	10
23.53	3.78	9
23.79	3.73	8
23.98	3.71	20
24.43	3.64	15
24.68	3.60	14
25.00	3.56	17

[00144] In Table V above, the value "2-theta [°]" denotes the angle of diffraction in degrees and the d-value [Å] denotes the specified distances in Å between the lattice planes.

[00145] (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone esilate is characterised in that the x-ray powder diagram has, inter alia, the characteristic values 2-theta = 17.9° (100% relative intensity), 13.3 (83% relative intensity), 5.3° (66% relative intensity), 20.9° (66% relative intensity), and 20.0° (63% relative intensity) (which are the most prominent peaks in the diagram of Figure 11, Table V).

Methanesulfonate Salt of Compound of Formula (I)

[00146] The **methanesulfonate salt** of compound of formula (I) is of medium crystallinity as can be seen in the X-ray powder diffraction diagram in Figure 14. The X-ray powder reflection and intensities (standardised) are shown in Table VI.

Table VI.

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
5.36	16.48	30
5.57	15.85	27
7.84	11.27	43
9.91	8.92	51
11.05	8.00	21
12.33	7.17	77
13.26	6.67	26
14.69	6.03	100
14.95	5.92	50
15.78	5.61	20
16.47	5.38	23
17.74	4.99	53
18.42	4.81	38
19.09	4.65	33
19.29	4.60	41
19.91	4.46	32
20.67	4.29	55
21.23	4.18	21
22.28	3.99	28

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
23.74	3.74	16
24.33	3.66	23
24.84	3.58	15
25.60	3.48	21
29.79	3.00	16
17.74	16.48	30
18.42	15.85	27
19.09	11.27	43

[00147] In Table VI above, the value "2-theta [°]" denotes the angle of diffraction in degrees and the d-value [Å] denotes the specified distances in Å between the lattice planes.

[00148] (4-((3*R*,4*R*)-3-Methoxytetrahydro-pyran-4-ylamino)piperidin-1-yl)(5-methyl-6-(((2*R*,6*S*)-6-(p-tolyl)tetrahydro-2H-pyran-2-yl)methylamino)pyrimidin-4-yl)methanone methanesulfonate is characterised in that the x-ray powder diagram has, inter alia, the characteristic values 2-theta = 14.7° (100% relative intensity), 12.3 (77% relative intensity), 20.7° (55% relative intensity), 17.7° (53% relative intensity), and 9.9° (51% relative intensity) (which are the most prominent peaks in the diagram of Figure 14, Table VI).

Thermoanalysis

[00149] The thermoanalysis of the crystalline **citrate salt 1** shows a melting point = 212 ± 5 °C (onset, DSC: 10 $K \cdot min^{-1}$ heating rate; DSC/TG diagram is shown in Figure 3). 1.6% weight loss occurs on drying. Consequently, the citrate salt has a low tendency to absorb solvents (in case of water meaning low hygroscopicity).

[00150] The thermoanalysis of the crystalline **hydrobromide salt** of compound **I** shows a melting point = 248 ± 5 °C (onset, DSC: 10 $K \cdot min^{-1}$ heating rate; DSC/TG diagram is shown in Figure 6). A broad endothermic effect occurs between 40 – 110 °C with concomitant weight loss (2.9% weight loss on drying).

[00151] The thermoanalysis of the crystalline **hydrochloride** salt of compound **I** shows a melting point = 233 ± 5 °C (onset, DSC: 10 $K \cdot min^{-1}$ heating rate; DSC/TG diagram is shown in

Figure 9). A broad endothermic effect occurs between 40 – 80 °C. A weak endothermic effect occurs between 130 – 150 °C (2.8% weight loss on drying).

[00152] The thermoanalysis of the crystalline **esilate salt** of compound **I** shows a melting point = 199 ± 5 °C (onset, DSC: 10 $K \cdot min^{-1}$ heating rate; DSC/TG diagram is shown in Figure 12). A weak broad endothermic effect occurs between 40 – 100 °C. 2.4% loss on drying is correlated with the endothermic effect.

[00153] The thermoanalysis of the crystalline **methanesulfonate salt** of compound **I** shows a melting point = 226 ± 5 °C (onset, DSC: 10 $K \cdot min^{-1}$ heating rate; DSC/TG diagram is shown in Figure 15). A weak broad endothermic effect occurs between 30 – 110 °C.

Sorption Isotherms

[00154] The Sorption isotherm of the crystalline **citrate salt 1** shows a water uptake of 2.6% in the humidity range of 10-80% (diagram shown in Figure 4).

[00155] The Sorption isotherm of the crystalline **hydrobromide salt** of compound **I** shows a water uptake of 4.5% in the humidity range of 10-80% (diagram shown in Figure 7).

[00156] The Sorption isotherm of the crystalline **hydrochloride salt** of compound **I** shows a water uptake of 15% in the humidity range of 10-80% (diagram shown in Figure 10).

[00157] The Sorption isotherm of the crystalline **esilate salt** of compound **I** shows a water uptake of 20% in the humidity range of 10-80% (diagram shown in Figure 13).

[00158] The Sorption isotherm of the crystalline **methanesulfonate salt** of compound **I** shows a water uptake of 30% in the humidity range of 10-80% (diagram shown in Figure 16).

Summary of Selected Physical Properties for Salts of Compound I

[00159] Selected properties of the citrate, hydrobromide, hydrochloride, esilate and methanesulfonate salts of compound **I** are shown in Table VII.

Table VII.

Parameter	Salt Form of Compound I				
	Citrate salt	**Hydro-bromide Salt**	**Hydro-chloride Salt**	**Esilate Salt**	**Methane-sulfonate Salt**
crystallinity	high	medium	medium	high	Medium
melting point [°C] (onset)	212 ± 5	248 ± 5	233 ± 5	199 ± 5	226 ± 5
thermal behavior	no additional effect before melting	broad endo-thermic effect 40 - 110 °C	broad endo-thermic effect 40 - 80 °C weak endo-thermic effect 130 - 150 °C	weak broad endothermic effect 40 - 100 °C	weak broad endothermic effect 30 - 110 °C
loss on drying [%]	1.6	2.9	2.8	2.4	
hygroscopic behavior (up to 80% r.h.)	2.6% uptake of water	4.5% uptake of water deliquescent	15% uptake of water deliquescent	20% uptake of water deliquescent	30% uptake of water
hygroscopic behavior (up to 90% r.h.)	3.4 % uptake of water	20% uptake of water deliquescent	40% uptake of water deliquescent	45% uptake of water deliquescent	45% uptake of water
indications for poly-morphism	no	Yes	yes	no	No

EXAMPLE 2 -- Biological Activity Data Characterizing Compound I and Its Citrate Salt 1

[00160] Experiments were performed to evaluate the biological activity of compound **I** and its citrate salt **1**. A description of the experimental procedures and results are provided below.

Part I: Description of Biological Assays

Plasma protein binding

[00161] Dianorm Teflon dialysis cells (micro 0.2) are used. Each cell consists of a donor (i.e., buffer chamber) and an acceptor chamber (i.e., plasma chamber), separated by an ultrathin semipermeable membrane with a 5 kDa molecular weight cutoff. Stock solutions for each test compound are prepared in DMSO at 1 mM and diluted to a final concentration of 1.0 µM. Aliquots of 200 µL dialysis buffer (100 mM potassium phosphate, pH 7.4) are dispensed into the buffer chamber. Aliquots of 200 µL test compound dialysis solution are dispensed into the plasma chambers. Incubation is carried out for 2 hours under rotation at 37°C. Then, the dialysate is transferred into reaction tubes. The tubes for the buffer fraction contain 0.2 mL acetonitril/water (80/20 volume/volume). Aliquots of 25µL of the plasma dialysate are transferred into deep well plates and mixed with 25 µL acetonitril/water (80/20 volume/volume), 25 µL buffer, 25 µL calibration solution and 25 µL Internal Standard solution. Protein precipitation is done by adding 200 µL acetonitrile. Aliquots of 50 µL of the buffer dialysate are transferred into deep well plates and mixed with 25 µL blank plasma, 25 µL Internal Standard solution and 200 µL acetonitril. Percent bound is calculated with the formula: %bound = (plasma concentration - buffer concentration/ plasma concentration) x 100.

***In vitro* metabolic stability**

[00162] Metabolic degradation of the test compound is assayed in a hepatocyte suspension. Hepatocytes are incubated in an appropriate buffer system. Following a (typically) 30 min preincubation in an incubator (37°C, 10% CO_2) 5 µL of test compound solution (1 µM) are added into 395 µL hepatocyte suspension (cell density in the range 0.25-5 Mio cells/mL, typically 1 Mio cells/mL, final DMSO concentration 0.05%). The cells are incubated for six hours (incubator, orbital shaker) and samples (25 µL) are taken at 0, 0.5, 1, 2, 4 and 6 hours. Samples are transferred into acetonitrile and pelleted by centrifugation (5 min). The supernatant is transferred to a new 96-deepwell plate, evaporated under nitrogen and resuspended. Decline of parent compound is analyzed by HPLC-MS/MS. CLint is calculated as follows CL_INTRINSIC = Dose / AUC = (C0/CD) / (AUD + clast/k) x 1000/60. C0: initial concentration in the incubation [µM], CD: cell density of vital cells [10e6cells/mL], AUD: area under the data [µM x h], clast: concentration of last data point [µM], k: slope of the regression line for parent decline [h-1]. The calculated *in vitro* hepatic intrinsic clearance can be scaled up

to the intrinsic *in vivo* hepatic Clearance and used to predict hepatic *in vivo* blood clearance (CL) by the use of a liver model (well stirred model).

- CL_INTRINSIC_INVIVO [ml/min/kg] = (CL_INTRINSIC [µL/min/10e6cells] x hepatocellularity [10e6 cells/g liver] x liver factor [g/kg bodyweight]) / 1000
- CL [ml/min/kg] = CL_INTRINSIC_INVIVO [ml/min/kg] x hepatic blood flow [ml/min/kg] / (CL_INTRINSIC_INVIVO [ml/min/kg] + hepatic blood flow [ml/min/kg])

Pharmacokinetics (animal experiments)

[00163] The pharmacokinetics of the test compound following single intravenous (IV) or oral (PO) doses were examined in

- female BALB/c mice (average weight: 25g)
- male Wistar(Han) rats (average weight: 260g)
- male and female Göttingen Minipigs (average weight: 24kg)
- male beagle dogs (average weight: 15kg)

All non-rodent species were fasted overnight prior to dosing, while mice and rats had food and water available ad libitum. The p.o. dose of the compound was usually administered as suspension in 0.5% Natrosol or as a 0.5% Natrosol / 0.015% Tween 80 suspension. For i.v. dosing purposes, the doses were applied as a solution in 0.9% NaCL, or as a solution containing 9.1 % HP-beta Cyclodextrin in water.

[00164] Blood was collected by venous sampling and soaking of the blood in EDTA coated tubes. Samples were collected for up to 48h after administration of the test compound. Plasma was then separated by centrifugation (5 min by approximately 9000 g at 4°C). For determination of the test compound, plasma was transferred into PCR plates. All samples were stored at approximately -20° C until bioanalytics. The test compound concentrations in plasma were determined by HPLC MS/MS. The lower limit of quantification was between 0.5 nmol/L and 1 nmol/L.

hERG-channel assay

Cells:

[00165] HEK (human embryonic kidney) 293 cells were stably transfected with hERG cDNA. Cells determined for use in patch clamp experiments were cultivated without antibiotic.

Pipettes and Solutions

[00166] Cells were superfused with a bath solution containing (mM): NaCl (137), KCl (4.0), $MgCl_2$ (1.0), $CaCl_2$ (1.8), Glucose (10), HEPES (10), pH 7.4 with NaOH. Patch pipettes were made from borosilicate glass tubing (Hilgenberg, Malsfeld, Germany) using a horizontal puller (DMZ-Universal Puller, Zeitz-Instrumente, Martinsried, Germany) and filled with pipette solution containing (mM): K-aspartate (130), $MgCl_2$ (5.0), EGTA (5.0), K_2ATP (4.0), HEPES (10.0), pH 7.2 with KOH. Resistance of the microelectrodes was in the range between 2 and 5 MΩ.

Stimulation and Recording:

[00167] Membrane currents were recorded using an EPC-10 patch clamp amplifier (HEKA Electronics, Lambrecht, Germany) and PatchMaster software (HEKA). The current signals were Bessel filtered at 2.5 kHz before being digitized at 5 kHz.

[00168] hERG-mediated membrane currents were recorded at typically 28 °C, using the whole-cell configuration of the patch-clamp technique. Transfected HEK293 cells were clamped at a holding potential of -60 mV and hERG-mediated inactivating tail currents were elicited using a pulse pattern with fixed amplitudes (activation/inactivation: 40 mV for 2000 ms; recovery: 120 mV for 2 ms; ramp to 40 mV in 2 ms; inactivating tail current: 40 mV for 50 ms) repeated at 15 s intervals. During each inter-pulse interval 4 pulses scaled down by a factor of 0.2 were recorded for a P/n leak subtraction procedure. R_s compensation was employed up to a level that safely allowed recording devoid of ringing. The remaining uncompensated R_s was recorded as well as actual temperature and holding current.

Compound Preparation and Application:

[00169] The concentrations of the test item were applied sequentially on each of the different cells investigated. A steady state level of baseline current was measured for at least 90 s prior to the application of the first test article concentration.

[00170] The test item was dissolved in DMSO to yield a stock solution of 1000-fold the highest final concentration. This stock was diluted further in DMSO to stock solutions of 1000-fold the remaining final concentrations. Final dilutions in extracellular buffer were prepared freshly from these stocks by a 1:1000 dilution step each before starting the experiments.

Data Analysis:

[00171] Peak current amplitudes were measured 3 ms after the ramp to +40 mV. For baseline and each concentration the peak currents of the three last sweeps before application of the next concentration were averaged. Residual currents (I/I_0) were calculated for each cell as the fraction of actual average peak current and average baseline peak current. Current inhibition was expressed as $(1 - I/I_0) * 100\%$. Current inhibition for all cells is reported as mean ± SD. From mean current inhibition data, the IC_{50} is estimated based on the Hill equation using a least squares procedure.

***In vitro* Phospholipidosis Assay**

1. Cell culture:

[00172] Cell line: U937. Cell density: 0.5 Mio. cells/mL. Amount of medium: 3 mL/well.

2. Materials and devices:

- Falcon Tissue Culture Flask 175 cm^2
- test tubes Sarstedt
- 6-well microplates
- laminar flow
- refrigerated centrifuge
- pipettes
- Flow cytometer: Coulter Epics XL/MCL (Beckman Coulter Inc., Bullerton, California, USA)

3. Medium and additives:

3.1 Preparation of RPMI1640 with 10% FCS and 0.005% Gentamicin:

Media:

-VLE RPMI 1640 medium (1x), store at 2-8°C

Additives:

- fetal bovine serum, store at –20°C

-Gentamicin, Gibco® Invitrogen, conc. 10 mg/mL (= 1% solution)

[00173] Add 56 mL FCS and 2.6 mL Gentamicin to 500 mL RPMI1640. Store the ready-to-use medium at 2 – 8°C.

3.2 Preparation of Formaldehyde working solution (conc. 3.7%):

[00174] Dilute Formaldehyde 37% in 1 x PBS (dilution ratio 1:10) to make a 3.7% working solution, which is stored at 2 – 8°C.

3.3 Buffer

[00175] PBS-Dulbecco (1x) w/o Ca^{2+}, Mg^{2+}. Store at RT.

4. Dyes for cell staining

4.1 live cell staining:

4.1.1 Propidium Iodide (PI; Molecular Probes, Eugene, Oregon, USA)

[00176] PI stock solution: 1 mg/mL PBS (stored at 4°C in the dark).

[00177] PI ready to use solution: stock solution 1:100 diluted with PBS (freshly prepared for each experiment).

4.1.2 Nile Red (NR; Molecular Probes, Eugene, Oregon)

[00178] NR stock solution: 1 mg/mL DMSO (stored at 4°C in the dark).

[00179] NR ready to use solution for live cell staining: NR stock solution 1:100 diluted with PBS (freshly prepared for each experiment).

4.2 fixed cell staining

[00180] Preparation of Nile Red stock solution (conc. 1 mg/mL) : solve 1 mg Nile Red in 1 mL 100% DMSO, store at 2 – 8°C.

[00181] Preparation of Nile Red working solution for fixed cell staining (conc. 1 µg/mL): dilute Nile Red stock solution in 1 x PBS (dilution ratio 1:1000). The working solution must be prepared and used immediately before staining the cells.

5. Cell seeding and treatment:

[00182] Cell seeding and treatment may be performed as follows:

- solve the test compounds in 100% DMSO to the 100 fold final concentration and dilute them according to the experiment planned.
- firstly fill 30 µL of the stock solution in the relevant well of the 6 well plate and re-suspend with

3 mL cell suspension/well containing 0.5 Mio. cells/mL (final concentration DMSO = 1%).

- use one well per compound and concentration
- incubate 48 hours without changing the medium at 37°C, 5% CO_2 and 95% relative humidity

6. Cell harvesting:

[00183] Cell harvesting may be performed as follows:

- transfer the cell suspension in Sarstedt tubes (on ice)
- centrifugation: 4 min at 130 x g, 4°C; discard the supernatant
- re-suspend in 3 mL PBS per tube (ice cold)
- fill 1 mL of the cell suspension in a Sarstedt tube (on ice) for flow cytometric determination (0.5mL for Propidium-iodide and 0.5mL for Nile Red live cell staining)
- centrifugation of the residual: 4 min. at 130 x g, 4°C; discard the supernatant
- add 1 mL 3.7% Formaldehyde solution per tube
- fixation for 30 minutes (cells after fixation at RT)
- centrifugation: 4 min at 130 x g, RT; discard the supernatant
- re-suspend each tube in 1.3 mL Nile Red working solution for fixed cell staining
- incubate dye for 5 min
- centrifugation: 4 min at 130 x g, RT; discard the supernatant
- re-suspend in 3 mL PBS
- centrifugation: 4 min at 130 x g, RT; discard the supernatant
- re-suspend in 0.5 mL PBS (= fraction of Nile Red stained fixed cells), determination of phospholipidosis using a flow cytometric method

7. Cell staining and flow cytometric measurement

[00184] 3 x 0.5 mL suspensions of cells are prepared from each sample for flow cytometry measurement (non-fixed cells for viability determination, non-fixed cells and fixed cells for phospholipidosis analysis).

7.1 PI staining and flow cytometric measurement for viability determination

[00185] Immediately before measurement, 12.5 µL of the PI ready to use solution is added per sample (0.5 mL non-fixed cell suspension), which are kept on ice for another 15 min before measurement.

[00186] Per sample, ten-thousand (10 000) cells are analyzed at high flow rate for the following parameter:

-time to measure 10,000 cells, ungated

-forward scatter (linear) versus sideward scatter (linear), ungated

-yellow fluorescence (λ = 568 – 590 nm; logarithmic) versus cell number (linear), ungated.

[00187] The time to measure 10,000 cells correlates to cell density in the sample.

[00188] Cut-off gates for the fluorescence-dependent differentiation between life and dead cells are defined based on the analysis of cell culture medium plus vehicle exposed Control cells. Cells with a fluorescence lower than the cut-off are defined as viable. Absolute viability of a sample is the relation of viable cells to total cell number and expressed as percentage.

7.2 Nile Red staining and flow cytometric measurement for PL determination

7.2.1 Nile Red live cell staining

[00189] Immediately before measurement, 50 µL of the NR ready to use solution for live cell staining is added per sample (0.5 mL non-fixed cell suspension). Samples are kept on ice for another 5 min. Thereafter, they are washed once with 4 mL PBS (4°C, 250xG for 8 min) and finally resuspended in 400 µL PBS.

7.2.2 Nile Red fixed cell staining

[00190] Description see above (6. Cell harvesting). Both the Nile Red stained non-fixed cells as well as the Nile Red stained fixed cells are measured according the following procedure.

[00191] Per sample, 10,000 cells are analyzed at high flow rate for the following parameter:

- forward scatter (linear) versus sideward scatter (linear), ungated
- green fluorescence (λ = 504 – 541 nm; logarithmic) versus cell number (linear), ungated
- far red fluorescence (λ = 660 – 680 nm; logarithmic) versus cell number (linear), ungated

8. Signal Analysis

[00192] Samples of less than 90% relative viability are excluded from analysis of the phospholipidogenic potential of a test compound. Samples with a viability between 90 to 95% are selected for assessment case by case depending on the consistency of all analyzed parameters and the absolute fluorescence intensity.

[00193] For all samples with a viability relative to Control of >90% (based on PI exclusion), the mean absolute fluorescence intensity following NR staining is calculated for green fluorescence as well as for far red fluorescence.

[00194] For each channel, absolute fluorescence intensity of a specific sample is correlated to the mean absolute fluorescence intensity of all cell culture medium plus vehicle exposed Control cells of the respective experiment. Per channel, relative fluorescence intensity of a sample is the relation of absolute fluorescence intensity of this sample to the mean absolute fluorescence intensity of Controls, which is set at 100, and is expressed as percentage of Control cell fluorescence intensity.

9. Assessment of phopholipidosis

[00195] Assessment of the phospholipidogenic potential of a test compound is done manually based on the signal intensities at both wavelengths for the fixed cells as well as for the non-fixed cells.

Part II: Results of Biological Activity Assays for Compound I (free base) and Its Citrate Salt 1

[00196] Tables below summarize biological data on compound **I** and its citrate salt **1**, as determined in the assays as described above.

***In vitro* plasma protein binding of compound I.**

Species	Mouse	Rat	Dog	Minipig	Human
Fraction bound [%]	95.1	68.9	70.4	60.8	84.7
Fraction unbound [%]	4.9	31.1	29.6	39.2	15.3

***In vitro* metabolic stability of compound I in hepatocyte incubations.**

Species	Mouse	Rat	Dog	Minipig	Human
CL intrinsic, *in vitro* [µL/min/10e6 cells]	16.4	8.77	3.15	2.73	4.11
CL, *in vivo* [mL/min/kg]	49	26	14	6.8	7.9

Intravenous pharmacokinetics of compound I in animals.

Species	**Mouse**	**Rat**	**Dog**	**Minipig**
Animal number / gender	***n = 2f***	***n = 2m***	***n = 3m***	***n = 1m/1f***
Intravenous PK parameters (mean values)				
IV dose (µmol/kg)	10	5	5	5
AUC(0-inf) (nM•h)	1990	1490	5990	4310
CL (mL/min/kg)	86.0	56.1	14.0	20.0
V_{ss} (L/kg)	3.29	5.04	4.94	5.07
MRT_{disp} (h)	0.623	1.49	6.40	4.15

Oral pharmacokinetics of compound I in animals.

Species	**Mouse**	**Rat**	**Dog**	**Minipig**
Animal number / gender	***n = 3m/0f***	***n = 3m/0f***	***n = 3m/0f***	***n = 3m/0f***
Oral PK parameters (mean values)				
Oral Dose (µmol/kg)	20	20	5	not done
C_{max} (nM)	974	580	317	not done
t_{max} (h)	1.00	1.50	0.917	not done
AUC(0-inf) (nM•h)	3160	2270	1500	not done
MRT_{tot} (h)	3.99	5.49	5.77	not done
F (%)	79	38	25	Not calculated

Oral pharmacokinetics of citrate salt 1 in rats.

Species	**Rat**
Animal number / gender	***n = 3m/0f***
Oral PK parameters [c] (mean values)	
Oral Dose (μmol/kg)	20
C_{max} (nM)	454
t_{max} (h)	1.08
AUC(0-inf) (nM•h)	1710
MRT_{tot} (h)	3.3

Inhibition of hERG-mediated potassium current

[00197] Compound **I** inhibited the hERG-mediated potassium current with $IC_{50} > 30$ μM (12% inhibition at 10 μM, 28% inhibition at 30 μM).

***In vitro* Phospholipidosis Assay**

[00198] Compound **I** shows the propensitiy to be phospholipidogenic in the *in vitro* Phospholipidosis assay; the lowest phospholipidogenic concentration of compound **I** in this *in vitro* assay is 200 μM.

INCORPORATION BY REFERENCE

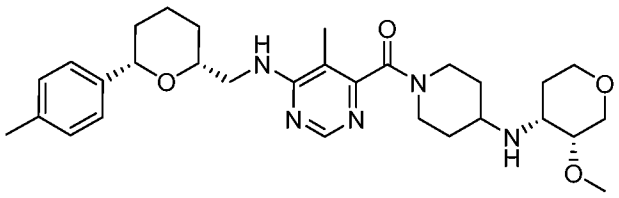
[00199] The entire disclosure of each of the patent documents and scientific articles referred to herein is incorporated by reference for all purposes.

EQUIVALENTS

[00200] The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The foregoing embodiments are therefore to be considered in all respects illustrative rather than limiting the invention described herein. Scope of the invention is thus indicated by the appended claims rather than by the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are intended to be embraced therein.

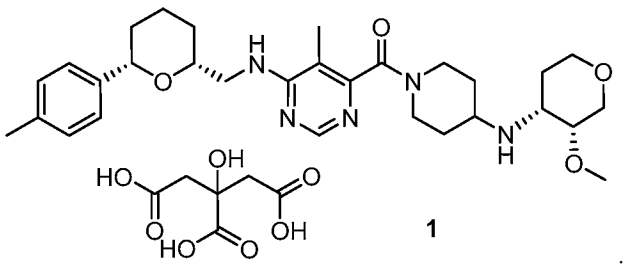
What is claimed is:

1. Citrate salt of compound I:



I

having the formula



1

2. The salt according to claim 1 in crystalline form.

3. The crystalline form according to claim 2 showing a X-ray powder diffraction pattern comprising peaks at the following 2-theta values measured using monochromatic CuKα1 radiation of λ = 1.54056 Å, 40kV, 40mA: 19.1° and 22.4°.

4. The crystalline form according to claim 3, characterized in that the X-ray powder diffraction pattern further comprises a peak at 12.2°.

5. The crystalline form according to any of claims 3 or 4, characterized in that the X-ray powder diffraction pattern further comprises a peak at 13.7°.

6. The crystalline form according to any of claims 3 to 5, characterized in that the X-ray powder diffraction pattern further comprises a peak at 14.6°.

7. The crystalline form according to any of claims 3 to 6, characterized in that the X-ray powder diffraction pattern further comprises a peak at 18.7°.

8. The crystalline form according to any of claims 3 to 7, characterized in that the X-ray powder diffraction pattern further comprises a peak at 24.6°.

9. The crystalline form according to any of claims 3 to 8, characterized in that X-ray powder diffraction pattern further comprises a peak at 26.3°.

10. The crystalline form according to claim 2, exhibiting a X-ray powder diffraction pattern comprising peaks at the following 2-theta values measured using monochromatic CuKα1

radiation of λ = 1.54056 Å, 40kV, 40mA: 12.2 ± 0.2, 13.7 ± 0.2, 14.6 ± 0.2, 19.1 ± 0.2, and 22.4 ± 0.2.

11. The crystalline form according to claim 2, exhibiting a X-ray powder diffraction pattern comprising peaks at the following 2-theta values measured using monochromatic CuKα1 radiation of λ = 1.54056 Å, 40kV, 40mA: 12.2 ± 0.2, 13.7 ± 0.2, 14.6 ± 0.2, 18.7 ± 0.2, 19.1 ± 0.2, 22.4 ± 0.2, 24.6 ± 0.2, and 26.3 ± 0.2.

12. The crystalline form according to any one of claims 3-11, wherein the relative intensity of the peak at said diffraction angles 2-theta is at least 10%.

13. The crystalline form according to any one of claims 3-11, wherein the relative intensity of the peak at said diffraction angles 2-theta is at least 15%.

14. The crystalline form according to claim 2, wherein the X-ray powder diffraction pattern is substantially as shown in Figure 2.

15. The crystalline form according to claim 2, characterized by the following X-ray powder diffraction pattern expressed in terms of diffraction angle 2θ, inter-planar distances d, and relative intensity (expressed as a percentage with respect to the most intense peak):

2-theta [°]	**d-value [Å]**	**Intensity I/I_0 [%]**
4.36	20.24	17
12.17	7.27	41
12.51	7.07	6
13.13	6.74	7
13.66	6.48	39
14.20	6.23	14
14.60	6.06	32
15.03	5.89	5
15.25	5.81	4
15.97	5.54	11
16.51	5.37	13
17.05	5.20	13
17.54	5.05	4
17.88	4.96	5

2-theta [°]	d-value [Å]	Intensity I/I_0 [%]
18.65	4.75	22
19.05	4.66	100
19.68	4.51	11
20.42	4.35	6
20.84	4.26	4
21.25	4.18	3
21.90	4.06	5
22.42	3.96	92
23.19	3.83	9
23.70	3.75	16
24.34	3.65	4
24.56	3.62	23
24.89	3.57	16
25.20	3.53	7
25.36	3.51	7
25.67	3.47	6
26.26	3.39	23
26.59	3.35	12
27.51	3.24	6
27.71	3.22	6
28.01	3.18	7
28.23	3.16	5
28.57	3.12	3
29.44	3.03	12
30.15	2.96	4

.

16. The crystalline form according to any one claims 2-15, wherein the form has a Raman spectrum comprising peaks at any one or all of the following Raman shifts expressed in wavenumbers in cm^{-1} : 1718, 1242, 731, 662, 553.

17. The crystalline form according to any one of claims 2-16, wherein the form has a melting point of 212 ± 5°C.

18. The crystalline form according to any one of claims 2-16, wherein the form has a differential scanning calorimetry curve substantially the same as shown in Figure 3.

19. A pharmaceutical composition comprising a salt according to claim 1 together with one or more inert carriers and/or diluents.

20. A pharmaceutical composition comprising a crystalline form according to any one of claims 2-9 together with one or more inert carriers and/or diluents.

21. A pharmaceutical composition comprising a crystalline form according to claim 10 together with one or more inert carriers and/or diluents.

22. A pharmaceutical composition comprising a crystalline form according to any one of claims 11-18 together with one or more inert carriers and/or diluents.

23. The salt according to claim 2 or a crystalline form according to any one of the claims 2-18 for use as a medicament.

24. A method of treating a condition selected from pain, osteroarthritis, diabetic nephropathy, and diabetic polyneuropathy, comprising administering to a patient in need thereof a therapeutically effective amount of a salt of claim 1 or a crystalline form of any one of claims 2-18 to treat the condition.

25. The method of claim 24, wherein the condition is pain.

26. The method of claim 25, wherein the condition is inflammatory pain.

27. The method of claim 24, wherein the condition is chronic pain.

28. The method of claim 24, wherein the condition is pain due to osteoarthritis.

29. The method of claim 24, wherein the condition is neuropathic pain or visceral pain.

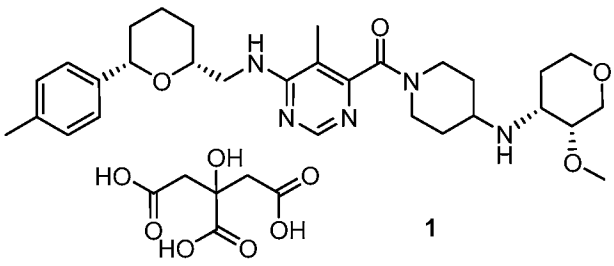
30. The method of claim 24, wherein the condition is selected from the group consisting of acute and chronic mild to moderate musculoskeletal pain, low back pain, chronic low back pain, pain related to rheumatoid arthritis, shoulder pain, dental pain, signs and symptoms of osteoarthritis, osteoarthritis of the knee, osteoarthritis of the hip, osteoarthritis of the hand, pain associated with osteoarthritis, cancer pain, diabetic polyneuropathy, visceral pain, acute pain, diabetic nephropathy, and neuropathic pain.

31. The method of claim 24, wherein the condition is pain selected from (a) trigeminal neuralgia and (b) pain due to chemotherapy caused nerve injury.

32. The method of claim 24, wherein the condition is osteoarthritis.

33. The method of any one of claims 24-32, wherein the method comprises administering to the patient a therapeutically effective amount of a salt of claim 1 to treat the condition.

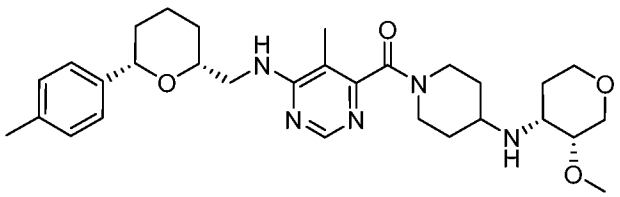
34. A method for preparing compound **1**



1

comprising the following steps:

c) addition of citric acid to a solution of compound **I**



in an organic solvent

d) isolation of the resulting salt **1** in pure form.

35. The method according to claim 34 characterized in that the organic solvent in step a) is selected from the group consisting of ethyl acetate, isopropanol and a mixture of isopropanol and water.

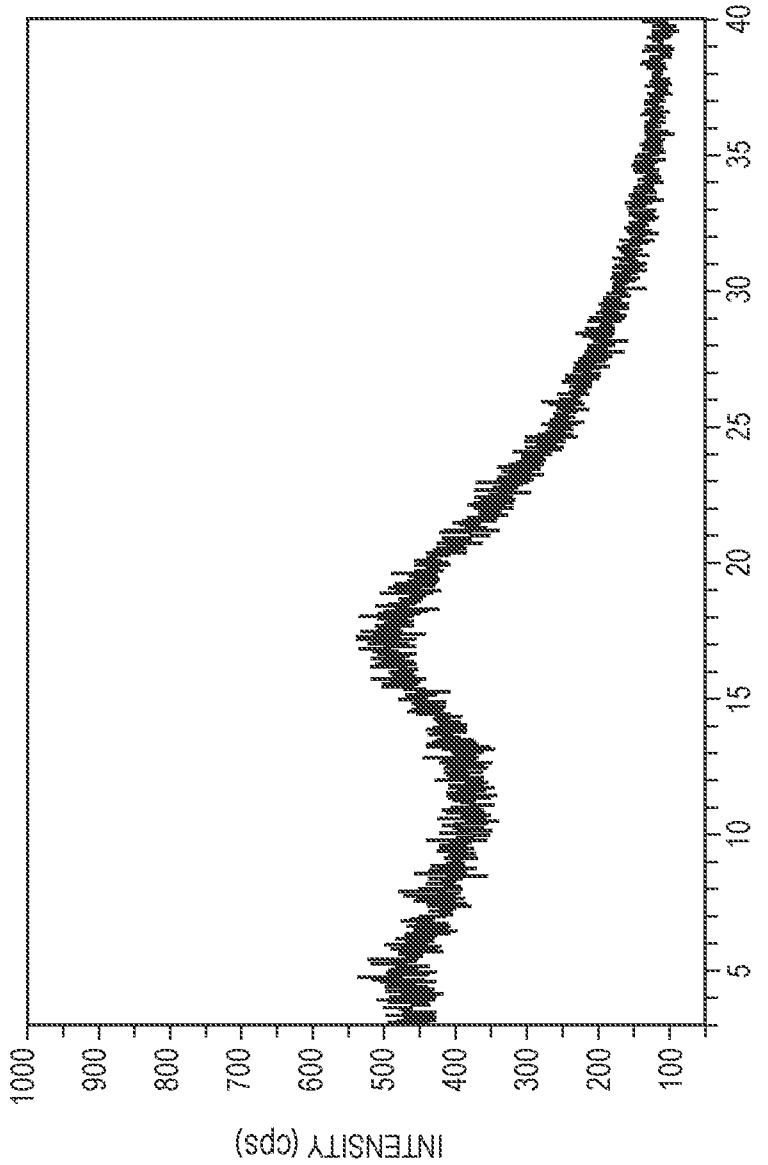
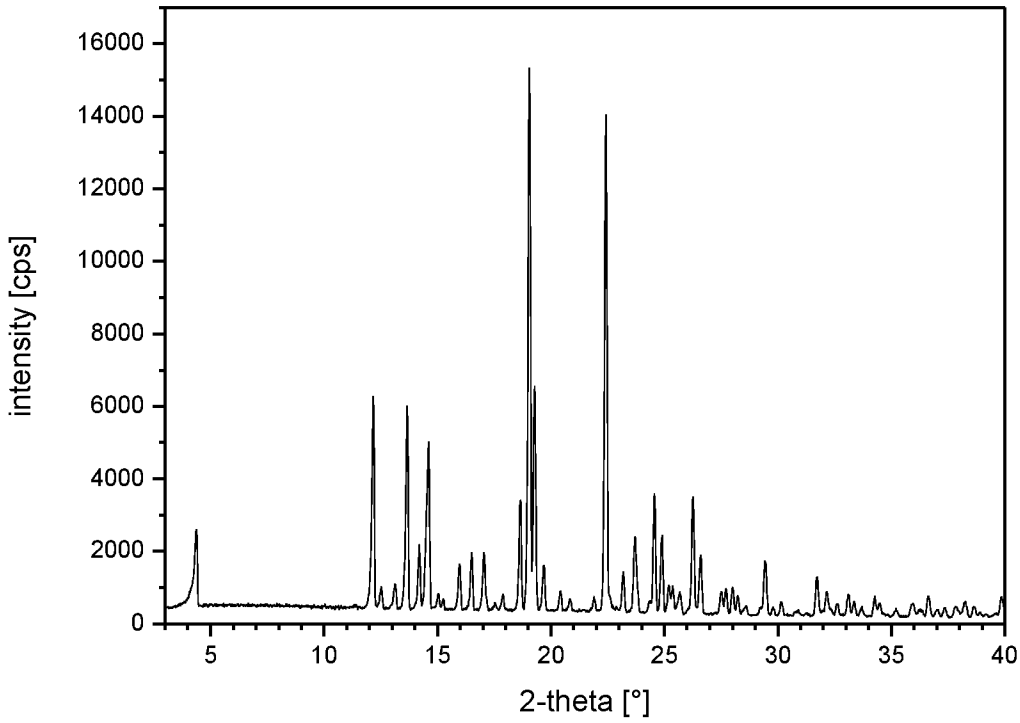

INTENSITY (cps)
1000
900
800
700
600
500
400
300
200
100
5
10
15
20
25
30
35
40
2-theta (°)

FIG. 1

FIGURE 2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14000
12000
10000
8000
6000
4000
2000
0
5
10
15
20
25
30
35
40
2-theta [°]

FIGURE 3

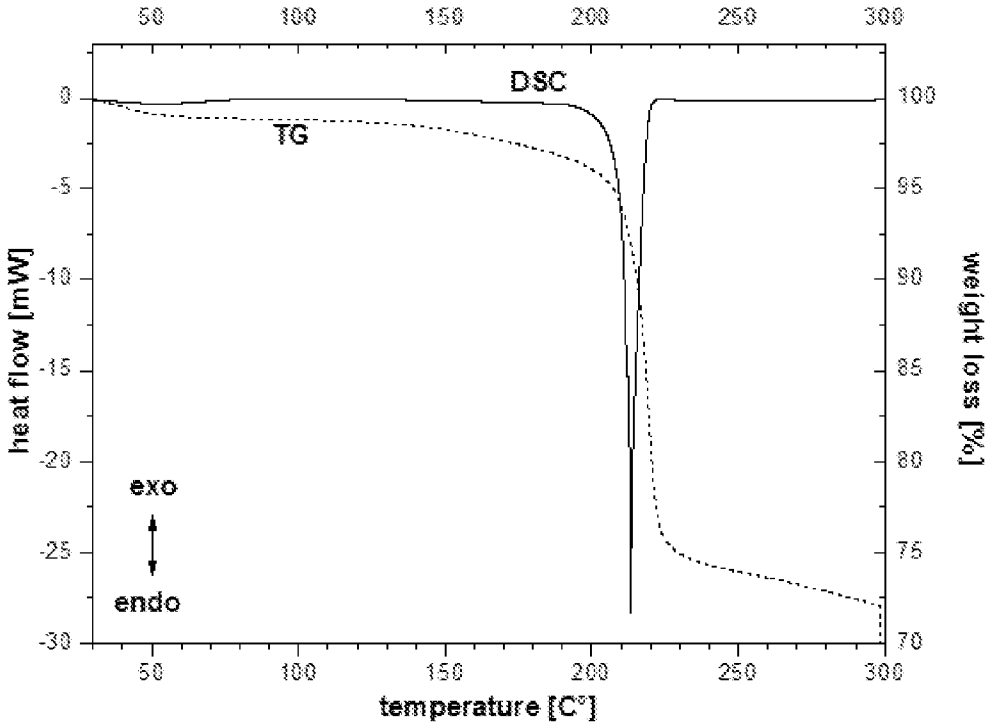

DSC
TG
exo
endo
heat flow [mW]
weight loss [%]
temperature [C°]
50
100
150
200
250
300
0
-5
-10
-15
-20
-25
-30
100
95
90
85
80
75
70

FIGURE 4

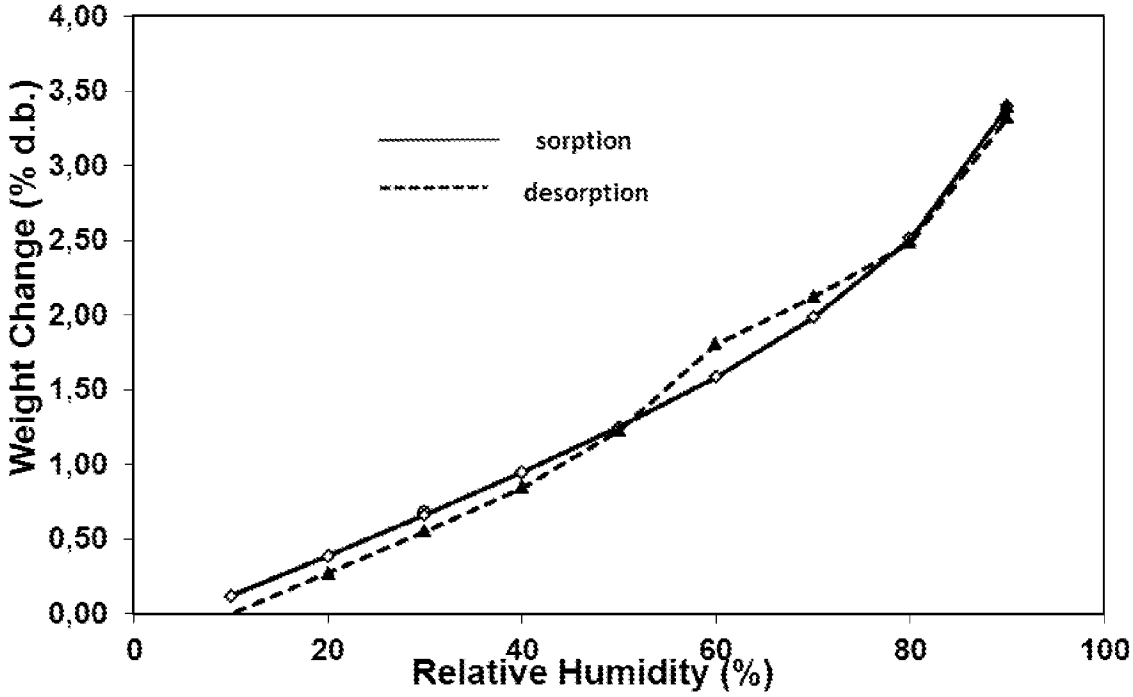

4,00
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
Weight Change (% d.b.)
sorption
desorption
0
20
40
60
80
100
Relative Humidity (%)

FIGURE 5

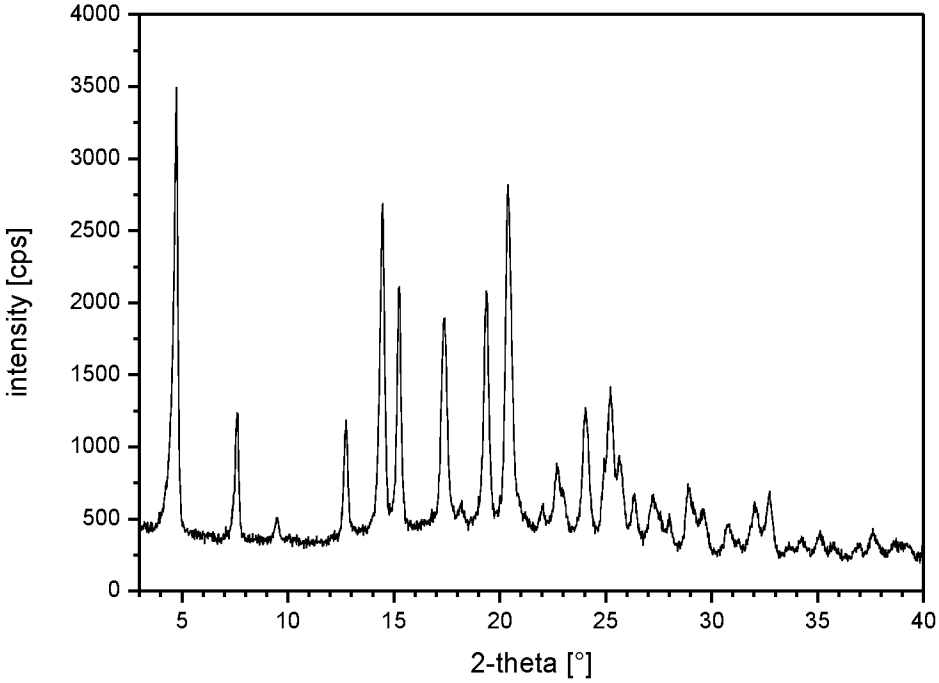

4000
3500
3000
2500
2000
1500
1000
500
0
intensity [cps]
5
10
15
20
25
30
35
40
2-theta [°]

FIGURE 6

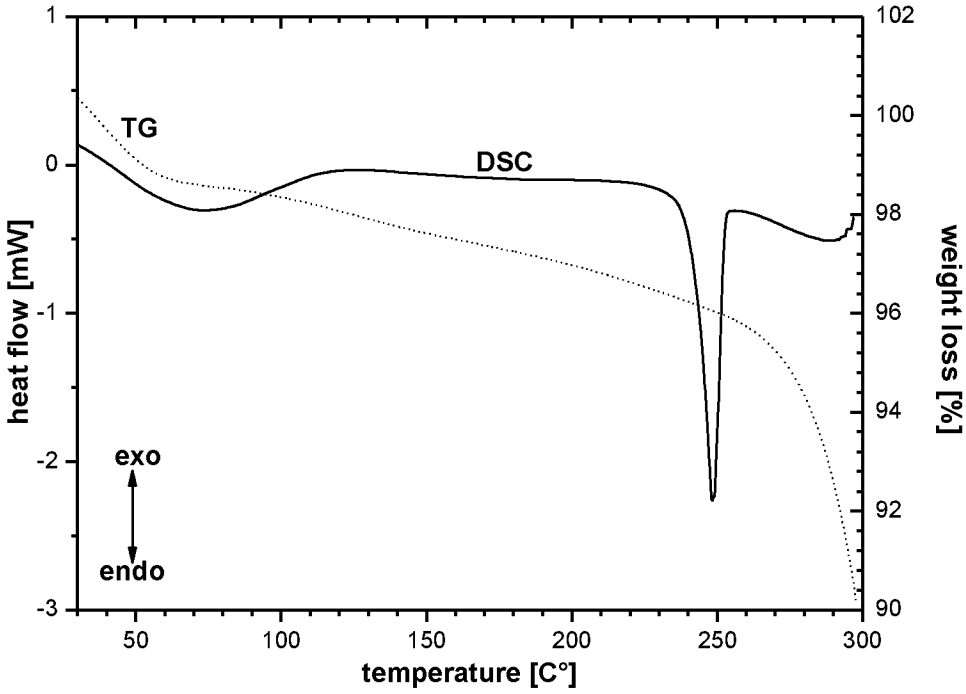

TG
DSC
exo
endo
heat flow [mW]
weight loss [%]
temperature [C°]
1
0
-1
-2
-3
102
100
98
96
94
92
90
50
100
150
200
250
300

FIGURE 7

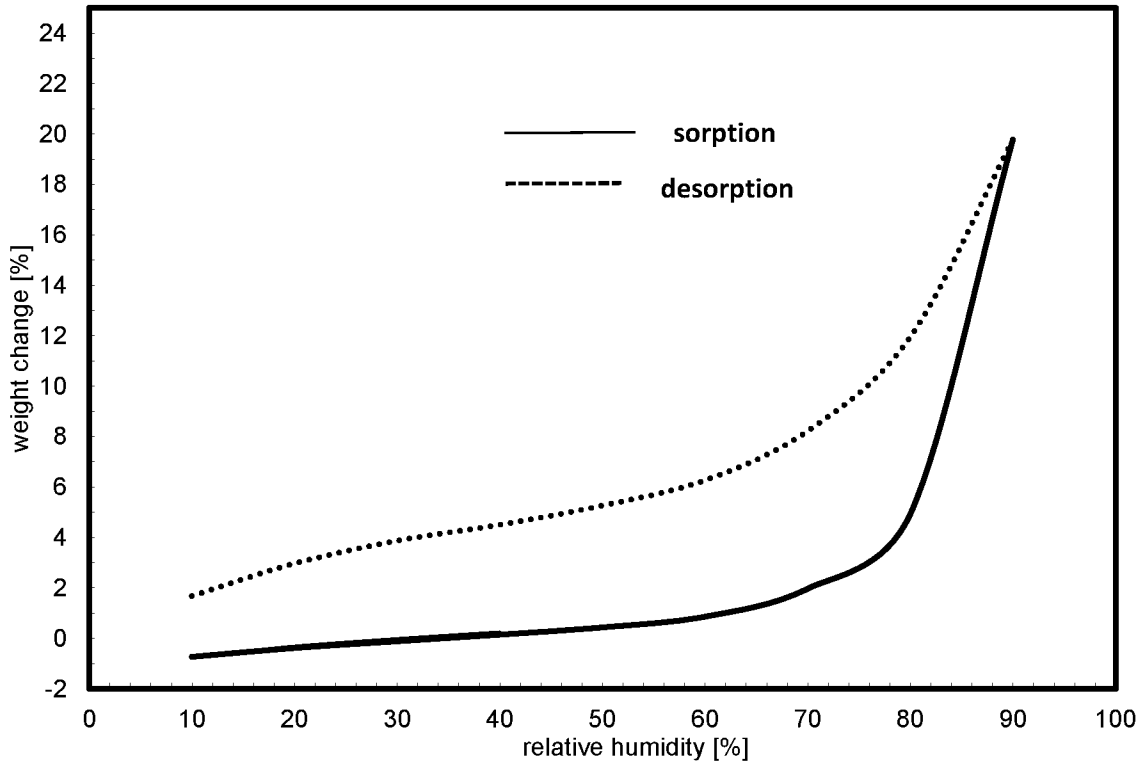

sorption
desorption
weight change [%]
relative humidity [%]
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
0
10
20
30
40
50
60
70
80
90
100

FIGURE 8

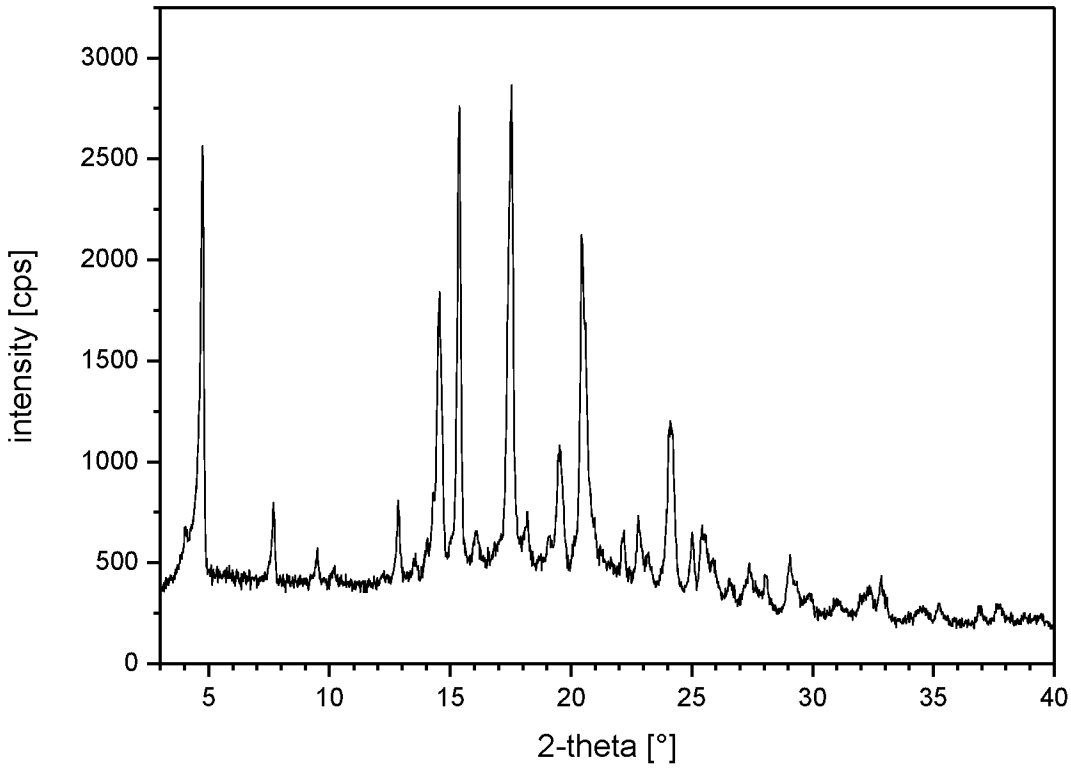

intensity [cps]
3000
2500
2000
1500
1000
500
0
5
10
15
20
25
30
35
40
2-theta [°]

FIGURE 9

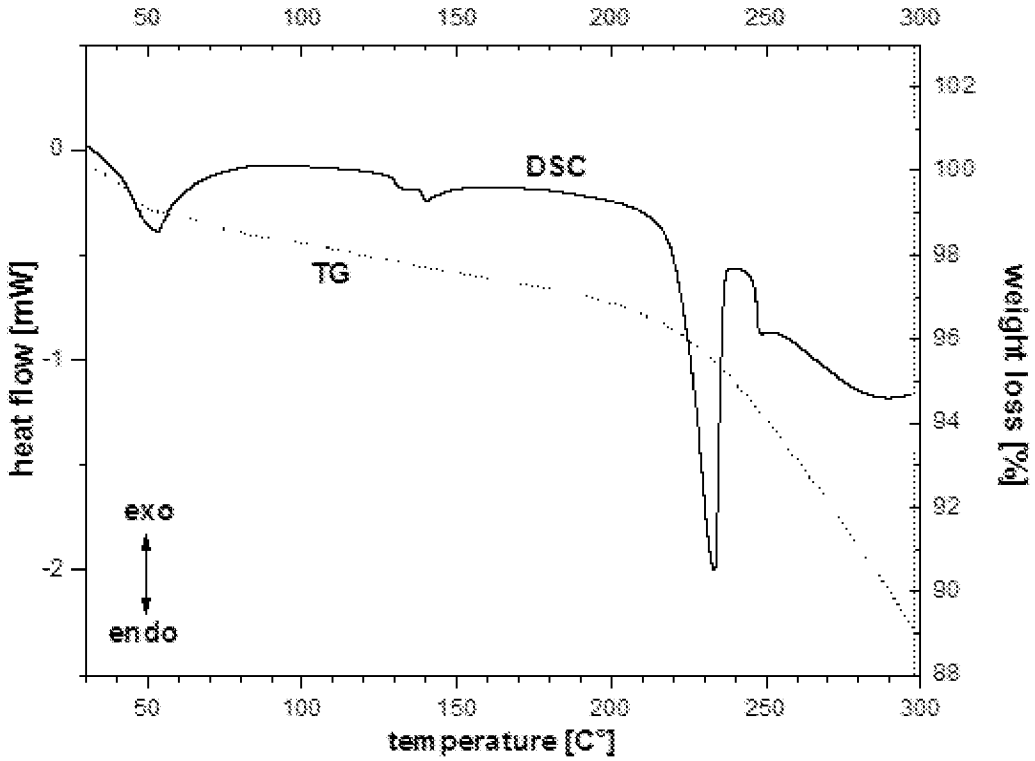

50
100
150
200
250
300
102
100
98
96
94
92
90
88
0
-1
-2
DSC
TG
heat flow [mW]
weight loss [%]
exo
endo
temperature [C°]

FIGURE 10

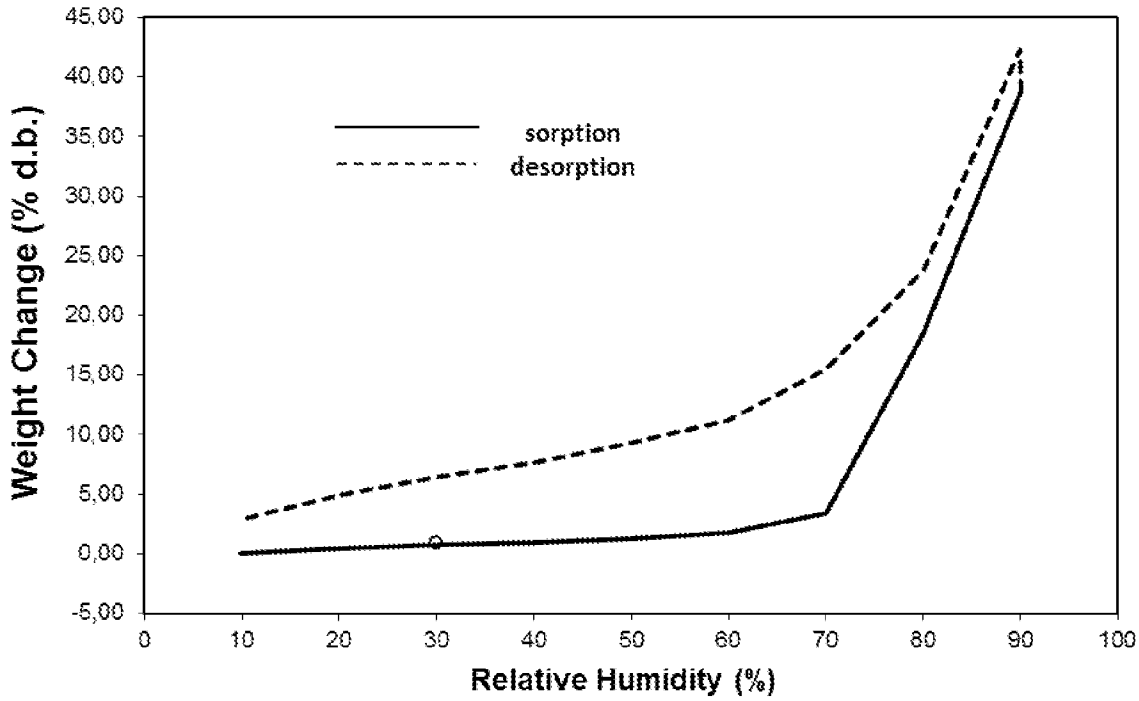

45,00
40,00
35,00
30,00
25,00
20,00
15,00
10,00
5,00
0,00
-5,00
Weight Change (% d.b.)
sorption
desorption
0
10
20
30
40
50
60
70
80
90
100
Relative Humidity (%)

FIGURE 11

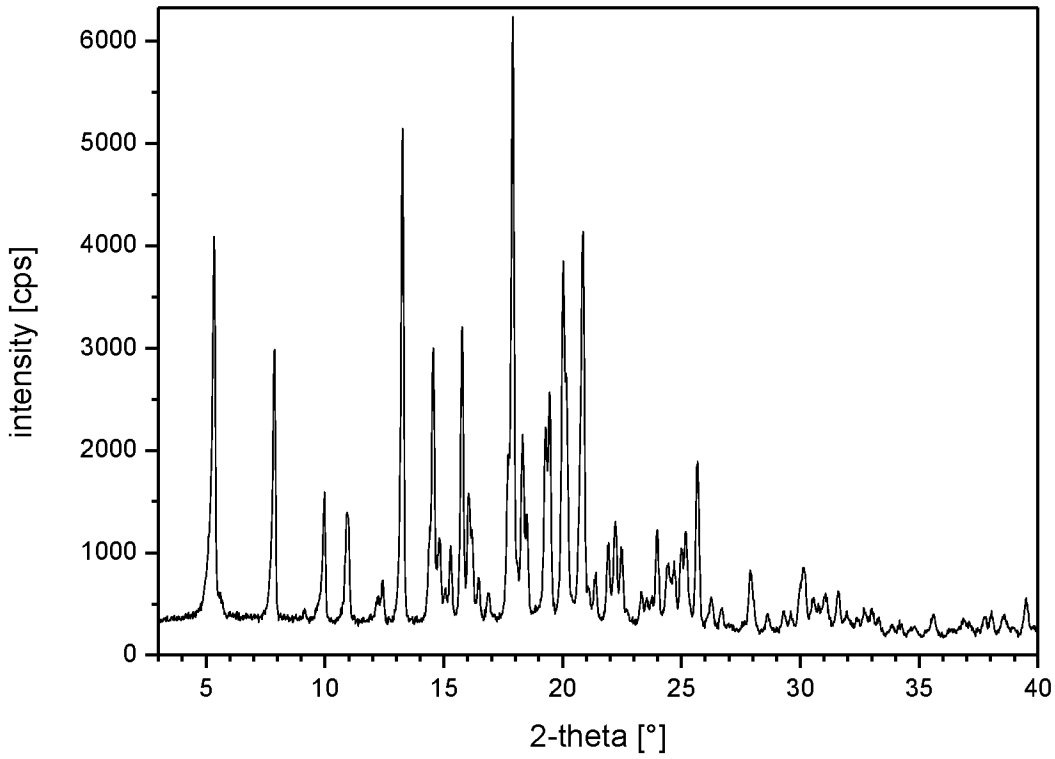

intensity [cps]
6000
5000
4000
3000
2000
1000
0
5
10
15
20
25
30
35
40
2-theta [°]

FIGURE 12

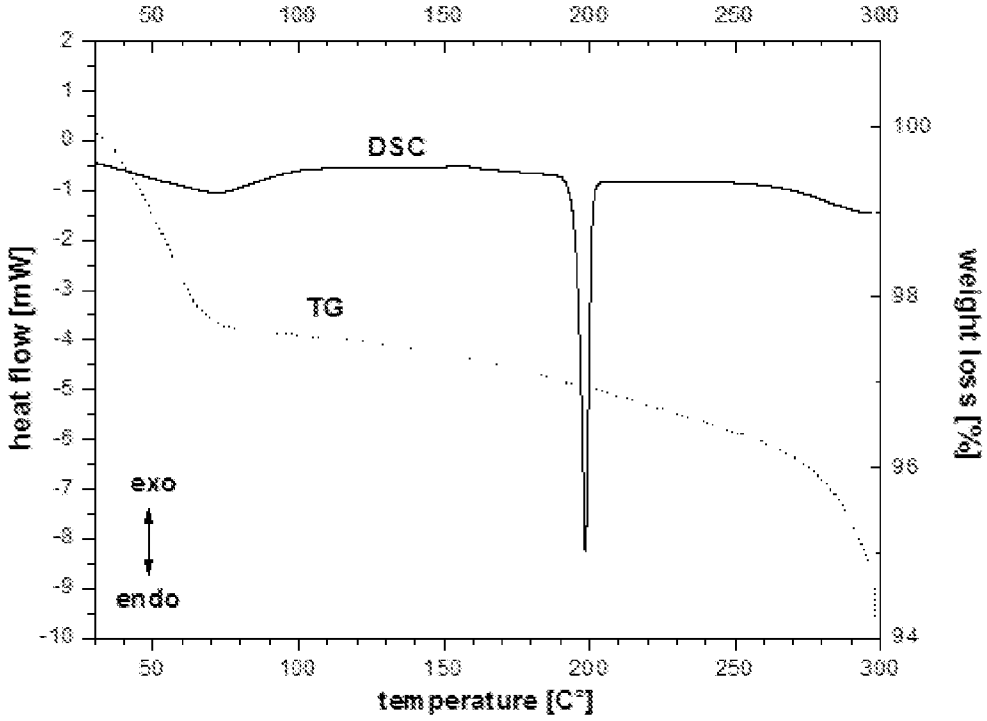

DSC
TG
exo
endo
heat flow [mW]
weight loss [%]
temperature [C°]
50
100
150
200
250
300
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
100
98
96
94

FIGURE 13

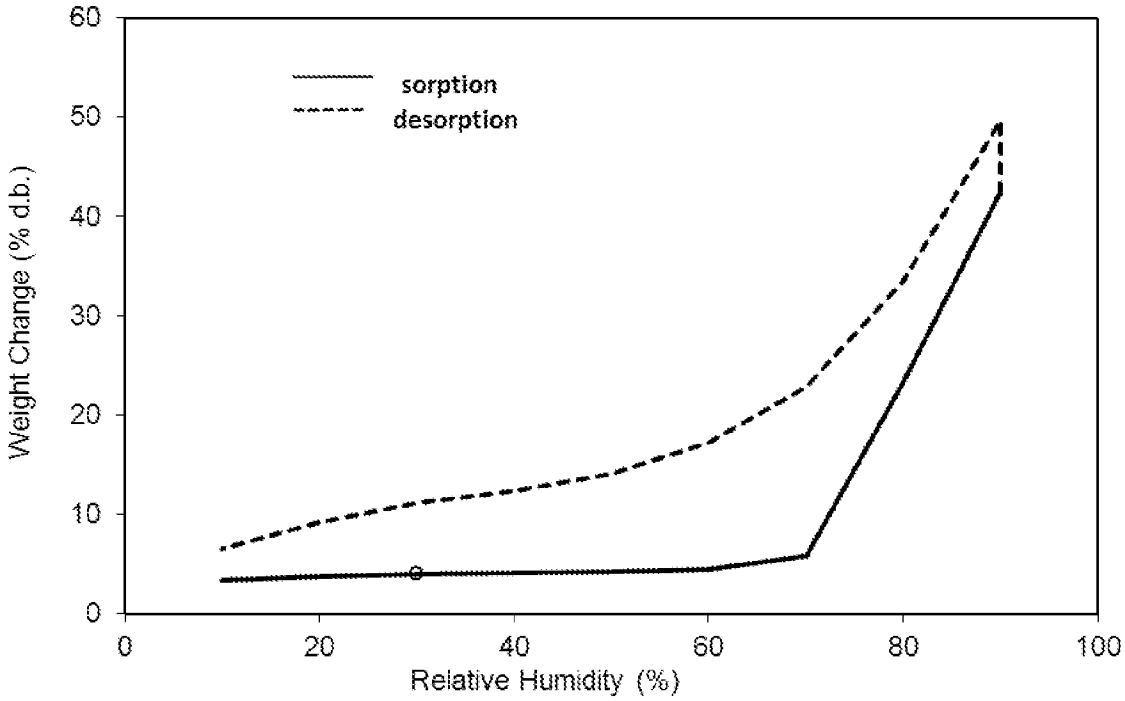

sorption
desorption
Weight Change (% d.b.)
Relative Humidity (%)
0
10
20
30
40
50
60
0
20
40
60
80
100

FIGURE 14

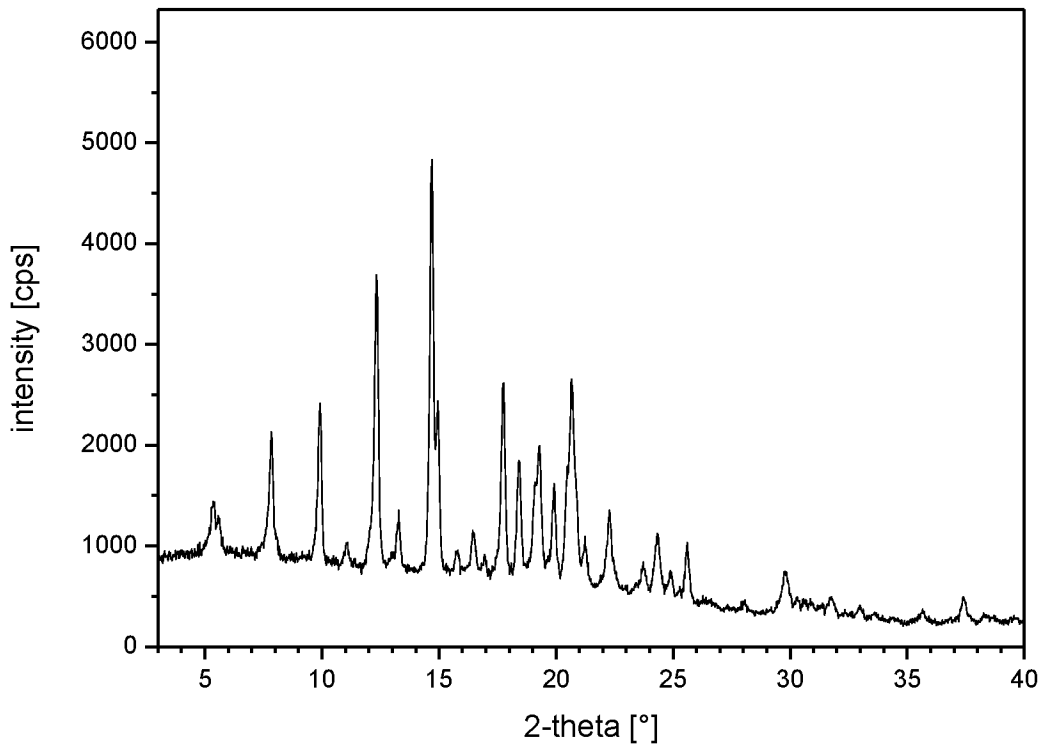

intensity [cps]
6000
5000
4000
3000
2000
1000
0
5
10
15
20
25
30
35
40
2-theta [°]

FIGURE 15

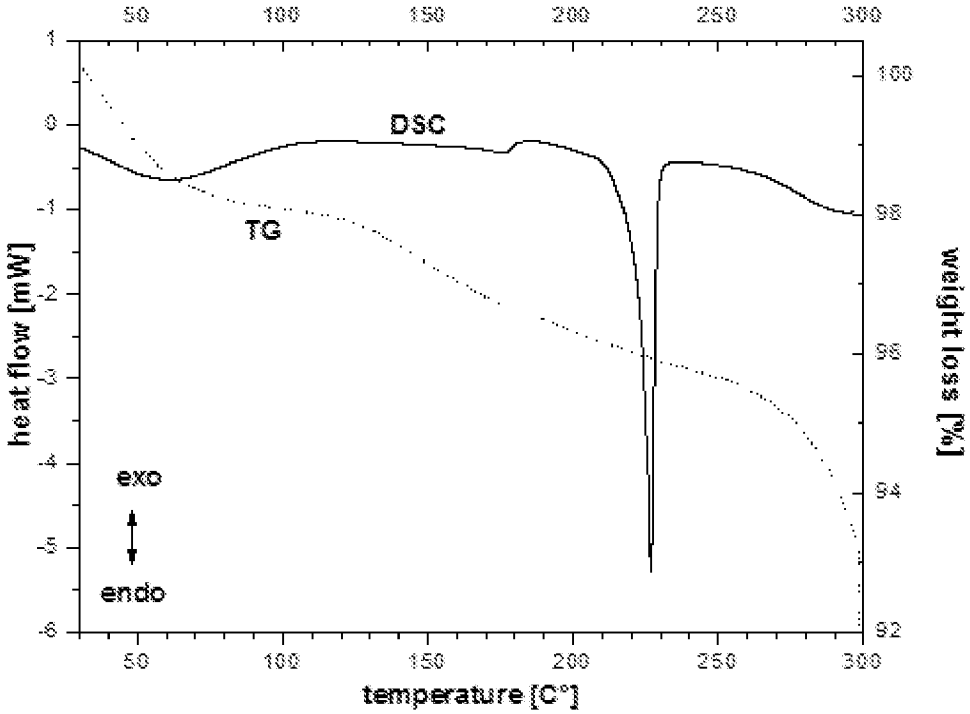
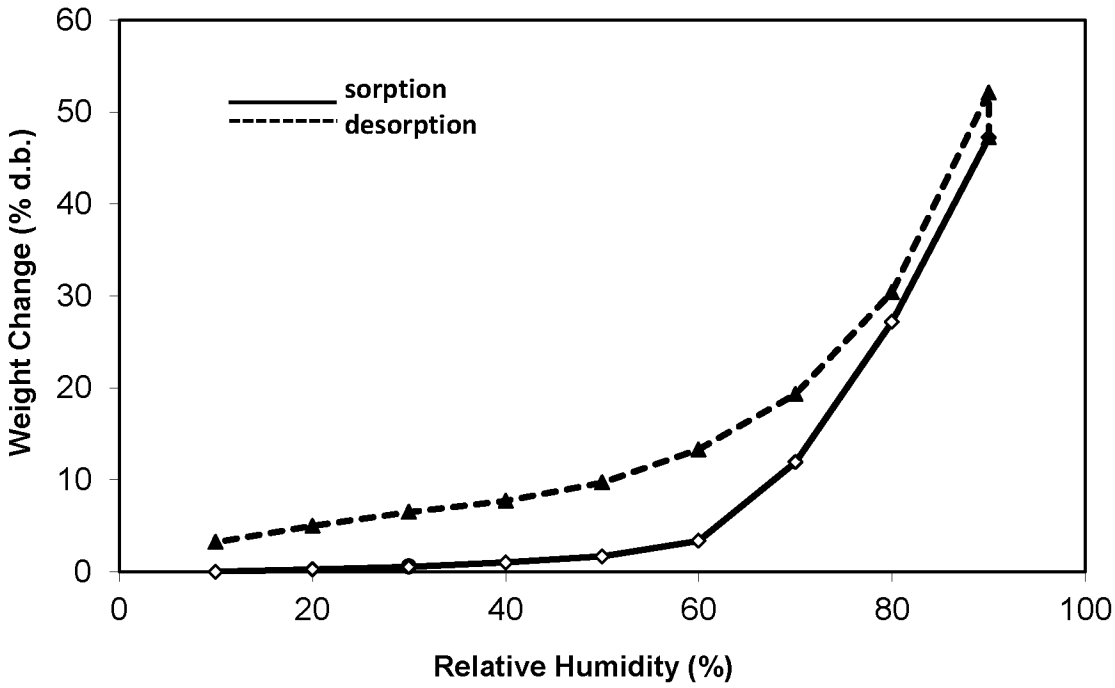

DSC
TG
exo
endo
heat flow [mW]
weight loss [%]
temperature [C°]
50
100
150
200
250
300
1
0
-1
-2
-3
-4
-5
-6
100
98
96
94
92

FIGURE 16


sorption
desorption
Weight Change (% d.b.)
Relative Humidity (%)
0
10
20
30
40
50
60
0
20
40
60
80
100

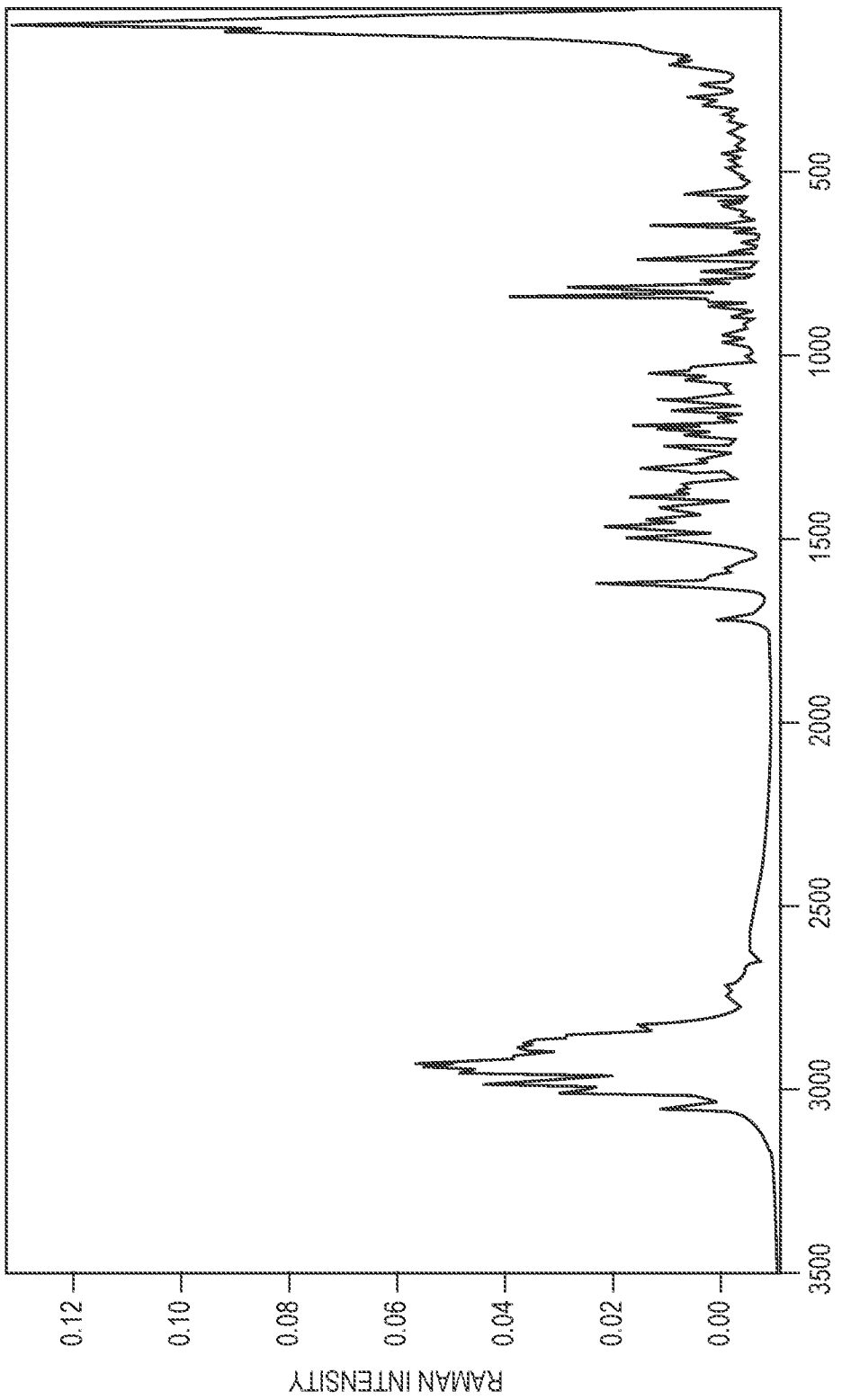

RAMAN INTENSITY
0.12
0.10
0.08
0.06
0.04
0.02
0.00
3500
3000
2500
2000
1500
1000
500
WAVENUMBER cm-1

FIG. 17

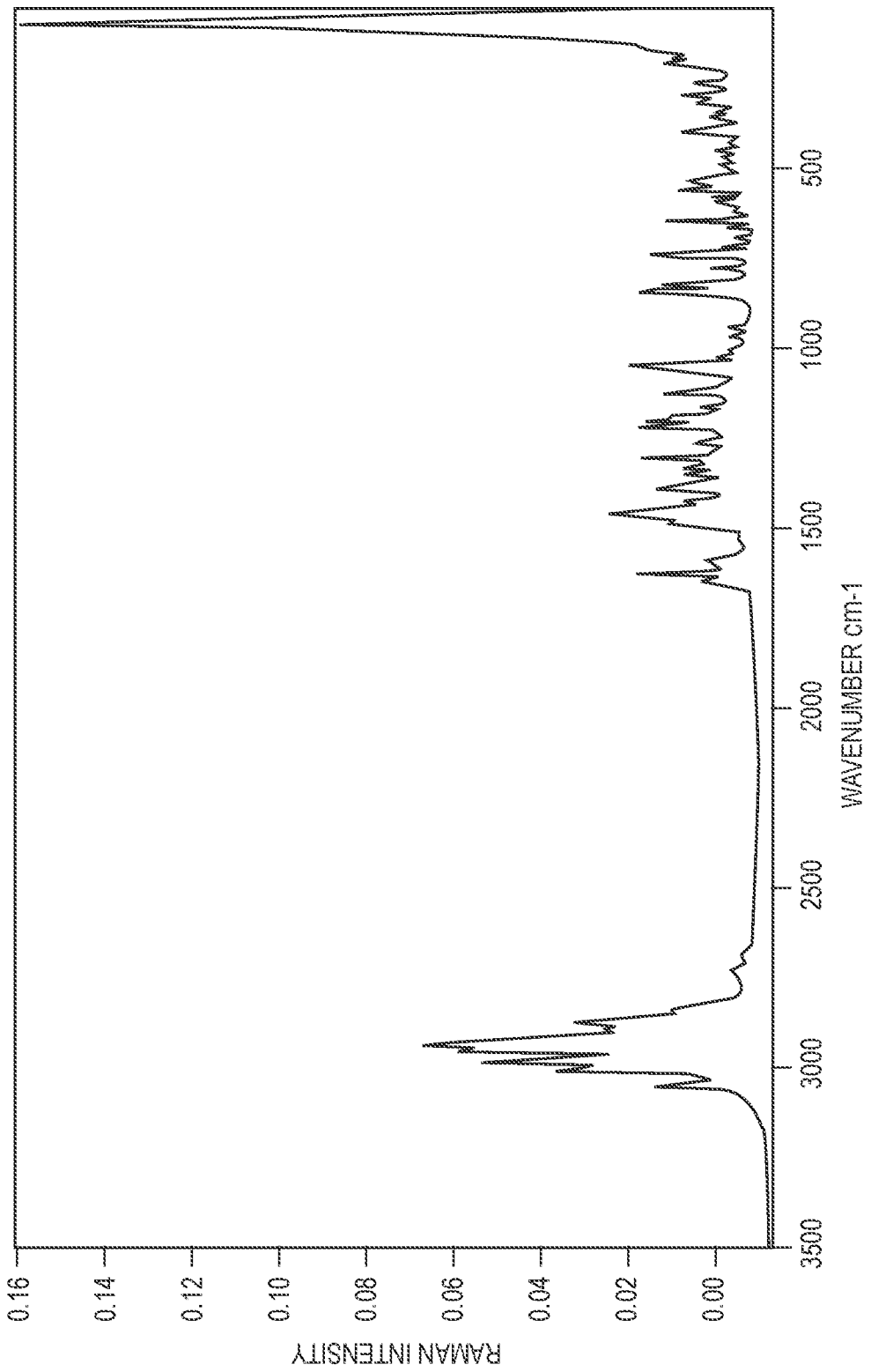

RAMAN INTENSITY
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
3500
3000
2500
2000
1500
1000
500
WAVENUMBER cm-1

FIG. 18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/040728

A. CLASSIFICATION OF SUBJECT MATTER

C07D 405/14 (2006.01) A61K 31/506 (2006.01) A61P 29/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Esp@cenet: CENTREXION as applicant; OSTERMEIER OR WERTHMANN as inventor

CHEMICAL ABSTRACTS REGISTRY, CAPLUS: Search based on registry numbers obtained for molecular formula of compound I.

Applicant(s)/Inventor(s) name searched in internal databases provided by IP Australia

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2016	28 September 2016
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Matthew Francis AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832424

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/US2016/040728**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/073154 A1 (BOEHRINGER INGELHEIM INTERNATIOANAL GMBH) 23 June 2011 Example 30; page 44, line 16;	1-35

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/US2016/040728**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
WO 2011/073154 A1	23 June 2011	WO 2011073154 A1	23 Jun 2011
		AP 3170 A	31 Mar 2015
		AR 079636 A1	08 Feb 2012
		AU 2010332969 A1	31 May 2012
		AU 2010332969 B2	12 Feb 2015
		CA 2782464 A1	23 Jun 2011
		CN 102933579 A	13 Feb 2013
		CN 102933579 B	15 Jul 2015
		CO 6650336 A2	15 Apr 2013
		EA 201200876 A1	30 Jan 2013
		EC SP12012010 A	31 Aug 2012
		EP 2513093 A1	24 Oct 2012
		EP 2513093 B1	27 Aug 2014
		EP 2813503 A1	17 Dec 2014
		EP 2813503 B1	20 Apr 2016
		HK 1178147 A1	10 Jun 2016
		IL 219421 A	30 Jul 2015
		JP 2013514301 A	25 Apr 2013
		JP 5632014 B2	26 Nov 2014
		KR 20120123652 A	09 Nov 2012
		KR 101530234 B1	19 Jun 2015
		MA 33818 B1	03 Dec 2012
		MX 2012006964 A	17 Jul 2012
		NZ 599770 A	27 Jun 2014
		PE 16142012 A1	21 Dec 2012
		RS 53555 B1	27 Feb 2015
		SG 181722 A1	30 Jul 2012
		TW 201130816 A	16 Sep 2011
		TW I473800 B	21 Feb 2015
		US 2012004252 A1	05 Jan 2012
		US 8765949 B2	01 Jul 2014
		US 2014235661 A1	21 Aug 2014

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.