(12) STANDARD PATENT (11) Application No. **AU 2019370926 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Novel salt of a Bcl-2 inhibitor, related crystalline form, method for preparing the same and pharmaceutical compositions containing the same

(51) International Patent Classification(s)
C07D 401/14 (2006.01) ***A61P 35/00*** (2006.01)

(21) Application No: **2019370926** (22) Date of Filing: **2019.10.30**

(87) WIPO No: **WO20/089281**

(30) Priority Data

(31) Number	(32) Date	(33) Country
18306430.2	**2018.10.31**	**EP**

(43) Publication Date: **2020.05.07**
(44) Accepted Journal Date: **2024.11.07**

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(56) Related Art
WO 2015/011400 A1

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
07 May 2020 (07.05.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/089281 A1

(51) International Patent Classification:
C07D 401/14 (2006.01) *A61P 35/00* (2006.01)

(21) International Application Number:
PCT/EP2019/079621

(22) International Filing Date:
30 October 2019 (30.10.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
18306430.2 31 October 2018 (31.10.2018) EP

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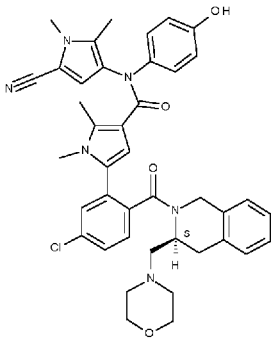
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: NOVEL SALT OF A BCL-2 INHIBITOR, RELATED CRYSTALLINE FORM, METHOD FOR PREPARING THE SAME AND PHARMACEUTICAL COMPOSITIONS CONTAINING THE SAME

(57) Abstract: Novel salt and related crystalline forms of Compound (A) wherein the salt is the hydrogen sulfate salt, characterised by its X-ray powder diffraction diagram, method for preparing the same and pharmaceutical compositions containing it.



(A)

WO 2020/089281 A1

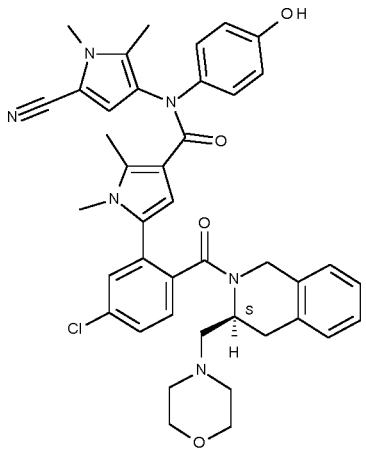
NOVEL SALT OF A BCL-2 INHIBITOR, RELATED CRYSTALLINE FORM, METHOD FOR PREPARING THE SAME AND PHARMACEUTICAL COMPOSITIONS CONTAINING THE SAME

FIELD OF THE INVENTION

The invention relates to a novel salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide, referred to herein as 'Compound A', or polymorphs or solvates thereof, methods for preparing the same as well as pharmaceutical compositions thereof. In particular, the invention relates to the hydrogen sulfate salt of Compound A, referred to herein as 'Compound A, H_2SO_4', and the crystalline form I thereof. The present invention further discloses a process for preparing said crystalline form and pharmaceutical compositions comprising said crystalline form. The invention also relates to the use of such compositions for the treatment of cancer, diseases of the immune system and auto-immune diseases. Last, an anhydrous crystalline form of Compound A, H_2SO_4 is disclosed.

BACKGROUND OF THE INVENTION

The chemical structure of Compound A is:



Its preparation, its use as a Bcl-2 inhibitor for the treatment of cancer and pharmaceutical formulations thereof are described in WO 2015/011400 (Example 386), the content of which is incorporated by reference. The preparation of Compound A in the form of a

hydrochloride salt ('Compound A.HCl') is specifically disclosed in this document. It is obtained as a lyophilisate.

Although Compound A is a very promising drug, it is a difficult compound to formulate. In particular, it is slightly soluble in water (< 0.01 mg/mL for the free base). As a chemical substance can exhibit different physical properties being in one or another salt form or crystalline form thereof, this polymorphism of the drug molecule can affect the shelf life, solubility, formulation properties, processing properties, and the action of a drug. In addition, different polymorphs can have different rates of uptake in the body, leading to lower or higher biological activity than desired. In extreme cases, an undesired polymorph can even show toxicity. Understanding and controlling polymorphism, then, gives a decided advantage in bringing new drugs to the marketplace, which may be more active, more stable, or more cheaply manufactured. However, even though polymorphism has been a subject for intensive investigations, understanding and controlling this phenomenon represents a substantial scientific challenge. It is hard to predict whether a given molecule will crystallize in one or several crystal forms, and to find conditions leading to such crystallization.

From the industrial point of view, it is imperative to be able to synthesise the compound with excellent purity, and in particular in a highly reproducible form, having valuable characteristics of dissolution, filtration, drying, ease of formulation and stability enabling the prolonged storage thereof without particular requirements for temperature, light, humidity or oxygen levels.

The present invention also describes a process for obtaining Compound A, H_2SO_4 in a well-defined, perfectly reproducible crystalline form (Form I) having very good stability that is compatible with the industrial constraints of preparation, especially filtration, and storage of pharmaceutical compositions.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows the X-ray powder diffraction pattern (XPRD) of the crystalline form I of Compound A, H_2SO_4.

Figure 2 shows the X-ray powder diffraction pattern (XPRD) of the anhydrous crystalline form of Compound A, hydrogen sulfate salt.

Figure 3 shows the X-ray powder diffraction pattern (XPRD) of the crystalline form I of Compound A, hydrochloride salt

Figure 4 shows the DSC and TGA profiles of the crystalline form I of Compound A, hydrogen sulfate salt

Figure 5 shows the DSC and TGA profiles of the crystalline form I of Compound A, hydrochloride salt

Figure 6 shows the solid-state ^{13}C NMR spectrum of the crystalline form I of Compound A, H_2SO_4.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the term 'comprising' means 'including', and is not intended to exclude the presence of any additional component, unless the context suggests otherwise, for example when the components together sum to 100%.

The term "alcohols" means C_1-C_6 alcohols such as methanol, ethanol, n-propanol, isopropanol, n-butanol, isobutanol, pentanol, 2-pentanol, 3-pentanol, isopentanol, hexanol.

'Cancer' means a class of disease in which a group of cells display uncontrolled growth. Cancer types include haematological cancers (lymphoma and leukemia) and solid tumors including carcinoma, sarcoma, or blastoma. 'Cancer' includes cancer of the bladder, brain, breast and uterus, chronic lymphoid leukaemias, colorectal cancer, cancers of the œsophagus and liver, lymphoblastic leukaemias, acute myeloid leukaemia, lymphomas, for example non-Hodgkin's B-cell lymphoma and diffuse large B-cell lymphoma, melanomas, malignant haemopathies, for example myelodysplastic syndrome, myelomas,

for example multiple myeloma, ovarian cancer, non-small-cell lung cancer, prostate cancer, pancreatic cancer and small-cell lung cancer.

'Free molecule' and 'free base' are used interchangeably herein and refer to Compound A when not in salt form.

Any reference to or discussion of any document, act or item of knowledge in this specification is included solely for the purpose of providing a context for the present invention. It is not suggested or represented that any of these matters or any combination thereof formed at the priority date part of the common general knowledge, or was known to be relevant to an attempt to solve any problem with which this specification is concerned.

Embodiments of the invention

Described below are a number of embodiments of the invention.

E1. A hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4).

E2. A crystalline form I of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to E1, wherein the crystalline form has an X-ray powder diffraction diagram showing the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.55 ; 6.62 and 7.39.

E3. A crystalline form I of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to E1, wherein the crystalline form has an X-ray powder

diffraction diagram showing at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or all of the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.55; 5.62; 6.62; 7.39; 10.17; 11.49; 11.83; 16.01; 16.54; 17.04; 18.98; 19.18; 21.90; 22.28; 24.89.

E4. The crystalline form I of the hydrogen sulfate salt of Compound A according to E3, characterized in that it has an X-ray powder diffraction diagram having the following

diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.55; 5.62; 6.62; 7.39; 10.17; 11.49; 11.83; 16.01; 16.54; 17.04; 18.98; 19.18; 21.90; 22.28; 24.89.

E5. The crystalline form I of the hydrogen sulfate salt of Compound A according to E4, characterized in that it has the following X-ray powder diffraction diagram, measured using a PANalytical X'Pert Pro MPD diffractometer with an X'Celerator detector and expressed in terms of line position (Bragg's angle 2 theta, expressed in degrees ±0.2°) and interplanar distances d (expressed in Å):

Line no.	Angle 2-theta (degrees)	Interplanar distance (Å)
1	5.55	15.93
2	5.62	15.73
3	6.62	13.36
4	7.39	11.95
5	10.17	8.70
6	11.49	7.70
7	11.83	7.48
8	16.01	5.53
9	16.54	5.36
10	17.04	5.20
11	18.98	4.67
12	19.18	4.63
13	21.90	4.06
14	22.28	3.99
15	24.89	3.58

E6. The crystalline form I of the hydrogen sulfate salt of Compound A according to any one of E1 to E5, characterised in that it has a solid-state ^{13}C CP/MAS NMR spectrum having the following peaks (expressed in ppm ± 0.2 ppm): 173.31 ppm, 155.32 ppm, 140.46 ppm, 139.19 ppm, 137.42 ppm, 134.68 ppm, 131.65 ppm, 131.14 ppm, 129.37 ppm, 126.32 ppm, 118.77 ppm, 117.36 ppm, 116.54 ppm, 113.61 ppm, 112.69 ppm,

110.74 ppm, 102.33 ppm, 101.45 ppm, 63.06 ppm, 57.19 ppm, 54.87 ppm, 52.06 ppm, 44.71 ppm, 43.94 ppm, 34.42 ppm, 32.89 ppm, 31.28 ppm, 30.66 ppm, 14.40 ppm, 13.34 ppm, 12.49 ppm and 10.50 ppm.

E7. Pharmaceutical composition comprising as active ingredient the hydrogen sulfate salt of Compound A according to E1 in association with one or more pharmaceutically acceptable excipients.

E8. Pharmaceutical composition comprising as active ingredient the crystalline form I of the hydrogen sulfate salt of Compound A according to any one of E2 to E6 in association with one or more pharmaceutically acceptable excipients.

E9. Pharmaceutical composition according to E7 or E8 for use in the treatment of cancers, auto-immune diseases and diseases of the immune system.

E10. Pharmaceutical composition according to E9, wherein the cancer is selected from the bladder, brain, breast and uterus cancers, chronic lymphoid leukaemias, colorectal cancer, cancers of the œsophagus and liver, lymphoblastic leukaemias, acute myeloid leukaemia, lymphomas, for example non-Hodgkin's B-cell lymphoma and diffuse large B-cell lymphoma, melanomas, malignant haemopathies, for example myelodysplastic syndrome, myelomas, for example multiple myeloma, ovarian cancer, non-small-cell lung cancer, prostate cancer, pancreatic cancer and small-cell lung cancer.

E11. The hydrogen sulfate salt of Compound A according to E1 for use as a medicament.

E12. The hydrogen sulfate salt of Compound A according to E1 for use in the treatment of cancers, auto-immune diseases and diseases of the immune system.

E13. The hydrogen sulfate salt of Compound A according to E12 wherein the cancer is selected from the bladder, brain, breast and uterus cancers, chronic lymphoid leukaemias, colorectal cancer, cancers of the œsophagus and liver, lymphoblastic leukaemias, acute myeloid leukaemia, lymphomas, for example non-Hodgkin's B-cell lymphoma and diffuse large B-cell lymphoma, melanomas, malignant haemopathies, for example myelodysplastic syndrome, myelomas, for example multiple myeloma, ovarian cancer, non-small-cell lung cancer, prostate cancer, pancreatic cancer and small-cell lung cancer.

E14. The crystalline form I of the hydrogen sulfate salt of Compound A according to any one of E2 to E6 for use as a medicament.

E15. The crystalline form I of the hydrogen sulfate salt of Compound A according to any one of E2 to E6 for use in the treatment of cancers, auto-immune diseases and diseases of the immune system.

E16. The crystalline form I of the hydrogen sulfate salt of Compound A according to E15 wherein the cancer is selected from the bladder, brain, breast and uterus cancers, chronic lymphoid leukaemias, colorectal cancer, cancers of the œsophagus and liver, lymphoblastic leukaemias, acute myeloid leukaemia, lymphomas, for example non-Hodgkin's B-cell lymphoma and diffuse large B-cell lymphoma, melanomas, malignant haemopathies, for example myelodysplastic syndrome, myelomas, for example multiple myeloma, ovarian cancer, non-small-cell lung cancer, prostate cancer, pancreatic cancer and small-cell lung cancer.

E17. Process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to any one of E2 to E6, wherein the hydrogen sulfate salt of Compound A is crystallised in a polar medium.

E18. Process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to E17, wherein the polar medium is composed of one or more solvents selected from water and alcohols.

E19. Process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to E18, wherein the alcohol is ethanol.

E20. Process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to E18, wherein the polar medium is an ethanol/water mixture.

E21. Process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to any one of E17 to E20, in which process the crystallisation is seeded using a very small amount of the crystalline form I of the hydrogen sulfate salt of Compound A.

E22. Anhydrous crystalline form of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to E1, wherein the crystalline form has an X-ray powder diffraction diagram showing at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 or all of the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.19; 5.64; 6.74; 7.14; 8.04; 8.33; 9.17; 9.40; 10.68; 11.03; 11.35; 12.18; 12.59; 13.64; 14.78; 15.09.

E23. The anhydrous crystalline form according to E22, characterized in that it has the following X-ray powder diffraction diagram, measured using a PANalytical X'Pert Pro MPD diffractometer with an X'Celerator detector and expressed in terms of line position (Bragg's angle 2 theta, expressed in degrees ±0.2°) and interplanar distances d (expressed in Å):

Line no.	Angle 2-theta (degrees)	Interplanar distance (Å)
1	5.19	17.03
2	5.64	15.66
3	6.74	13.12
4	7.14	12.39
5	8.04	10.99
6	8.33	10.61
7	9.17	9.64
8	9.40	9.41
9	10.68	8.29
10	11.03	8.02
11	11.35	7.79
12	12.18	7.26
13	12.59	7.03
14	13.64	6.49
15	14.78	5.99
16	15.09	5.87

Obtaining the crystalline form I of the hydrogen sulfate salt of Compound A has the advantage of having good characteristics of stability. More especially, only one crystalline form was observed in the range of solvents and temperatures used for the screening, showing a limited polymorphism of the hydrogen sulfate salt in the tested conditions. Furthermore, the crystalline form I of the hydrogen sulfate salt of Compound A thereby obtained is sufficiently stable to allow its storage for an extended period without particular conditions for temperature, light, humidity or oxygen levels.

Summary of the invention

In a first aspect, the invention relates to a hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4).

In a second aspect, the invention relates to a crystalline form I of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl}phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to the first aspect, wherein the crystalline form has an X-ray powder diffraction diagram showing the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.55 ; 6.62 and 7.39.

In a third aspect, the invention relates to a crystalline form I of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to the first aspect, wherein the crystalline form has an X-ray powder diffraction diagram showing at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or all of the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.55; 5.62; 6.62; 7.39; 10.17; 11.49; 11.83; 16.01; 16.54; 17.04; 18.98; 19.18; 21.90; 22.28; 24.89.

In a fourth aspect, the invention relates to a pharmaceutical composition comprising as an active ingredient the hydrogen sulfate salt of Compound A according to the first aspect in association with one or more pharmaceutically acceptable excipients.

In a fifth aspect, the invention relates to a pharmaceutical composition comprising as an active ingredient the crystalline form I of the hydrogen sulfate salt of Compound A according to the second or third aspect in association with one or more pharmaceutically acceptable excipients.

In a sixth aspect, the invention relates to use of the hydrogen sulfate salt of Compound A according to the first aspect, the crystalline form I of the hydrogen sulfate salt of Compound A according to the second or third aspect, or the pharmaceutical composition according to the fourth or fifth aspect for the manufacture of a medicament for the

treatment of Bcl-2 associated cancers, Bcl-2 associated auto-immune diseases, or Bcl-2 associated diseases of the immune system.

In a seventh aspect, the invention relates to a process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to the second or third aspect, wherein the hydrogen sulfate salt of Compound A is crystallised in a polar medium.

In an eighth aspect, the invention relates to an anhydrous crystalline form of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to the first aspect, wherein the crystalline form has an X-ray powder diffraction diagram showing at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 or all of the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.19; 5.64; 6.74; 7.14; 8.04; 8.33; 9.17; 9.40; 10.68; 11.03; 11.35; 12.18; 12.59; 13.64; 14.78; 15.09.

In a ninth aspect, the invention relates to a method of treatment of Bcl-2 associated cancers, Bcl-2 associated auto-immune diseases, or Bcl-2 associated diseases of the immune system comprising administering to a subject in need thereof the hydrogen sulfate salt of Compound A according to the first aspect, the crystalline form I of the hydrogen sulfate salt of Compound A according to the second or third aspect, or the pharmaceutical composition according to the fourth or fifth aspect.

The Examples herein below illustrate the invention but do not limit it in any way.

<u>Example 1</u>: Process for obtaining crystalline form I of the hydrogen sulfate salt of Compound A

25 g of Compound A (free base) was placed in 239.5 g of ethanol at ambient temperature. The mixture was then heated at 65°C. A solution of sulphuric acid in water (4.27 g of H_2SO_4 + 59.87 g of water) was then added gradually. The mixture was stirred for 1 h

before being cooled to 10°C. When the crystallisation was complete, the suspension was filtered, washed with an ethanol/water mixture à 10°C, filtered and dried under reduced pressure. After drying, crystalline form I of the hydrogen sulfate salt of Compound A was obtained in a yield of about 70% and with a purity greater than 99.8%. The solid was characterised by the X-ray powder as set out in Example 3.

In the crystallisation process according to the invention, Compound A (free base) is obtained by any process which may be used.

Example 2: Process for obtaining crystalline form I of the hydrogen sulfate salt of Compound A (seeding)

25 g of Compound A (free base) was placed in 239.5 g of ethanol at ambient temperature. The mixture was then heated at 65°C. A solution of sulphuric acid in water (4.27 g of H_2SO_4 + 59.87 g of water) was then added gradually. The mixture was stirred for 30 minutes. The mixture was then cooled slightly before being seeded with the crystalline form I of the hydrogen sulfate salt of Compound A (2% by weight of starting material). The mixture was stirred for 30 minutes before being cooled to 10°C. When the crystallisation was complete, the suspension was filtered, washed with an ethanol/water mixture à 10°C, filtered and dried under reduced pressure. After drying, crystalline form I of the hydrogen sulfate salt of Compound A was obtained in a yield of about 70% and with a purity greater than 99.8%. The solid was characterised by the X-ray powder as set out in Example 3.

In the crystallisation process according to the invention, Compound A (free base) is obtained by any process which may be used.

Example 3: Crystalline form I of the hydrogen sulfate salt of Compound A (X-ray powder diffraction diagram)

Recording of the data was carried out in the transmission mode using a PANalytical X'Pert Pro MPD diffractometer with an X'Celerator detector under the following conditions:

- Voltage 45 kV, current 40 mA,
- Mounting: theta/theta,

- Anode: copper,
- K alpha-1 wavelength: 1.54060 Å,
- K alpha-2 wavelength: 1.54443 Å,
- K alpha-2/K alpha-1 ratio: 0.5,
- Measurement mode: continuous from 3° to 55° (Bragg's angle 2 theta) in increments of 0.017°,
- Measurement time per step: 35.5301 s.

The X-ray powder diffraction diagram of the form I of the hydrogen sulfate salt of Compound A obtained according to the process of Example 1 or 2 is expressed in terms of line position (Bragg's angle 2 theta, expressed in degrees ±0.2°) and interplanar distances (expressed in Å) (Figure 1). The significant lines have been collated in the following table:

Line no.	Angle 2-theta (degrees)	Interplanar distance (Å)
1	5.55	15.93
2	5.62	15.73
3	6.62	13.36
4	7.39	11.95
5	10.17	8.70
6	11.49	7.70
7	11.83	7.48
8	16.01	5.53
9	16.54	5.36
10	17.04	5.20
11	18.98	4.67
12	19.18	4.63
13	21.90	4.06
14	22.28	3.99
15	24.89	3.58

Example 4: Stability Studies

For all storage conditions and storage periods, 20 mg of crystalline form of the salt of Compound A were introduced in a 30-mL vial for post-storage HPLC analysis.

The drug substance content was determined by LC (% m/m).

Temperature	Packaging	Hydrogen sulfate salt, crystalline form I
T_0		>99.9
25°C / 60%RH	Double polyethylene bag placed in a plastic drum	100.7 after 3 months of storage
30°C / 65%RH	Double polyethylene bag placed in a plastic drum	100.6 after 3 months of storage
40°C / 75%RH	Double polyethylene bag placed in a plastic drum	100.0 after 3 months of storage
50°C / 75%RH	Open glass bottle	101.0 after 6 weeks of storage

The appearance of the powder (white) and chemical stability remains unchanged under all conditions tested: over 3 months at 25°C/60%RH, 30°C/65%RH, 40°C/75%RH, and for 6 weeks at 50°C/75%RH.

Furthermore, the X-ray diffraction results show that the form does not change after analysis at T_0 and after 6 weeks storage in open glass bottles at 25°C/90%RH.

In conclusion, the drug substance can be considered physically and chemically stable over the periods tested.

Example 5: Process for obtaining the anhydrous crystalline form of the hydrogen sulfate salt of Compound A (seeding)

5.83 kg of Compound A (free base) was placed in 55.85 kg of ethanol at ambient temperature. The mixture was then heated at 65°C. A solution of sulphuric acid in water (1 kg of H_2SO_4 + 13,96 kg of water) was then added gradually. The mixture was stirred for 30 minutes. The mixture was then cooled slightly before being seeded with the crystalline form I of the hydrogen sulfate salt of Compound A (2% by weight of starting material). The mixture was stirred for 30 minutes before being cooled to 10°C. When the

crystallisation was complete, the suspension was filtered, washed with an ethanol/water mixture à 10°C, filtered and dried under reduced pressure. Then, the dried product is stored under an inert atmosphere (nitrogen). The anhydrous crystalline form of the hydrogen sulfate salt of Compound A was obtained in a yield of about 78 ± 5% and with a purity greater than 99.9% and a water content of about 0.43%. The solid was characterised by the X-ray powder as set out in Example 6.

In the crystallisation process according to the invention, Compound A (free base) is obtained by any process which may be used.

Example 6: Anhydrous crystalline form of the hydrogen sulfate salt of Compound A (X-ray powder diffraction diagram)

Recording of the data was carried out in the following conditions:

Approximately 30-50 mg of the sample to be analysed is placed between two polymeric films (Kapton®) fixed in a sample holder disc. The X-ray diffraction pattern of the test sample is recorded from 3° 2theta to at least 40° 2-theta in 15 min using an X-ray diffractometer operating in the transmission mode with CuKα radiation (λ = 1.5418 Å) at 40kV and 30mA and with a step size ranging from 0.01 to 0.02° 2-theta. These settings may vary according to the diffractometer used.

The X-ray powder diffraction diagram of the anhydrous form of the hydrogen sulfate salt of Compound A obtained according to the process of Example 5 is expressed in terms of line position (Bragg's angle 2 theta, expressed in degrees ±0.2°) and interplanar distances (expressed in Å) (Figure 2). The significant lines have been collated in the following table:

Line no.	Angle 2-theta (degrees)	Interplanar distance (Å)
1	5.19	17.03
2	5.64	15.66
3	6.74	13.12
4	7.14	12.39
5	8.04	10.99
6	8.33	10.61

7	9.17	9.64
8	9.40	9.41
9	10.68	8.29
10	11.03	8.02
11	11.35	7.79
12	12.18	7.26
13	12.59	7.03
14	13.64	6.49
15	14.78	5.99
16	15.09	5.87

Example 7: Process for obtaining crystalline form I of the hydrogen sulfate salt of Compound A (seeding, batch size of the order of the kilogram)

5.83 kg of Compound A (free base) was placed in 55.85 kg of ethanol at ambient temperature. The mixture was then heated at 65°C. A solution of sulphuric acid in water (1 kg of H_2SO_4 + 13.96 kg of water) was then added gradually. The mixture was stirred for 30 minutes. The mixture was then cooled slightly before being seeded with the crystalline form I of the hydrogen sulfate salt of Compound A (2% by weight of starting material). The mixture was stirred for 30 minutes before being cooled to 10°C. When the crystallisation was complete, the suspension was filtered, washed with an ethanol/water mixture at 10°C, filtered and dried under reduced pressure. The product was rehydrated thereafter at 40°C under an atmosphere with 50% of relative humidity (RH). The resulting product was stored under an inert atmosphere (nitrogen). The crystalline form I of the hydrogen sulfate salt of Compound A was obtained in a yield of about 78 ± 5% and with a purity greater than 99.9% and a water content of about 6.5 ± 1%. The solid was characterised by the X-ray powder as set out in Example 3.

In the crystallisation process according to the invention, Compound A (free base) is obtained by any process which may be used.

Example 8: Process for obtaining the crystalline form I of the hydrochloride salt of Compound A and the X-ray powder diffraction diagram characterising it

1510 mg of the amorphous hydrochloride salt of Compound A (Example 386 of WO 2015/011400) was converted into its crystalline ethanol solvate by slurrying in 15 mL of ethanol for 48h hours. The residual solid was filtered, washed twice with 1 mL of ethanol and then suspended in 10 mL of water for 5 min. After a difficult filtration, the residual solid was dried overnight at 30°C/10 mbar and analysed by X-ray diffraction (3-30° 2 theta/10 min).

The mode of preparation for the HCl salt is complicated by the fact that it initially results in an ethanol solvate which is replaced by H_2O after resuspension in water to give the hydrated form. The resulting hydrated HCl salt formed fine needles which were quite difficult to filter.

The X-ray powder diffraction diagram of the form I of the hydrochloride salt of Compound A obtained according to the process described previously is expressed in terms of line position (Bragg's angle 2 theta, expressed in degrees ±0.2°) and relative intensity (expressed in %) (Figure 3). The significant lines have been collated in the following table:

Line no.	Angle 2-theta (degrees)	Relative Intensity(%)
1	5.53	100.00
2	7.37	65.92
3	9.96	92.98
4	11.26	31.90
5	11.62	30.11
6	12.29	67.53
7	12.76	25.47
8	15.34	29.27
9	17.04	32.91
10	18.82	25.98
11	19.07	27.10
12	19.48	27.89
13	20.41	25.05

14	21.99	28.88
15	23.14	29.52
16	24.69	23.99
17	25.66	29.09
18	27.28	25.49

Example 9: DSC and TGA profiles of the crystalline forms I of the hydrochloride and hydrogen sulfate salts of Compound A

H_2SO_4 salt

The Differential Scanning Calorimetry (DSC) profile of a sample of the hydrogensulfate salt, form I weighing approximately 4 mg was recorded between 0°C and 250°C at 10°C/min in pin-hole pierced aluminium pans under a positive flow of nitrogen on a TA Instruments Q1000 (or Q2000) Differential Scanning Calorimeter (Figure 4).

The Thermal Gravimetric Analysis (TGA) profile of a sample of the hydrogensulfate salt, form I weighing approximately 10 mg was recorded between 25°C and 250°C at 10°C/min in an open aluminium pan under a positive flow of nitrogen on a TA Instruments Q5000 Thermogravimetric Analyser (Figure 4).

HCl salt

The DSC profile of a sample of the hydrochloride salt, form I weighing approximately 4 mg was recorded between 0°C and 250°C at 10°C/min in pin-hole pierced aluminium pans under a positive flow of nitrogen on a TA Instruments Q1000 (or Q2000) Differential Scanning Calorimeter (Figure 5).

The TGA profile of a sample of the hydrochloride salt, form I weighing approximately 6 mg was recorded between 25°C and 250°C at 10°C/min in an open aluminium pan under a positive flow of nitrogen on a TA Instruments Q5000 Thermogravimetric Analyser (Figure 5).

The DSC profile of the H_2SO_4 salt is less complicated compared to that of the HCl salt. Water loss is visible in the TGA profile of the H_2SO_4 salt between 25 and 100°C. A melting/degradation endotherm is visible in the DSC profile towards 224°C. The melting

temperature and enthalpy of the HCl salt is lower than that of the H_2SO_4 salt. This may suggest that the HCl has a lower degree of crystallinity following dehydration compared to the H_2SO_4 salt.

Example 10: Crystalline form I of Compound A, H_2SO_4(solid NMR Spectrum)

Crystalline form I of Compound A, H_2SO_4 was also characterized by solid-state Nuclear Magnetic Resonance spectroscopy (Figure 6). Solid-state ^{13}C NMR spectra of Compound A, H_2SO_4 were recorded at ambient temperature using a Bruker SB Avance III HD 500 spectrometer with a 4 mm CP/MAS SB VTN type probe under the following conditions:

- Frequency: 125.76 MHz,
- Spectral width: 37 kHz,
- Magic angle spinning rate: 10 kHz,
- Pulse program: Cross Polarization with SPINAL64 decoupling
- Recycle delay: 10 s,
- Acquisition time: 46 ms,
- Contact time: 4 ms,
- Number of scans: 4096.

A 5 Hz line-broadening was applied prior to Fourier Transformation.

The spectrum thereby obtained was referenced relative to a sample of adamantane (the high frequency peak of adamantane was set to 38.5 ppm).

Crystalline form I of Compound A, H_2SO_4 can be defined by the presence of a set of peaks whose chemical shifts are given in the table below (expressed in ppm ± 0.2 ppm):

No.	(ppm)
1	173.31
2	155.32
3	140.46
4	139.19
5	137.42
6	134.68
7	131.65
8	131.14
9	129.37
10	126.32
11	118.77
12	117.36
13	116.54
14	113.61
15	112.69
16	110.74
17	102.33
18	101.45
19	63.06
20	57.19
21	54.87
22	52.06
23	44.71
24	43.94
25	34.42
26	32.89
27	31.28
28	30.66
29	14.40
30	13.34
31	12.49
32	10.50

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4).

2. A crystalline form I of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl}phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to claim 1, wherein the crystalline form has an X-ray powder diffraction diagram showing the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.55 ; 6.62 and 7.39.

3. A crystalline form I of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to claim 1, wherein the crystalline form has an X-ray powder diffraction diagram showing at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or all of the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.55; 5.62; 6.62; 7.39; 10.17; 11.49; 11.83; 16.01; 16.54; 17.04; 18.98; 19.18; 21.90; 22.28; 24.89.

4. The crystalline form I of the hydrogen sulfate salt of Compound A according to claim 3, wherein the crystalline form I has an X-ray powder diffraction diagram having the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.55; 5.62; 6.62; 7.39; 10.17; 11.49; 11.83; 16.01; 16.54; 17.04; 18.98; 19.18; 21.90; 22.28; 24.89.

5. The crystalline form I of the hydrogen sulfate salt of Compound A according to claim 4, wherein the crystalline form I has the following X-ray powder diffraction diagram, measured using a PANalytical X'Pert Pro MPD diffractometer with an X'Celerator detector

and expressed in terms of line position (Bragg's angle 2 theta, expressed in degrees ±0.2°) and interplanar distances d (expressed in Å):

Line no.	Angle 2-theta (degrees)	Interplanar distance (Å)
1	5.55	15.93
2	5.62	15.73
3	6.62	13.36
4	7.39	11.95
5	10.17	8.70
6	11.49	7.70
7	11.83	7.48
8	16.01	5.53
9	16.54	5.36
10	17.04	5.20
11	18.98	4.67
12	19.18	4.63
13	21.90	4.06
14	22.28	3.99
15	24.89	3.58

6. The crystalline form I of the hydrogen sulfate salt of Compound A according to any one of claims 2 to 5, wherein the crystalline form I has a solid-state ^{13}C CP/MAS NMR spectrum having the following peaks (expressed in ppm ± 0.2 ppm): 173.31 ppm, 155.32 ppm, 140.46 ppm, 139.19 ppm, 137.42 ppm, 134.68 ppm, 131.65 ppm, 131.14 ppm, 129.37 ppm, 126.32 ppm, 118.77 ppm, 117.36 ppm, 116.54 ppm, 113.61 ppm, 112.69 ppm, 110.74 ppm, 102.33 ppm, 101.45 ppm, 63.06 ppm, 57.19 ppm, 54.87 ppm, 52.06 ppm, 44.71 ppm, 43.94 ppm, 34.42 ppm, 32.89 ppm, 31.28 ppm, 30.66 ppm, 14.40 ppm, 13.34 ppm, 12.49 ppm and 10.50 ppm.

7. A pharmaceutical composition comprising as an active ingredient the hydrogen sulfate salt of Compound A according to claim 1 in association with one or more pharmaceutically acceptable excipients.

8. A pharmaceutical composition comprising as an active ingredient the crystalline form I of the hydrogen sulfate salt of Compound A according to any one of claims 2 to 6 in association with one or more pharmaceutically acceptable excipients.

9. Use of the hydrogen sulfate salt of Compound A according to claim 1, the crystalline form I of the hydrogen sulfate salt of Compound A according to any one of claims 2 to 6, or the pharmaceutical composition according to claim 7 or 8 for the manufacture of a medicament for the treatment of Bcl-2 associated cancers, Bcl-2 associated auto-immune diseases, or Bcl-2 associated diseases of the immune system.

10. The use according to claim 9, wherein the cancer is selected from bladder, brain, breast and uterus cancers, chronic lymphoid leukaemias, colorectal cancer, cancers of the œsophagus and liver, lymphoblastic leukaemias, acute myeloid leukaemia, lymphomas, melanomas, malignant haemopathies, myelomas, ovarian cancer, non-small-cell lung cancer, prostate cancer, pancreatic cancer and small-cell lung cancer.

11. A process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to any one of claims 2 to 6, wherein the hydrogen sulfate salt of Compound A is crystallised in a polar medium.

12. The process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to claim 11, wherein the polar medium is composed of one or more solvents selected from water and alcohols.

13. The process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to claim 12, wherein the alcohol is ethanol.

14. The process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to claim 12 or 13, wherein the polar medium is an ethanol/water mixture.

15. The process for the preparation of the crystalline form I of the hydrogen sulfate salt of Compound A according to any one of claim 11 to 14, wherein the crystallisation is seeded using a very small amount of the crystalline form I of the hydrogen sulfate salt of Compound A.

16. Anhydrous crystalline form of the hydrogen sulfate salt of 5-(5-chloro-2-{[(3*S*)-3-(morpholin-4-ylmethyl)-3,4-dihydroisoquinolin-2(1*H*)-yl]carbonyl} phenyl)-*N*-(5-cyano-1,2-dimethyl-1*H*-pyrrol-3-yl)-*N*-(4-hydroxyphenyl)-1,2-dimethyl-1*H*-pyrrole-3-carboxamide (Compound A, H_2SO_4) according to claim 1, wherein the crystalline form has an X-ray powder diffraction diagram showing at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 or all of the following diffraction lines (Bragg's angle 2 theta, expressed in degrees ±0.2°): 5.19; 5.64; 6.74; 7.14; 8.04; 8.33; 9.17; 9.40; 10.68; 11.03; 11.35; 12.18; 12.59; 13.64; 14.78; 15.09.

17. The anhydrous crystalline form of the hydrogen sulfate salt of Compound A according to claim 16, wherein the crystalline form has the following X-ray powder diffraction diagram, measured using a PANalytical X'Pert Pro MPD diffractometer with an X'Celerator detector and expressed in terms of line position (Bragg's angle 2 theta, expressed in degrees ±0.2°) and interplanar distances d (expressed in Å):

Line no.	Angle 2-theta (degrees)	Interplanar distance (Å)
1	5.19	17.03
2	5.64	15.66
3	6.74	13.12
4	7.14	12.39
5	8.04	10.99
6	8.33	10.61

7	9.17	9.64
8	9.40	9.41
9	10.68	8.29
10	11.03	8.02
11	11.35	7.79
12	12.18	7.26
13	12.59	7.03
14	13.64	6.49
15	14.78	5.99
16	15.09	5.87

18. A method of treatment of Bcl-2 associated cancers, Bcl-2 associated auto-immune diseases, or Bcl-2 associated diseases of the immune system comprising administering to a subject in need thereof the hydrogen sulfate salt of Compound A according to claim 1, the crystalline form I of the hydrogen sulfate salt of Compound A according to any one of claims 2 to 6, or the pharmaceutical composition according to claim 7 or 8.

19. The method according to claim 18, wherein the cancer is selected from bladder, brain, breast and uterus cancers, chronic lymphoid leukaemias, colorectal cancer, cancers of the œsophagus and liver, lymphoblastic leukaemias, acute myeloid leukaemia, lymphomas, melanomas, malignant haemopathies, myelomas, ovarian cancer, non-small-cell lung cancer, prostate cancer, pancreatic cancer and small-cell lung cancer.

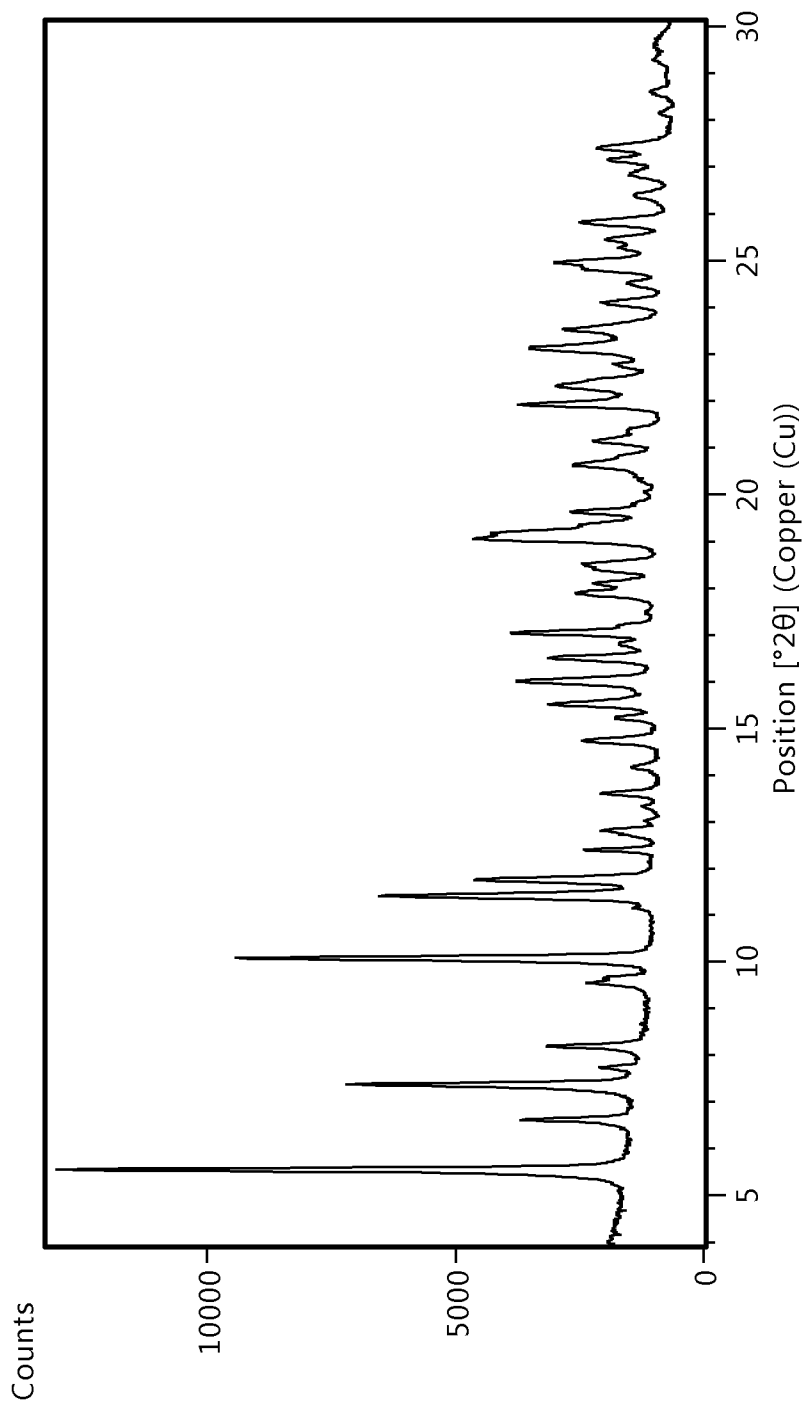


Figure 1: X-ray powder diffraction pattern (XPRD) of the crystalline form I of Compound A, hydrogen sulfate salt

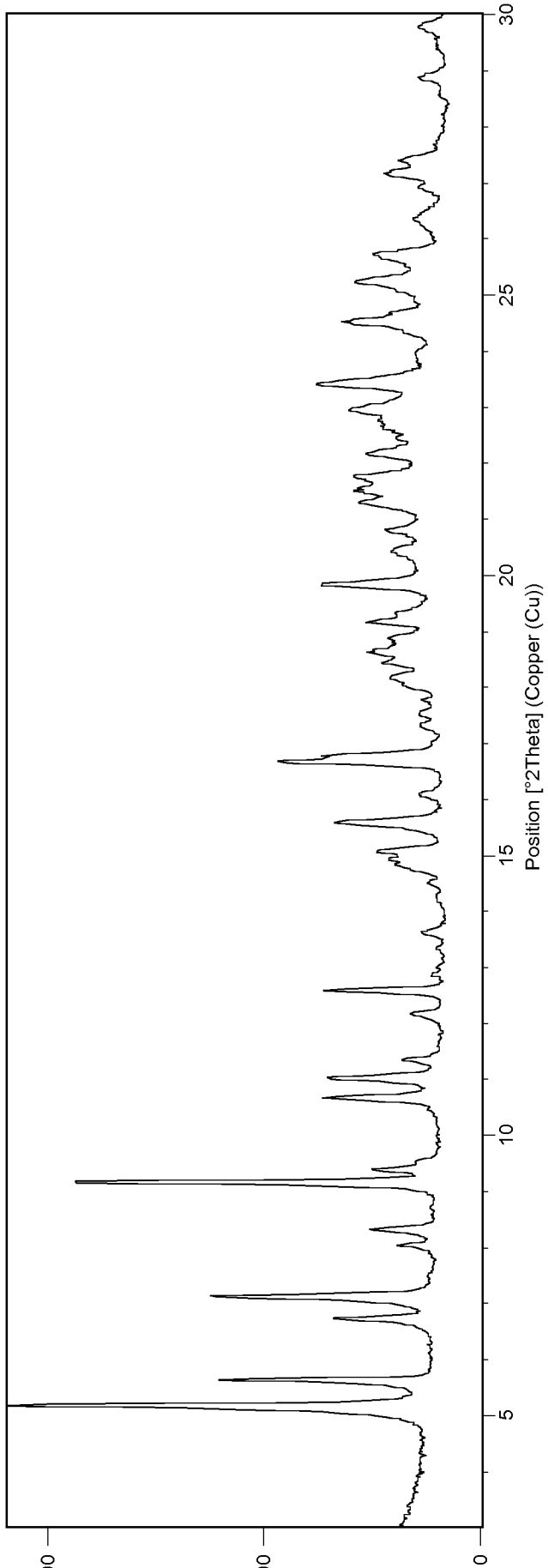


Figure 2: X-ray powder diffraction pattern (XPRD) of the anhydrous crystalline form of Compound A, hydrogen sulfate salt

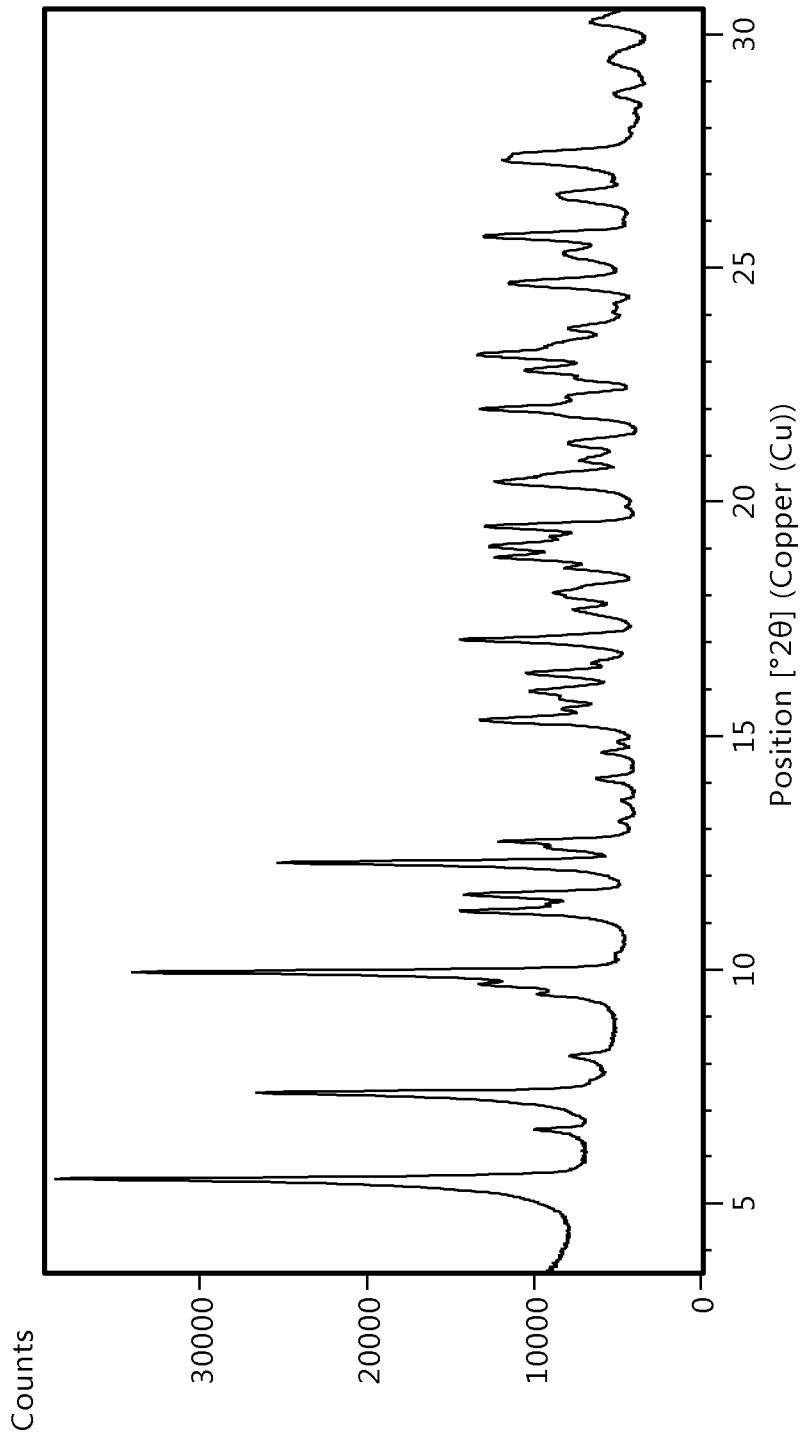


Figure 3: X-ray powder diffraction pattern (XPRD) of the crystalline form I of Compound A, hydrochloride salt

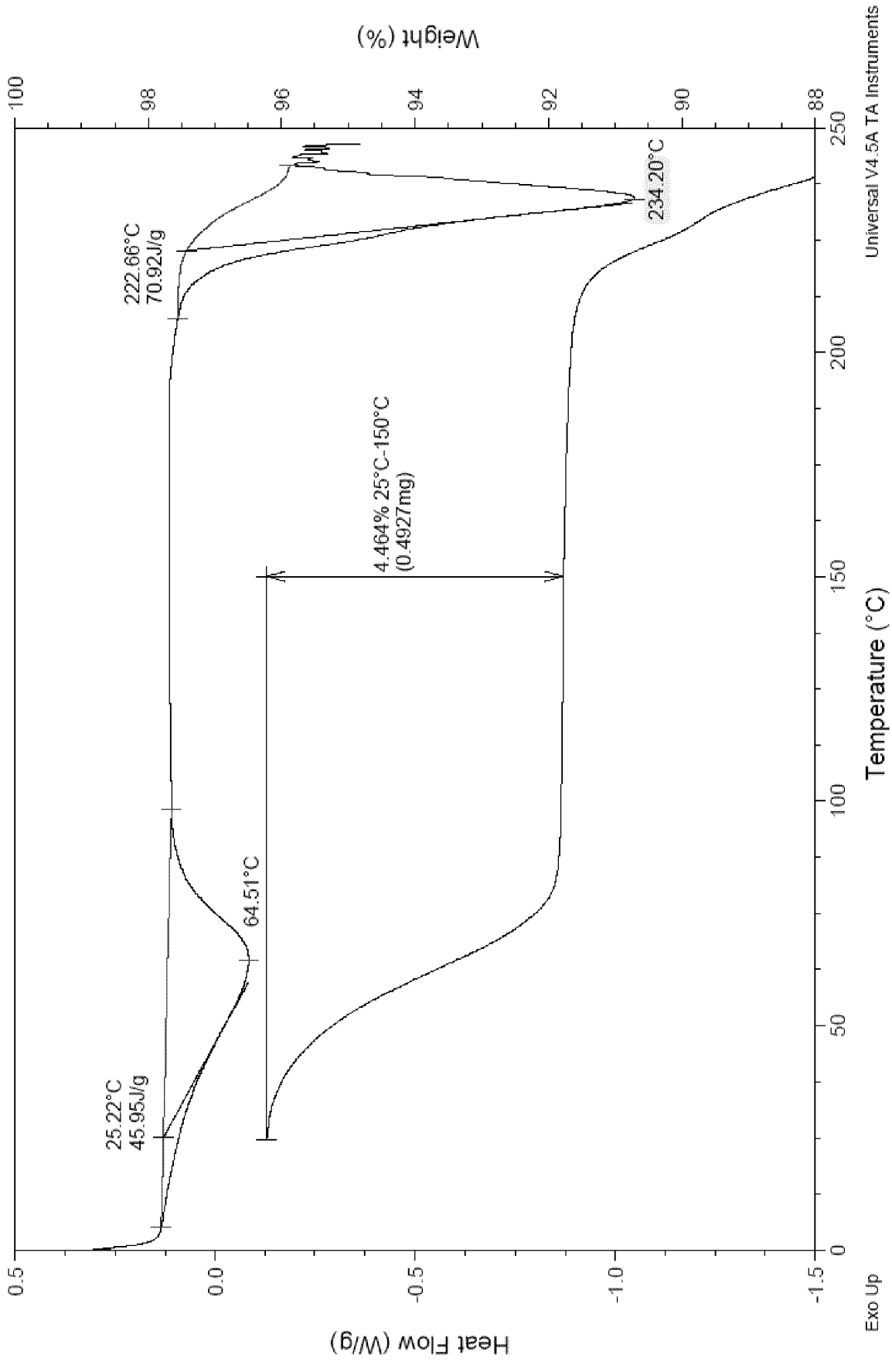


Figure 4: DSC and TGA profiles of the crystalline form I of Compound A, hydrogen sulfate salt

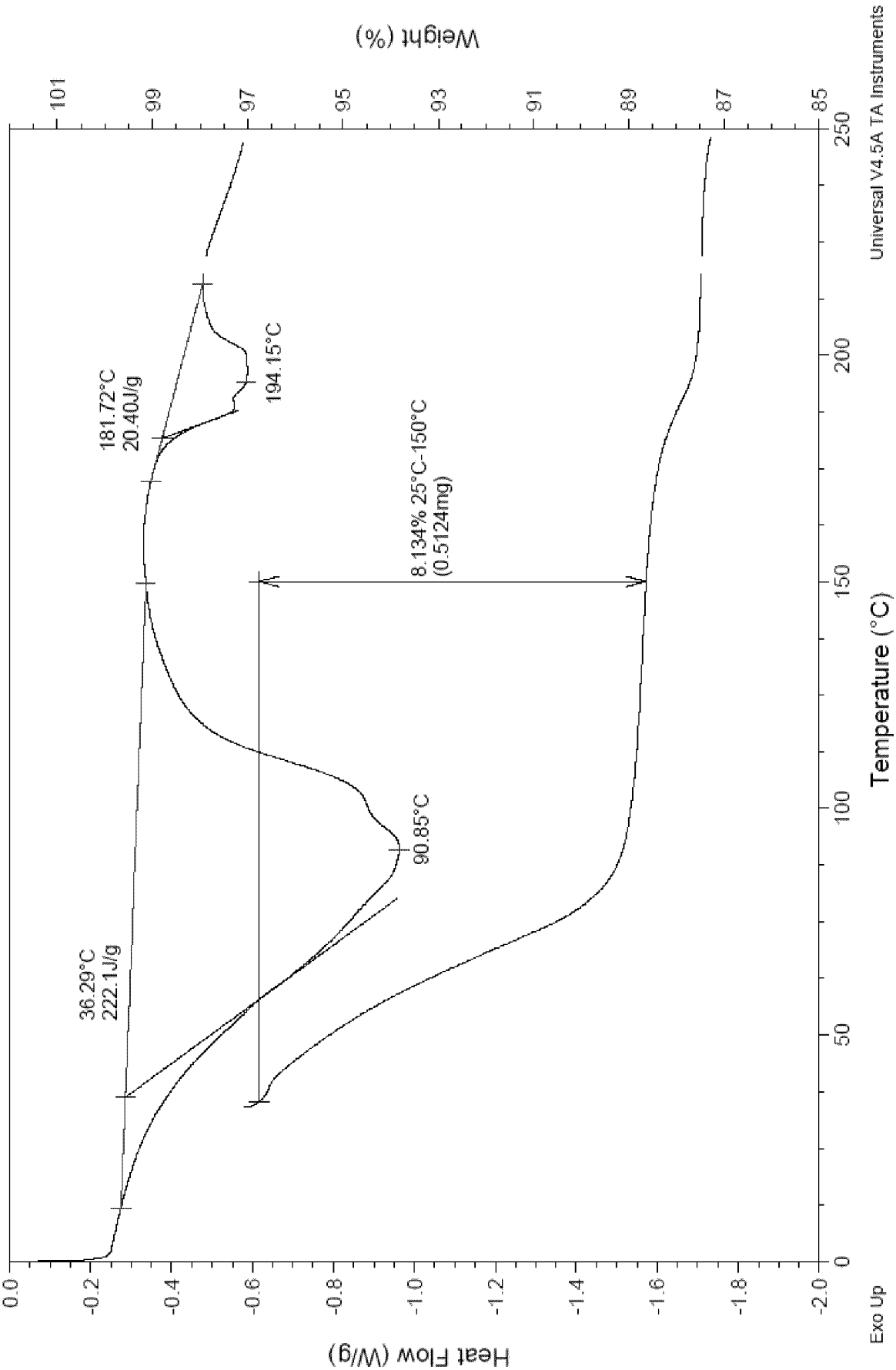


Figure 5: DSC and TGA profiles of the crystalline form I of Compound A, hydrochloride salt

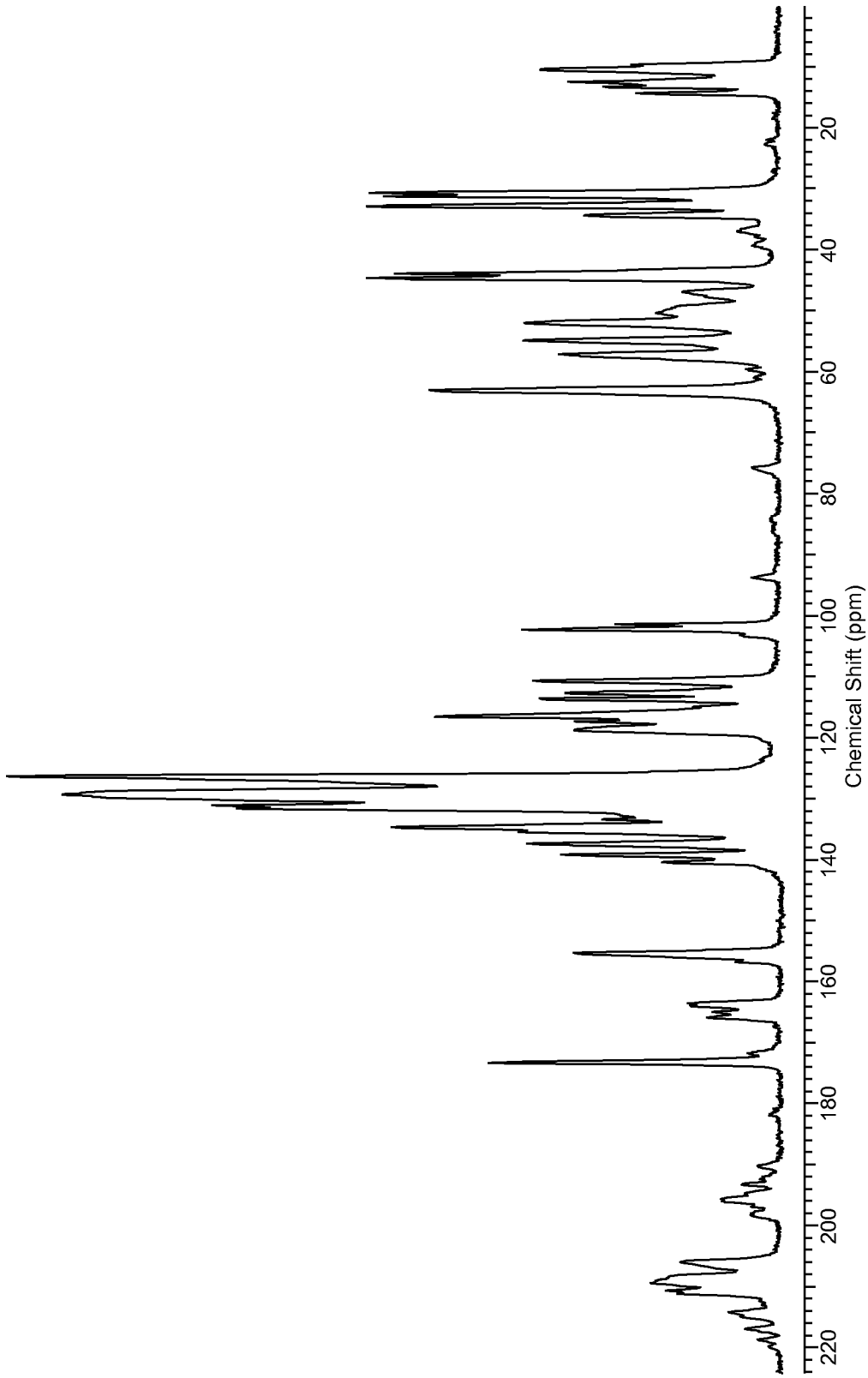


Figure 6: Solid-state ^{13}C NMR spectrum of the crystalline form I of Compound A, H_2SO_4