

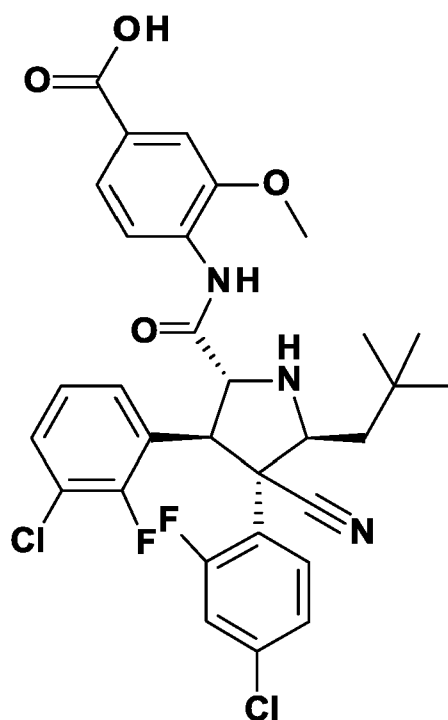
SOLID FORMS OF A PHARMACEUTICALLY ACTIVE COMPOUND

FIELD OF THE INVENTION

The present invention relates to various forms of compounds, for example, compounds that have use in pharmaceutical applications.

BACKGROUND OF THE INVENTION

- 5 The compound 4-[(2R, 3S,4R,5S)-4-(4-Chloro-2-Fluoro-Phenyl)-3-(3-Chloro-2-Fluoro-Phenyl)-4-Cyano-5-(2,2-Dimethyl-Propyl)-Pyrrolidine-2-Carbonyl]-Amino}-3- Methoxy - Benzoic Acid is represented by formula (1)



(1).

The compound of formula (1), or compound (1), as well as methods for making it, are disclosed
 10 in U.S. Patent No. 8,354,444 and WO2011/098398.

4-[(2R,3S,4R,5S)-4-(4-Chloro-2-fluoro-phenyl)-3-(3-chloro-2-fluoro-phenyl)-4-cyano-5-(2,2-dimethyl-propyl)-pyrrolidine-2-carbonyl]-amino}-3-methoxy-benzoic acid (C₃₁H₂₉Cl₂F₂N₃O₄) is a potent and selective inhibitor of the p53-MDM2 interaction that activates the p53 pathway and

induces cell cycle arrest and/or apoptosis in a variety of tumor types expressing wild-type p53 in vitro and in vivo. Compound (1) belongs to a novel class of MDM2 inhibitors having potent anti-cancer therapeutic activity, in particular in leukemia such as acute myeloid leukemia (AML) and solid tumors such as for example head and neck, non-small cell lung, breast and colorectal
5 cancers, as well as sarcoma.

The above-identified international patent application and US Patent describe Compound A in crystalline form and is herein incorporated by reference in its totality. The crystalline form of the compound has an on-set melting point of approximately 277 °C. The crystalline forms have
10 relatively low aqueous solubility (<0.05 µg/mL in water) at physiological pHs (which range from pH1.5-8.0) and consequently less than optimal bioavailability (high variability). It is thus desirable to obtain a form of the compound which has improved solubility/dissolution rate and bioavailability.

15 Active pharmaceutical ingredients (API's) may be prepared in a variety of different forms, such as for example salts, solvates, hydrates, co-crystals. API's may also be in their amorphous state or one or several crystalline forms (polymorphs). Depending on the form, the physicochemical properties of an API may change, leading to e.g. different solubility, thermodynamic stability, density or melting point of different forms. Such physicochemical properties therefore may have
20 significant influence of the efficacy or bioavailability of a known API.

SUMMARY OF THE INVENTION

The present invention provides solid forms of compound (1) selected from the group consisting of,

- a) a substantially amorphous form of compound (1);
- 25 b) a hemi-hydrate, hydrate, hemi-solvate or solvate of compound (1);
- c) a polymorph of compound (1); or
- d) a pharmaceutically acceptable salt of compound (1).

In one particular embodiment, said solid form is selected from a hemi-hydrate or -solvate designated form IV, V, VI, VII of compound (1).

In another particularly preferred embodiment, said solid form is selected from a polymorph designated form I, II and III of compound (1).

In yet another preferred embodiment, said solid form is selected from the substantially amorphous form of compound (1).

- 5 In another embodiment, the invention provides a method of for treating a disease or condition in a mammal in need thereof. The method includes administering to the mammal an effective amount of a composition comprising a solid form compound as described herein.

The solid forms disclosed herein may be further processed into any type of solid pharmaceutical preparations or dosage forms, which are known to the person of skill in the art. Particularly
10 preferred are oral dosage forms such as tablets, capsules, pills, powders, suspensions, pasts and the like. Detailed descriptions of suitable excipients as well as methods for making such pharmaceutical preparations can for example be found in: Raymond C. Rowe et al, *Handbook of Pharmaceutical Excipients*, 6th edition, **2009**, Pharmaceutical Press (Publ.); ISBN-10: 0853697922.

- 15 Consequently, so obtained pharmaceutical preparations form further embodiments provided herein.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1: FTIR spectra of amorpheous form of compound (1);

Fig. 2: FTIR spectra of Form I of compound (1);

- 20 Fig. 3: FTIR spectra of Form III of compound (1);

Fig. 4: FTIR spectra of Form IV of compound (1);

Fig. 5: FTIR spectra of Form V of compound (1);

Fig. 6: FTIR spectra of Form VI of compound (1);

Fig. 7: FTIR spectra of Form VII of compound (1);

- 25 Fig. 8: XRPD curve of Form I of compound (1);

Fig. 9: XRPD curve of Form II of compound (1);

Fig. 10: XRPD curve of Form III of compound (1);

Fig. 11: XRPD curve of Form IV of compound (1);

Fig. 12: XRPD curve of Form V of compound (1);

5 Fig. 13: XRPD curve of Form VI of compound (1);

Fig. 14: XRPD curve of Form VII of compound (1);

Fig. 15: XRPD curve of the amorphous form of compound (1).

DETAILED DESCRIPTION OF THE INVENTION

10 As used herein, the general term “amorphous forms” denote a material that lacks long range order and as such does not show sharp X-ray peaks. The X-Ray Powder Diffraction (XRPD) pattern of an amorphous material is characterized by one or more amorphous halos. More specifically, the term “amorphous form” as used herein refers to the amorphous form of 4-
15 CC(C)C1CCN(C1C(=O)Nc2ccc(OC)cc2)C3=CC=C(C=C3)C(F)=CC(F)=C3 [(2R,3S,4R,5S)-4-(4-Chloro-2-fluoro-phenyl)-3-(3-chloro-2-fluoro-phenyl)-4-cyano-5-(2,2-dimethyl-propyl)-pyrrolidine-2-carbonyl]-amino}-3-methoxy-benzoic acid (compound 1) *as such*, provided said amorphous form does not form a one phase system, such as for example a solid dispersion or microprecipitated bulk powder (MBP) together with any type of supporting material such as polymers or the like.

20 The amorphous form of the invention is preferentially substantially pure, meaning the amorphous form includes less than about 15%, preferably less than about 10%, preferably less than about 5%, preferably less than about 1%, even more preferably less than 0.1% by weight of impurities, including other polymorph forms of compound (1). In some embodiments, at least about 30-99% by weight of the total of compound 1 in the composition is present as the amorphous form. In further embodiments, at least about 70%, at least about 80%, at least about
25 90%, at least about 99% or at least about 99.9% by weight of the total of compound 1 in the composition is present as the amorphous form. Also provided by the invention are compositions consisting essentially of compound (1) wherein at least about 97-99% by weight of the compound (1) is present in the composition as an amorphous form, a polymorph form, a solvate form as described herein or combinations thereof.

The term “polymorph” as used herein means one of the different crystal structures in which a compound can crystallize. Polymorphs are best characterized by their space group and unit-cell parameters. This term is reserved for materials with the same elemental analysis.

“Ambient temperature” means any temperature in the range of 18 to 28 °C, preferably 20 to 24 °C.

The term “composition” refers to a pharmaceutical preparation suitable for administration to an intended animal subject for therapeutic purposes that contains at least one pharmaceutically active compound, including any solid form thereof. The composition may include at least one additional pharmaceutically acceptable component to provide an improved formulation of the compound, such as a suitable carrier or excipient.

The term “pharmaceutically acceptable” indicates that the indicated material does not have properties that would cause a reasonably prudent medical practitioner to avoid administration of the material to a patient, taking into consideration the disease or conditions to be treated and the respective route of administration. For example, it is commonly required that such a material be essentially sterile, e.g., for injectibles.

FTIR (Fourier-Transform Infrared) spectra were recorded as film of a Nujol suspension of approximately 5 mg of sample and few Nujol between two sodium chloride plates, with an FTIR spectrometer in transmittance. The Spectrometer is a Nicolet™ 20SXB or equivalent (resolution 2 cm⁻¹, 32 or more co-added scans, MCT detector). Characteristic wavenumbers for the solid forms according to the present invention are shown in Table 1 below:

Table 1: Characteristic Bands (cm⁻¹) in the IR Spectra for amorphous, polymorphs and solvates of Compound (1). (Error on wavenumbers is ± 1 cm⁻¹)

Form Amorphous	Form I	Form II	Form III	Form IV	Form V	Form VI	Form VII
1705	1703	n.d.	1687	1718	1684	1707	1752
1687	1688	n.d.	1599	1684	1588	1687	1702
1600	1599	n.d.	1586	1586	1524	1601	1652
1587	1588	n.d.	1524	1525	1484	1588	1591
1525	1525	n.d.	1482	1485	1458	1525	1531
1483	1484	n.d.	1457	1467	1406	1483	1492
1409	1408	n.d.	1408	1457	1273	1425	1460
1367	1368	n.d.	1344	1407	1247	1408	1419
1343	1342	n.d.	1274	1294	1229	1367	1266
1299	1297	n.d.	1249	1273	1176	1343	1221
1276	1274	n.d.	1221	1230	1128	1302	1179
1250	1248	n.d.	1178	1221	1086	1276	1114

1230	1230	n.d.	1126	1178	1029	1232	1031
1221	1130	n.d.	1084	1128	901	1221	899
1178	1035	n.d.	1031	1085	887	1086	884
1128	903	n.d.	901	1032	856	884	861
1086	886	n.d.	883	900	817	766	816
1034	764	n.d.	856	883	779	759	779
902	-	n.d.	846	856	763	-	768
885	-	n.d.	816	817	729	-	746
817	-	n.d.	777	777	706	-	731
778	-	n.d.	756	763	661	-	709
765	-	n.d.	731	729	-	-	663
729	-	n.d.	703	704	-	-	-
-	-	n.d.	661	661	-	-	-

n.d.: not determined

X-ray powder diffraction (XRPD) patterns were recorded at ambient conditions in transmission geometry with a STOE STADIP diffractometer (Cu K α radiation, primary monochromator, silicon strip detector, angular range 3° to 42° 2Theta, approximately 30 minutes total measurement time). The samples were prepared and analyzed without further processing (e.g. grinding or sieving) of the substance. Characteristic 2-theta values for the solid forms according to the present invention are shown in Table 2 below:

10 **Table 2:** Distinguishing Characteristic 2- θ (2-theta) values in the XRPD pattern for amorphous, polymorphs and solvates of Compound (1)

Form Amorphous	Form I	Form II	Form III	Form IV	Form V	Form VI	Form VII
-	4.9	4.1	5.9	5.1	3.9	5.5	6.6
-	6.9	5.0	8.3	8.0	7.8	7.4	10.7
-	7.7	5.7	9.5	8.3	8.7	14.5	14.6
-	9.1	6.3	10.1	8.8	9.1	14.8	15.7
-	10.9	6.9	11.3	9.3	13.7	15.6	16.0
-	13.5	7.9	14.2	10.0	14.5	16.9	16.4
-	14.5	8.1	15.8	10.3	18.2	17.8	18.9
-	17.2	9.0	17.6	13.7	20.3	18.6	19.8
-	20.4	10.0	19.0	14.3	-	19.9	21.4
-	22.3	14.3	19.4	18.7	-	20.5	22.0
-	25.5	19.5	19.8	20.2	-	24.8	25.3
-	-	-	20.3	20.8	-	26.7	26.1
-	-	-	25.5	27.6	-	-	-

Therefore, in one embodiment there is provided the form I of compound (1), characterized by the XRPD patterns at 2-theta values of 4.9, 6.9, 7.7, 9.1, 10.9, 13.5, 14.5, 17.2, 20.4, 22.3 and 25.5; or by the corresponding characteristic wavenumbers according to Table 1.

5 In another embodiment there is provided the form II of compound (1), characterized by the XRPD patterns at 2-theta values of 4.1, 5.0, 5.7, 6.3, 6.9, 7.9, 8.1, 9.0, 10.0, 14.3 and 19.5; or by the corresponding characteristic wavenumbers according to Table 1.

In another embodiment there is provided the form III of compound (1), characterized by the XRPD patterns at 2-theta values of 5.9, 8.3, 9.5, 10.1, 11.3, 14.2, 15.8, 17.6, 19.0, 19.4, 19.8, 20.3 and 25.5; or by the corresponding characteristic wavenumbers according to Table 1.

10 In another embodiment there is provided the form IV of compound (1), characterized by the XRPD patterns at 2-theta values of 5.1, 8.0, 8.3, 8.8, 9.3, 10.0, 10.3, 13.7, 14.3, 18.7, 20.2, 20.8 and 27.6; or by the corresponding characteristic wavenumbers according to Table 1.

In another embodiment there is provided the form V of compound (1), characterized by the XRPD patterns at 2-theta values of 3.9, 7.8, 8.7, 9.1, 13.7, 14.5, 18.2 and 20.3; or by the
15 corresponding characteristic wavenumbers according to Table 1.

In another embodiment there is provided the form VI of compound (1), characterized by the XRPD patterns at 2-theta values of 5.5, 7.4, 14.5, 14.8, 15.6, 16.9, 17.8, 18.6, 19.9, 20.5, 24.8 and 26.7; or by the corresponding characteristic wavenumbers according to Table 1.

In another embodiment there is provided the form VII of compound (1), characterized by
20 the XRPD patterns at 2-theta values of 6.6, 10.7, 14.6, 15.7, 16.0, 16.4, 18.9, 19.8, 21.4, 22.0, 25.3 and 26.1; or by the corresponding characteristic wavenumbers according to Table 1.

In another embodiment there is provided the amorphous form of compound (1), characterized by the FTIR wavenumbers, in cm^{-1} , of 1705, 1687, 1600, 1587, 1525, 1483, 1409, 1367, 1343, 1299, 1276, 1250, 1230, 1221, 1178, 1128, 1086, 1034, 902, 885, 817, 778, 765 and
25 729.

The solid forms of compound (1) as disclosed herein can be used in a wide variety of preparations for administration of drugs, and in particular for oral dosage forms. Exemplary dosage forms include powders or granules that can be taken orally either dry or reconstituted by addition of water to form a paste, slurry, suspension or solution; tablets, capsules, or pills.
30 Various additives can be mixed, ground or granulated with the solid dispersion as described herein to form a material suitable for the above dosage forms. Potentially beneficial additives may fall generally into the following classes: other matrix materials or diluents, surface active

agents, drug complexing agents or solubilizers, fillers, disintegrants, binders and lubricants. With respect to the solvates and polymorphs as disclosed herein, pH modifiers (e.g., acids, bases, or buffers) may also be added. Examples of other matrix materials, fillers, or diluents include lactose, mannitol, xylitol, microcrystalline cellulose, calcium diphosphate, and starch. Examples of surface active agents include sodium lauryl sulfate and polysorbate 80. Examples of drug complexing agents or solubilizers include the polyethylene glycols, caffeine, xanthene, gentisic acid and cyclodextrins. Examples of disintegrants include sodium starch glycolate, sodium alginate, carboxymethyl cellulose sodium, methyl cellulose, and croscarmellose sodium. Examples of binders include methyl cellulose, microcrystalline cellulose, starch, and gums such as guar gum, and tragacanth. Examples of lubricants include magnesium stearate and calcium stearate. Examples of pH modifiers include acids such as citric acid, acetic acid, ascorbic acid, lactic acid, aspartic acid, succinic acid, phosphoric acid, and the like; bases such as sodium acetate, potassium acetate, calcium oxide, magnesium oxide, trisodium phosphate, sodium hydroxide, calcium hydroxide, aluminum hydroxide, and the like, and buffers generally comprising mixtures of acids and the salts of said acids. At least one function of inclusion of such pH modifiers is to control the dissolution rate of the drug, matrix polymer, or both, thereby controlling the local drug concentration during dissolution.

In addition to the above additives or excipients, use of any conventional materials and procedures for formulation and preparation of oral dosage forms using the compositions disclosed herein known by those skilled in the art are potentially useful. For example, the skilled artisans may formulate the compositions in an appropriate manner, and in accordance with accepted practices, such as those described in Remington's Pharmaceutical Sciences (Gennaro, Ed., Mack Publishing Co., Pa. 1990).

Consequently, a further embodiment includes a pharmaceutical preparation containing the solid forms of compound (1) as obtained by a method as described herein.

In one embodiment, there is provided a pharmaceutical composition comprising one or several solid forms of compound (1) as disclosed herein together with pharmaceutically acceptable adjuvants or excipients.

In another embodiment, there is provided the use of one or several solid forms as disclosed herein as medicaments.

In another embodiment, there is provided the use of one or several solid forms as disclosed herein as medicaments for the treatment of cancer, in particular AML, head and neck cancer or sarcoma.

The invention is now further described by the following specific working, which are not
5 meant to limit in any way the scope of the present invention.

EXAMPLES

Amorphous Form

12.5 g of Compound (1) were dissolved in 487.5 g acetone and stirred at 25 °C for 1 hour. Subsequently the solution was filtered through a GF 5- filter. The clear solution was spray-dried in the Büchi Mini Spray Dryer B-290 (Inlet temperature: 90 °C, Outlet temperature: 130 °C, Respirator 100%, flow-rate 220 g/h. Subsequently the isolated material was dried at 50 °C under vacuum (0-20 mbar) for 24 hours.

Yield: 6.0 g (48.0%)

Form I (Polymorph)

To a solution of 15.8 g of Compound (1) in 264.2 g THF/ethylacetate (70/30 %-m/m) 450.0 g n-propanol were added. From the mixture 358 g solvent were distilled off (115 °C AT). The obtained suspension was cooled down to 10 °C within 5 h and hold for addition 30 min at 10 °C.

The suspension was filtered and the isolated crystals were washed with 50 mL n-propanol and dried at 80 °C under vacuum (0-20 mbar) for 16 hours.

Form II (Polymorph)

A suspension of 316 mg of Compound (1) (Form I) was equilibrated in 3.0 mL of acetonitrile/water 80:20 (v/v) at ambient temperature for 25 days. The product was isolated by filtration and dried at 25 °C/200 mbar for 4 days.

Form III (Polymorph)

Method A

0.5 g of Compound (1) were suspended in 5.0 g chloroform and dissolved at 60 °C. The mixture was filtered through a GF 5 Filter. Subsequently the solution was cooled to room temperature and crystals were formed spontaneously. After 2 hours at room temperature, the crystals were filtered off and dried at 50 °C under vacuum (0-20 mbar) for 24 hours.

Yield: 0.2 g (40 %)

Method B

20.0 g of Compound (1) were dissolved in 106.0 g tetrahydrofuran at 60 °C (AT). 300.0 g acetonitrile were added and the mixture was distilled (95 °C AT) until a volume of 300 mL was reached. The obtained suspension was cooled down to 10 °C within 1-5 h. The suspension was
5 filtered and the isolated crystals were washed with 39.1 g acetonitrile and dried at 80 °C under vacuum (0-20 mbar) for 72 hours.

Yield: 18.8 g (94 %)

Form IV (hemi-hydrate)

10 A Suspension of 2.0 g of Compound (1) in 15.8 g methanol was stirred at 25 °C for 3 days. Subsequently the white suspension was filtered and the isolated product was dried for 5 days in a vacuum oven (0-20 mbar, 50 °C) equipped with an open water bowl (to provide water vapor inside).

Yield: 1.9 g (94.0 %)

15

Form V (hemi-hydrate)

200 mg of Compound (1) (Form I) were incubated in a desiccator at 75 %-RH at ambient temperature for 23 days and analyzed under the same conditions.

20 *Form VI (2-methyl THF hemi-solvate)*

A suspension of 350 mg of Compound (1) (Form I) was agitated in 3.0 mL of 2-methyl tetrahydrofuran at ambient temperature for 28 days. The product was isolated by filtration stored at ambient conditions for 24 h.

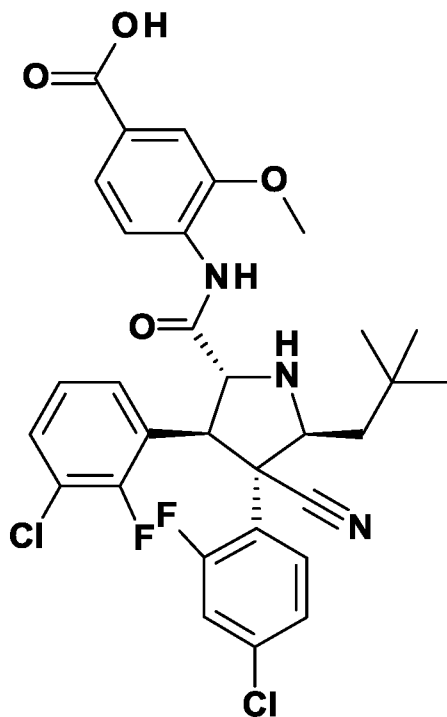
25 *Form VII (Acetic acid sesqui-solvate)*

A Suspension of 284 mg of Compound (1) (Form I) was agitated in 4.0 mL of acetic acid at ambient temperature for 26 days. The product was isolated by filtration and dried at 25 °C/400 mbar for 4 days.

30

CLAIMS

1. A solid form of compound (1)



(1),

5 selected from

- e) a substantially amorphous form of compound (1);
- f) a hemi-hydrate, hydrate, hemi-solvate or solvate of compound (1); or
- g) a polymorph of compound (1); or
- h) a pharmaceutically acceptable salt of compound (1).

10 2. A solid form according to claim 1, characterized in that said solid form is a polymorph, hydrate, hemi-hydrate, solvate, hemi-solvate or pharmaceutically acceptable salt.

3. A solid form according to claim 1, characterized in that it is the amorphous form.

4. A solid form according to claim 1 or 2, characterized by the XRPD patterns at 2-theta values of 4.9, 6.9, 7.7, 9.1, 10.9, 13.5, 14.5, 17.2, 20.4, 22.3 and 25.5.

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5. A solid form according to claim 1 or 2, characterized by the XRPD patterns at 2-theta values of 4.1, 5.0, 5.7, 6.3, 6.9, 7.9, 8.1, 9.0, 10.0, 14.3 and 19.5.

6. A solid form according to claim 1 or 2, characterized by the XRPD patterns at 2-theta values of 5.9, 8.3, 9.5, 10.1, 11.3, 14.2, 15.8, 17.6, 19.0, 19.4, 19.8, 20.3 and 25.5.

5 7. A solid form according to claim 1 or 2, characterized by the XRPD patterns at 2-theta values of 5.1, 8.0, 8.3, 8.8, 9.3, 10.0, 10.3, 13.7, 14.3, 18.7, 20.2, 20.8 and 27.6.

8. A solid form according to claim 1 or 2, characterized by the XRPD patterns at 2-theta values of 3.9, 7.8, 8.7, 9.1, 13.7, 14.5, 18.2 and 20.3.

9. A solid form according to claim 1 or 2, characterized by the XRPD patterns at 2-theta
10 values of 5.5, 7.4, 14.5, 14.8, 15.6, 16.9, 17.8, 18.6, 19.9, 20.5, 24.8 and 26.7.

10. A solid form according to claim 1 or 2, characterized by the XRPD patterns at 2-theta values of 6.6, 10.7, 14.6, 15.7, 16.0, 16.4, 18.9, 19.8, 21.4, 22.0, 25.3 and 26.1.

11. A solid form according to claim 3, characterized by the FTIR wavenumbers, in cm^{-1} , of
15 1705, 1687, 1600, 1587, 1525, 1483, 1409, 1367, 1343, 1299, 1276, 1250, 1230, 1221, 1178,
1128, 1086, 1034, 902, 885, 817, 778, 765 and 729.

12. A pharmaceutical composition comprising one or several solid forms according to any one of claims 1 to 11, together with pharmaceutically acceptable adjuvants or excipients.

13. The novel compounds, methods, compositions and uses substantially as described herein.