

**A CRYSTALLINE ANHYDROUS FORM OF CABAZITAXEL, PROCESS  
FOR THE PREPARATION AND PHARMACEUTICAL COMPOSITIONS  
THEREOF**

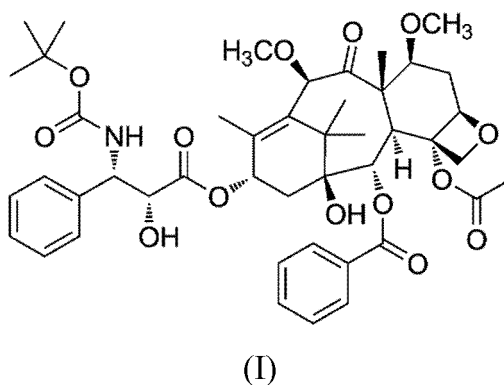
**FIELD OF THE INVENTION**

The present invention relates to a new crystalline anhydrous form of Cabazitaxel, to a process for its preparation and to pharmaceutical compositions thereof.

5 **BACKGROUND OF THE INVENTION**

Cabazitaxel is a semi-synthetic derivative of the natural taxoid 10-deacetylbaccatin III, commercialized as acetone solvate. It stabilizes microtubules leading eventually to the mitotic arrest of proliferating cells. It has been approved in the United States of America for the second line treatment of  
10 hormone-refractory prostate cancer following a docetaxel-based treatment.

Cabazitaxel has the following formula (I):



15 Its chemical name is 4 $\alpha$ -acetoxoy-2 $\alpha$ -benzoyloxy-5 $\beta$ ,20-epoxy-1 $\beta$ -hydroxy-7 $\beta$ ,10 $\beta$ -dimethoxy-9-oxo-11-taxen-13 $\alpha$ -yl (2R,3S)-3-*tert*-butoxycarbonylamino-2-hydroxy-3-phenylpropionate.

Cabazitaxel and methods for the preparation thereof are described in WO96/30355 and in WO99/25704.

20 WO2005/028462 describes an acetone solvate of Cabazitaxel, sometimes

referred to as form A. Despite the fact that crystallisation of the acetone solvate is a very effective way for removing impurities, a better pharmaceutical form will be pure Cabazitaxel without any crystallization solvent.

Additional crystalline solvate forms of Cabazitaxel referred to as form I  
5 (toluene solvate), form II (methyl *tert*-butyl ether solvate), form III  
(2-propanol solvate), form IV (1-butanol solvate), form V (1-propanol solvate) and  
an amorphous form of Cabazitaxel in a powdery, non-foamy form are described in  
WO2012/142117 (Teva). Solvates are rarely used in pharmaceuticals because the  
solvents are volatile thus making it difficult to maintain the solvent in the crystal.  
10 If the API desolvates due to storage conditions or otherwise, it could lead to the  
formation of multiple polymorphs with different physical properties. Additionally,  
amorphous solids are metastable and can lead with time to the formation of  
different polymorphs with different physical properties.

WO2009/115655 (Sanofi) discloses five anhydrous forms of the compound,  
15 referred to as forms B, C, D, E and F; three ethanol solvates, referred to as  
ethanolate forms B, D, E; an ethanol/water heterosolvate form F; and a  
monohydrate-solvent free form C and a dihydrate-solvent free form C. Reaching  
high purities with these forms is only possible providing the API has been  
previously purified by other techniques such as for example passing through the  
20 acetone solvate (as described in the application). However the introduction of a  
further purification technique hampers the manufacturing process with inefficiency  
due to longer production times and lower yield.

WO 2013/134534 discloses crystalline Cabazitaxel solvates with:

- alkyl acetates, such as the solvates with ethyl acetate (Form VII),  
25 isopropyl acetate (Form VIII), methyl acetate (Form XVII), butyl acetate (Form  
XVIII) and isobutyl acetate (Form XXI);

- ketones, such as the solvates with methyl ethyl ketone (Form IX) and  
methyl isobutyl ketone (Form X);

- alcohols, such as the solvates with 2-butanol (Form XI), isobutanol (Form XII) and amyl alcohol (Form XIII).

WO 2013/134534 also describes solvates with dioxolane (Form XIV), 1,4-dioxane (Form XV), 1,2-propanediol (Form XIX), glycerol (Form XX) and 1,3-dimethy-2-imidazolidinone (Form XXII). A crystalline Cabazitaxel form designated as Form XVI, which may be anhydrous, is also disclosed.

A crystalline ethyl acetate solvate of Cabazitaxel is disclosed also in WO 2013/088335.

WO2009/115655 discloses two hydrate forms of the compound in particular mono and di-hydrate, both hydrate forms are obtained from anhydrous form C by exposition to moisture. The anhydrous form C as described above is obtained in high purity only by passing through the acetone solvate.

A crystalline form of Cabazitaxel obtained from acetone/water is described in CN 102675257 A.

Crystalline forms, including an anhydrate form, of Cabazitaxel, designated as Forms C1, C2, C3, C4, C5, C6, C7, C8, C8b, C9 and C9p are described in WO2013/034979.

Finally, 13 crystalline forms referred to as Form-1, Form-2, Form-3, Form-4, Form-5, Form-6, Form-7, Form-8, Form-9, Form-10, Form-11, Form-12, and Form-13 are disclosed in WO2013/0109870.

It is still desirable to find new crystalline forms able to solve the aforementioned problems.

### **BRIEF DESCRIPTION OF THE INVENTION**

Object of the present invention is a new anhydrous crystalline form of Cabazitaxel, designated as form H. A further object of the present invention are processes for the preparation of the above mentioned crystalline form and pharmaceutical compositions thereof.

In the present invention the term “anhydrous” refers to a crystalline form of

Cabazitaxel which contains less than 1% of adsorbed moisture as determined by Karl Fisher analysis.

Form H is an anhydrous crystalline form of Cabazitaxel obtained crystallizing Cabazitaxel from a mixture of decanoyl- and octanoyl triglycerides (CAS number 52622-27-2), known under the trade name Miglyol® 812, or from glycerol trioctanoate.

### BRIEF DESCRIPTION OF THE FIGURES

Figure 1 X-RPD pattern of the crystalline form H of Cabazitaxel

Figure 2 FTIR spectrum of the anhydrous crystalline form H of Cabazitaxel in the 4000-550 cm<sup>-1</sup> spectral range

Figure 3 TG and DTA profiles of the anhydrous crystalline form H of Cabazitaxel

Figure 4 DSC profile of the anhydrous crystalline form H of Cabazitaxel

### DETAILED DESCRIPTION OF THE INVENTION

Form H of Cabazitaxel according to the present invention is characterised by a x-ray powder diffraction (X-RPD) pattern obtained using the copper wavelengths  $\lambda_1$  and  $\lambda_2$  of 1.54056 Å and 1.54439 Å, respectively, essentially as depicted in Figure 1. The X-RPD pattern shows a crystalline structure and comprises distinctive reflections, expressed as 2-theta degrees values, at 5.8, 6.5, 8.1, 9.5, 10.9, 11.5, 12.2, 13.0, 14.1, 14.8, 16.8, 17.2, 19.0, 19.4, 20.1, 21.9 and  $24.0 \pm 0.2$ .

The X-RPD pattern as depicted in Figure 1 was indexed by TOPAS with an orthorhombic cell and possible space group  $P2_12_12_1$ . A Pawley refinement converged to a  $R_{wp} = 7.065\%$  with the following cell parameters:  $a = 18.693(4)$  Å,  $b = 27.461(5)$  Å,  $c = 8.587(1)$  Å,  $\alpha = \beta = \gamma = 90^\circ$ ,  $V = 4408(1)$  Å<sup>3</sup> and space group  $P2_12_12_1$ , coherent with the presence of 4 molecules in the cell.

Form H may be further characterised by a Fourier-Transform InfraRed

Spectroscopy (FTIR) spectrum in the 4000-550  $\text{cm}^{-1}$  spectral range in ATR mode essentially as depicted in Figure 2. The FTIR spectrum of form H comprises characteristic absorption frequencies at 3615, 3449, 3060, 2982, 2939, 2893, 2826, 1742, 1711, 1489, 1450, 1390, 1368, 1315, 1273, 1263, 1247, 1172, 1098, 1071,  
5 1027, 989, 947, 919, 883, 832, 802, 781, 718, 704, 675 and  $637 \pm 4 \text{ cm}^{-1}$ .

Form H may be further characterised by Thermogravimetric (TG) and Differential Thermal Analysis (DTA) profiles as depicted in Figure 3. The DTA profile is characterised by a melting peak with onset at about  $184^{\circ}\text{C}$  and maximum at  $192.9^{\circ}\text{C}$  followed by an intense exothermic peak due to decomposition.

10 In the TG profile, the absence of weight loss until melting is coherent with an anhydrous product, free of residual solvents.

Form H may be further characterised by a DSC profile as depicted in Figure 4. The DSC profile is coherent with the DT signal and shows a thermal profile characterised by a melting peak with onset at  $187.4^{\circ}\text{C}$ , maximum at  $192.5^{\circ}\text{C}$ , and  
15  $\Delta H = -41.03 \text{ J/g}$ , followed by decomposition which takes place above  $200^{\circ}\text{C}$ .

When the crystalline form of Cabazitaxel according to the present invention is referred to herein as being characterized by graphical data essentially as depicted in a figure, such as for, for example, the X-RPD diffractogram, the TG/DTA, DSC profiles and the FTIR spectrum, the skilled person will understand that such  
20 graphical representations of data may be affected by small variations which may be triggered by experimental variability affecting the instrumental response and/or the sample concentration and purity. These variations are well known to the skilled person and they will not prevent him from comparing the graphical data in the figures herein with graphical data generated for an unknown crystal form and from  
25 assessing whether the two sets of graphical data are characterizing the same crystal form or two different crystal forms.

The anhydrous crystalline form H of Cabazitaxel of the present invention may be prepared starting from a solution of Cabazitaxel in a mixture of decanoyl-

and octanoyl triglycerides or in glycerol trioctanoate, as described in Example 1 or 2, respectively. Precipitation of the crystals of the anhydrous form H occurs spontaneously and may be completed by the-addition of an anti-solvent such as heptane. The obtained crystals are then recovered by filtration, washed with fresh  
5 anti-solvent and dried.

A further object of the invention is therefore a process for the preparation of the crystalline anhydrous form H of Cabazitaxel comprising the following steps:

- a) dissolution of Cabazitaxel in a mixture of decanoyl- and octanoyl triglycerides or in glycerol trioctanoate at 20-25°C;
- 10 b) stirring of the solution obtained in step a), wherein a product starts to crystallize;
- c) addition of heptane to the slurry obtained in step b);
- d) filtration and drying of the precipitate obtained in step c), to afford the crystalline form H of Cabazitaxel.

15 The crystalline anhydrous form H of the invention may be obtained with purity higher than 99% when obtained as described in the examples 1-2.

The anhydrous crystalline form of the invention is endowed with several advantageous properties as compared to the previously disclosed forms of Cabazitaxel in term of, for example, high purity obtainable without the need of an  
20 additional crystallization, stability to conversion to other polymorphic forms, better handling and improved processability.

In view of the above described advantages, the anhydrous crystalline form H of Cabazitaxel of the invention is useful for the preparation of Cabazitaxel, Cabazitaxel salts, and polymorphic forms thereof.

25 In addition, the anhydrous crystalline form H of the invention is particularly useful as a medicament, especially for the treatment of cancers and, in particular, of prostate cancers such as, for example, hormone-resistant prostate cancer.

The above uses of the anhydrous crystalline form H of Cabazitaxel

represent a further object of the invention.

For the therapeutic uses, the anhydrous crystalline form H of the invention may be incorporated in conventional pharmaceutical compositions containing at least one excipient suitable for the pharmaceutical uses, which represent a further  
5 object of the invention.

The invention is now further illustrated by the following examples, wherein a crude Cabazitaxel was used as starting material.

### EXAMPLE 1

#### Preparation of anhydrous crystalline form H of Cabazitaxel by Miglyol®

##### 10 812 recrystallization of crude Cabazitaxel

Crude Cabazitaxel (1 g) was dissolved in Miglyol® 812 (28 g) at room temperature. The solution was left to crystallized then heptane (112 mL) was added. The precipitate was filtered, washed with heptane and dried under vacuum for 16 hours at about 60°C. Cabazitaxel with purity higher than 99% was obtained.

15 Yield 85%.

### EXAMPLE 2

#### Preparation of anhydrous form H of Cabazitaxel by glycerol trioctanoate recrystallization of crude Cabazitaxel

Crude Cabazitaxel (1 g) was dissolved in glycerol trioctanoate (28 g) at  
20 room temperature. The solution was left to crystallize then heptane (112 mL) was added. The precipitate was filtered, washed with heptane and dried under vacuum for 16 hours at about 60°C. Cabazitaxel with purity higher than 99% was obtained. Yield 84%.

### EXAMPLE 3

25 The compound obtained according to Examples 1-2 was characterized using the below described techniques.

#### X-Ray Powder Diffraction (X-RPD) (Figure 1)

X-RPD patterns were collected on a Bruker D2-Phaser Diffractometer. The

x-ray generator was operated at 30kV and 10 mA, using the CuK $\alpha$  line as the radiation source. The sample was packed on a suitable slit and the irradiated length was 10mm. Data were collected between 2 and 50 deg 2-theta with a step size of 0.02 deg 2-theta and a counting time per step of 3 sec.

5        Fourier-Transform InfraRed Spectroscopy (FTIR) (Figure 2)

The infrared spectrum was recorded in Attenuated Total Reflectance (ATR) mode using Fourier-Transform spectrometer Perkin Elmer Spectrum One, equipped with Specac ATR Golden Gate accessory. The spectrum is the result of the acquisition and transformation of 16 co-added scans in the 4000-550 cm<sup>-1</sup>  
10       spectral region at a resolution of 4 cm<sup>-1</sup>.

Thermogravimetry (TG) and Differential Thermal Analysis (DTA) (Figure 3)

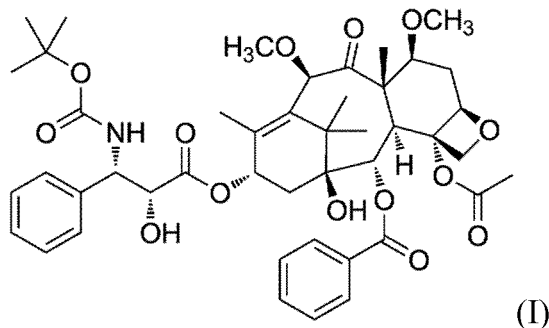
The analysis was performed using a Seiko TG/DTA7200 simultaneous system using open aluminum pans (40  $\mu$ l volume). The TG/DT signals were recorded from 30 to 300°C with linear heating rate (10°C/min) under a 200 ml/min  
15       nitrogen flow. About 10 mg of powder was used for the measurement.

Differential Scanning Calorimetry (DSC) (Figure 4)

The analysis was performed using a Mettler DSC1 System. Heat flow was recorded from 30 to 300°C with linear heating rate (10°C/min) under a 50 ml/min nitrogen flow. About 5 mg of powder was used for the measurement, in closed  
20       aluminum crucible (40  $\mu$ l volume) with a pinhole.

**CLAIMS**

1. An anhydrous crystalline form, referred to as form H, of Cabazitaxel of formula (I)



5 wherein the anhydrous crystalline form has one or more of the following:

- an X-RPD pattern obtained using the copper wavelengths  $\lambda_1$  and  $\lambda_2$  of 1.54056 Å and 1.54439 Å, respectively, comprising distinctive reflections, expressed as 2-theta degrees values, at 5.8, 6.5, 8.1, 9.5, 10.9, 11.5, 12.2, 13.0, 14.1, 14.8, 16.8, 17.2, 19.0, 19.4, 20.1, 21.9 and  $24.0 \pm 0.2$ ;
- an X-RPD pattern obtained using the copper wavelengths  $\lambda_1$  and  $\lambda_2$  of 1.54056 Å and 1.54439 Å, respectively, essentially as depicted in Figure 1;
- TG and DTA profiles obtained with a linear heating rate of 10°C/min essentially as depicted in Figure 3;
- a DSC profile obtained with a linear heating rate of 10°C/min essentially as depicted in Figure 4;

2. The crystalline form of Cabazitaxel according to claim 1, for use in the preparation of Cabazitaxel, Cabazitaxel salts and polymorphic forms thereof.

3. Pharmaceutical compositions containing the anhydrous crystalline form H according to claim 1 in admixture with at least one excipient suitable for the pharmaceutical use.

4. A process for the preparation of the anhydrous crystalline form H according to claim 1, comprising the recrystallization of Cabazitaxel from a mixture of decanoyl- and octanoyl triglycerides or from glycerol trioctanoate.