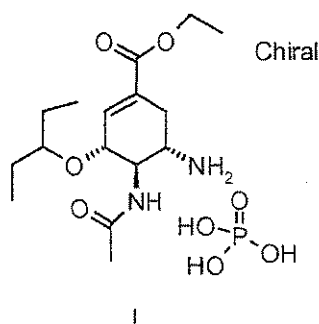


POLYMORPHIC FORMS OF OSELTAMIVIR PHOSPHATE

The present invention relates to polymorphic forms of Oseltamivir phosphate, especially especially the (3R,4R,5S)-5-amino-4-acetylamino-3-(1-ethyl-propoxy)-cyclohex-1-ene-carboxylic acid ethyl ester phosphate, which is a potent inhibitor of viral neuraminidase.

(3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid
5 ethyl ester phosphate of formula (I)



which is disclosed in J. C. Rohloff et al., J. Org. Chem. 63, 1998, 4545-4550 and WO 98/07685 has a potent inhibitory activity against virus neuraminidase. It has been used as an active ingredient of Tamiflu (Registered Trade Mark) that is a preventive or therapeutic agent of influenza.

10 The present invention is based on the certain crystalline forms of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate or amorphous forms thereof which are suitable for preparing a pharmaceutical formulation.

The specific crystalline forms of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate are herein referred to as "crystalline form A",
15 "crystalline form B" and "crystalline form C".

Crystalline form A of the compound of formula (I), which is characterized by an X ray powder diffraction pattern comprising at least three, preferably five, more preferably seven X-ray diffraction peaks (expressed in degrees 2-theta) selected from the group consisting of approximately 5.1, approximately 12.4, approximately 13.0, approximately 14.3; approximately
20 15.2, approximately 16.1, approximately 19.0, approximately 19.3, approximately 20.3, approximately 20.6, approximately 21.6, approximately 24.4 and approximately 26.3. The term

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"approximately" means in this context that there is an uncertainty in the measurements of the degrees 2Theta of ± 0.2 (expressed in degrees 2Theta).

A single crystal structure analysis of form A was conducted. Table 1 lists the some crystal structure data. The experimental X-ray powder diffraction pattern collected with the form A corresponds to the theoretical pattern calculated from crystal structure data. The absolute configuration of the molecules was determined from single crystal structure data. The crystal packing of form A shows hydrogen bonds of the protonated amino group to three phosphate molecules. The amide oxygen accepts a hydrogen from another phosphate molecule.

Consequently, also the phosphate molecule forms hydrogen bonds to four different molecules of the active molecule. It results a hydrogen bonding pattern of tightly bond columns parallel to the crystallographic c-axis. A thermal ellipsoid plot of the crystal structure is shown in figure 8.

Table 1: Crystal structure data of form A

form	---	A
crystal system	---	orthorhombic
space group	---	P 2(1) 2(1) 2
crystal habit	---	needle
unit cell dimensions	[Å] [Å] [Å]	a = 23.8 b = 24.4 c = 7.4
	[°]	$\alpha, \beta, \gamma = 90.0$
temperature	[K]	89
cell volume	[Å ³]	4289
molecules in unit cell	---	8
calculated density	[g/cm ³]	1.27

For single crystal structure analysis a single crystal was mounted in a loop on a goniometer and measured at ambient conditions. Alternatively, the crystal was cooled in a nitrogen stream during measurement. Data were collected on a STOE Imaging Plate Diffraction System (IPDS) from STOE (Darmstadt). In this case Mo-radiation of 0.71 Å wavelength was used for data collection. Data was processed with STOE IPDS-software. The crystal structure was solved and refined with standard crystallographic software. In this case the program ShelXTL from Bruker AXS (Karlsruhe) was used.

Alternatively, synchrotron radiation was used for data collection. A single crystal was mounted in a loop and cooled to 100 K in a nitrogen stream. Data was collected at the Swiss Light Source beamline X10SA using a MAR CCD225 detector with synchrotron radiation and data processed with the program XDS. The crystal structure was solved and refined with standard

crystallographic software. In this case the program ShelXTL from Bruker AXS (Karlsruhe) was used.

The active pharmaceutical ingredient of the commercially available medicament Tamiflu has a crystalline form A.

The present disclosure relates to new crystalline form B of the compound of formula (I), which is characterized by an X ray powder diffraction pattern comprising at least three, preferably five, more preferably seven X-ray diffraction peaks (expressed in degrees 2-theta) selected from the group consisting of approximately 5.3, approximately 6.0, approximately 7.4, approximately 12.1, approximately 12.8, approximately 13.6, approximately 16.1, approximately 18.0, approximately 18.7, approximately 21.4, approximately 23.8 and approximately 24.3. The term "approximately" means in this context that there is an uncertainty in the measurements of the degrees 2Theta of ± 0.2 (expressed in degrees 2Theta).

The present disclosure also relates to new crystalline form C of the compound of formula (I), which is characterized by an X ray powder diffraction pattern comprising at least one, preferably two, more preferably three X-ray diffraction peaks (expressed in degrees 2-theta) selected from the group consisting of approximately 4.5, approximately 9.1 and approximately 13.6. The term "approximately" means in this context that there is an uncertainty in the measurements of the degrees 2Theta of ± 0.2 (expressed in degrees 2Theta).

In one aspect, there is provided a crystalline form C of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate, which is characterized by an X ray powder diffraction pattern comprising at least one X-ray diffraction peaks (expressed in degrees 2-theta) selected from the group consisting of 4.5 ± 0.2 , 9.1 ± 0.2 and 13.6 ± 0.2 .

The present disclosure also relates to amorphous forms of the compound of formula (I), which is characterized by an X ray powder diffraction pattern lacking a Bragg diffraction peak. This amorphous form is also characterized by an X ray powder diffraction pattern comprising one or more amorphous halos.

The present disclosure also relates to pharmaceutical compositions comprising crystalline form(s) mentioned above or the above mentioned amorphous of the compound of formula (I) and a pharmaceutically acceptable excipient.

In another aspect, there is provided pharmaceutical compositions comprising the crystalline form as defined above and a pharmaceutically acceptable carrier.

In another aspect, there is provided an injectable pharmaceutical formulation comprising a pharmaceutically effective amount of crystalline form C as defined above and a pharmaceutically acceptable carrier.

The present disclosure also relates to crystalline form(s) mentioned above or the above mentioned amorphous form of the compound of formula (I) for use as a therapeutically active substance, especially as a therapeutically active substance for the inhibition of influenza viruses, in particular the selective inhibition of viral or bacterial neuraminidases.

In another aspect, there is provided the crystalline form as defined above for use as therapeutic active substance.

In another aspect, there is provided the crystalline form as defined above for use as therapeutic active substance for the treatment and /or prophylaxis of diseases which are associated with virus neuraminidase.

The present disclosure also relates to a use of crystalline form(s) mentioned above or the above mentioned amorphous form of the compound of formula (I) for the preparation of medicaments for the inhibition of influenza viruses, in particular the selective inhibition of viral or bacterial neuraminidases.

In another aspect, there is provided the use of the crystalline form as defined above for the preparation of medicaments for the therapeutic and/or prophylactic treatment of diseases which are associated with virus neuraminidase.

In another aspect, there is provided a method for preparing the crystalline form C of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate, comprising

Step a)

Dissolving compound of formula (I) into water and adjusting pH to 4.0;

Step b)

Sterile filtering the solution through a sterilized 0.22 µm membrane;

Step c)

Aseptic filling the solution into sterile depyrogenated vial and stoppering the vial with a sterile stopper;

Step d)

Lyophilizing the solution in a steam-sterilized freeze-dryer.

Unless otherwise indicated, the following definitions are set forth to illustrate and define the meaning and scope of the various terms used to describe the disclosure herein.

“Amorphous forms” or “amorphous” denote a material that does not show a Bragg diffraction peak. The XRPD pattern of an amorphous material is also characterized by one or more amorphous halos.

Bragg’s law describes the diffraction of crystalline material with the equation:

$$2d \sin \theta = n \lambda$$

wherein d = perpendicular distance between pairs of adjacent planes in a crystal (d -spacing), θ = Bragg angle, λ = wavelength and n = integer.

When Bragg’s law is fulfilled, the reflected beams are in phase and interfere constructively so that *Bragg diffraction peaks* are observed in the X-ray diffraction pattern. At angles of incidence other than the Bragg angle, reflected beams are out of phase and destructive interference or cancellation occurs. Amorphous material does not satisfy Bragg’s law and no *Bragg diffraction peaks* are observed in the X-ray diffraction pattern.

“An amorphous halo” is an approximately bell-shaped diffraction maximum in the X-ray powder diffraction pattern of an amorphous substance. The FWHM of an amorphous halo is on principle bigger than the FWHM of a peak of crystalline material.

“FWHM” means full width at half maximum, which is a width of a peak appearing in an XRPD pattern at its half height.

“Form A” is used herein as abbreviation for the crystalline form A of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

“Form B” is used herein as abbreviation for the crystalline form B of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

“Form C” is used herein as abbreviations for the crystalline form B of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

“IR” is used herein as an acronym of Infra Red spectroscopy. IR 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 coadded scans, MCT detector).

“XRPD (is used herein as an acronym of X-Ray Powder Diffraction)” X-ray diffraction patterns were recorded at ambient conditions in transmission geometry with a STOE STADI P diffractometer (Cu K_{α} radiation, primary monochromator, position sensitive detector, angular

range 3° to 42° 2Theta, approximately 60 minutes total measurement time). The samples were prepared and analyzed without further processing (e.g. grinding or sieving) of the substance.

"Excipient" and "pharmaceutically acceptable excipient" mean inactive pharmaceutically acceptable ingredients that are, other than drug substances, not intended to treat and/or prevent illnesses. It is to be understood that the excipients, including, but not limited to, diluents, surfactants, wetting agents, binders, lubricants, disintegrating agents, carriers, fillers, etc. are of pharmaceutically acceptable grade.

"Pharmaceutically active drug substance(s)" and "drug substance(s)" are used interchangeably to denote a pharmaceutically active principle which is intended to treat and/or prevent illnesses.

"Micronization" means the process whereby the particle size of a single drug substance, is diminished by the aid of a suitable mill, e.g. an air-jet mill.

"Co-micronization" means that a mixture comprising at least one drug substance and at least one excipient is micronized in a suitable mill to obtain a diminished particle size of the drug substance.

Figure 1 shows a XRPD (X-Ray Powder Diffraction) pattern of form A of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Figure 2 shows an IR (InfraRed spectroscopy) spectrum of form A of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Figure 3 shows a XRPD (X-Ray Powder Diffraction) pattern of form B of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Figure 4 shows an IR (InfraRed spectroscopy) spectrum of form B of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Figure 5.1 shows a XRPD (X-Ray Powder Diffraction) pattern of form C of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Figure 5.2 rescaled XRPD (X-Ray Powder Diffraction) pattern of figure 5.1.

Figure 6 shows an IR (InfraRed spectroscopy) spectrum of an amorphous form of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Figure 7 shows a XRPD (X-Ray Powder Diffraction) pattern of an amorphous form of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Figure 8 shows a thermal ellipsoid plot of the crystal structure of form A

Crystalline forms and amorphous forms of the present invention can be prepared, for example, by the general preparation procedures described below.

General Preparation Procedures

Preparation of form A of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Form A may be formed upon spontaneous or seeded solution mediated phase transformation or upon spontaneous or seeded crystallization in organic solvents such as methanol, ethanol, acetonitrile, isopropanol, ethyl acetate, methyl acetate, isopropyl acetate, acetone, benzyl alcohol, methyl cyclohexane and others eventually mixture thereof or other low polarity solvents. Form A is obtained after drying. The accessibility may be influenced by the impurity profile of the compound and the choice of solvent.

Preparation of form B of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Form B may be formed by adding (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester to the phosphoric acid and cooling the supersaturated solution from 50 °C to -40 °C as fast as possible (without seeding).

Preparation of form C of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Crystalline form C of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate may be formed by the method comprising following steps: Step a) dissolving compound of formula (I) into water and adjusting pH to 4.0; Step b) sterile filtering the solution through a sterilized 0.22 µm membrane; Step c) aseptic filling the solution into sterile depyrogenated vial and stoppering the vial with a sterile stopper; Step d) lyophilizing the solution in a steam-sterilized freeze-dryer.

An injectable pharmaceutical formulation may comprises a pharmaceutically effective amount of crystalline form C of compound of formula (I) and a pharmaceutically acceptable carrier.

Preparation of the amorphous form of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate.

Evaporation of a solution of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate in organic solvents such as dichloromethane, ethyl acetate or others leading to amorphous solid state usually as a foam.

A amorphous form of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate may surprisingly also be obtained by micronization of an initially crystalline sample of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate in a agate ball mill.

- 5 Alternatively the amorphous form is obtained by spray drying a solution of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate in organic solvents such as ethanol.

 The crystalline form(s) and the amorphous forms of the present invention can be used as medicaments, e.g. in the form of pharmaceutical preparations for enteral, parenteral or topical
10 administration. They can be administered, for example, perorally, e.g. in the form of tablets, coated tablets, dragées, hard and soft gelatine capsules, solutions, emulsions or suspensions, rectally, e.g. in the form of suppositories, parenterally, e.g. in the form of injection solutions or suspensions or infusion solutions, or topically, e.g. in the form of ointments, creams or oils. Oral administration is preferred.

- 15 The production of the pharmaceutical preparations can be effected in a manner which will be familiar to any person skilled in the art by bringing the described crystalline forms or the amorphous of the compounds of formula (I), optionally in combination with other therapeutically valuable substances, into a galenical administration form together with suitable, non-toxic, inert, therapeutically compatible solid or liquid carrier materials and, if desired, usual pharmaceutical
20 adjuvants.

 Suitable carrier materials are not only inorganic carrier materials, but also organic carrier materials. Thus, for example, lactose, corn starch or derivatives thereof, talc, stearic acid or its salts can be used as carrier materials for tablets, coated tablets, dragées and hard gelatine capsules. Suitable carrier materials for soft gelatine capsules are, for example, vegetable oils,
25 waxes, fats and semi-solid and liquid polyols (depending on the nature of the active ingredient no carriers might, however, be required in the case of soft gelatine capsules). Suitable carrier materials for the production of solutions and syrups are, for example, water, polyols, sucrose, invert sugar. Suitable carrier materials for injection solutions are, for example, water, alcohols, polyols, glycerol and vegetable oils. Suitable carrier materials for suppositories are, for example,
30 natural or hardened oils, waxes, fats and semi-liquid or liquid polyols. Suitable carrier materials for topical preparations are glycerides, semi-synthetic and synthetic glycerides, hydrogenated oils, liquid waxes, liquid paraffins, liquid fatty alcohols, sterols, polyethylene glycols and cellulose derivatives.

Usual stabilizers, preservatives, wetting and emulsifying agents, consistency-improving agents, flavour-improving agents, salts for varying the osmotic pressure, buffer substances, solubilizers, colorants and masking agents and antioxidants come into consideration as pharmaceutical adjuvants.

5 The dosage of the described crystalline forms or the amorphous of the compounds of formula (I) can vary within wide limits depending on the disease to be controlled, the age and the individual condition of the patient and the mode of administration, and will, of course, be fitted to the individual requirements in each particular case. For adult patients a daily dosage of about 1 to 1000 mg, especially about 1 to 100 mg, comes into consideration. Depending on severity of
10 the disease and the precise pharmacokinetic profile the crystalline forms or amorphous forms of the present invention could be administered with one or several daily dosage units, e.g. in 1 to 3 dosage units.

The pharmaceutical preparations conveniently contain about 1-500 mg, preferably 1-100 mg, of the crystalline form(s) or the amorphous forms of the compound of formula (I).

15 To prepare the pharmaceutical preparations, containing the crystalline form(s) or the amorphous forms of the compound of formula (I), these materials are often micronized. Micronization is a commonly used and well known process in the pharmaceutical industry to reduce the particle size of drug substances. The reason for micronization is usually to increase the bioavailability of the drug substance or to improve its overall technical processability.

20 Examples

The following Examples serve to illustrate the present invention in more detail. They are, however, not intended to limit its scope in any manner.

Example 1

Preparation of crystalline form A of the compound of formula (I)

25 0.2 g of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate was heated to reflux in the quantity of solvent stated in table 1 until it was dissolved. The solution was then allowed to cool slowly in an oil bath and then place in a refrigerator at approximately 4 °C overnight. All samples were dried in a vacuum at room temperature.

30 The crystals obtained were analyzed and did not exhibit significant differences between the samples and the reference substance.

Table 1 Experimental conditions of crystallization of form A of formula (I)

Solvent (incl. temperatures range)	Volume of solvent
Ethanol (78 °C to RT)	6.7 ml
Ethanol/acetone (59 °C to RT)	16 ml/72 ml
Isopropanol (83 °C to RT)	32.5 ml
Ethanol/ethyl acetate (77 °C to 4 °C)	25 ml/40 ml
Methanol/acetonitrile (80 °C to 4 °C)	16 ml/60 ml
Methanol/acetone (36 °C to 4 °C)	2 ml/7 ml
Dimethyl formamide (125 °C to RT)	1 ml
Benzyl alcohol/methyl cyclohexane (120 °C to 4 °C)	1 ml/5 ml
Ethanol (60 °C to RT)	7 ml
Methanol/acetone (50 °C to RT)	2 ml/7 ml

Characterization of crystal form A

Form A can be characterized:

-by an X-ray powder diffraction pattern obtained with a Cu K α radiation having characteristic peaks expressed in degrees 2Theta at approximately: approximately 5.1, 12.4, 13.0, 14.3, 15.2, 16.1, 19.0, 19.3, 20.3, 20.6, 21.6, 24.4 and 26.3. The term "approximately" means in this context that there is an uncertainty in the measurements of the degrees 2Theta of ± 0.2 (expressed in degrees 2Theta).

-by an infrared spectrum having sharp bands at approximately: 3352, 3162, 1724, 1663, 1623, 1551, 1376, 1337, 1263, 1173, 1132, 1071, 1027, 953, 880, 854, 731 cm⁻¹. The term "approximately" means in this context that there is an uncertainty in the measurements of the wavenumbers of ± 3 cm⁻¹.

Example 2

Preparation of crystalline form B of the compound of formula (I)

16.9 g of phosphoric acid were mixed with 700 ml ethanol in a nitrogen purged 1000 ml glass reactor fitted with a mechanic stirrer and heated to 50 to 55 °C. A solution of 45.8 g of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester in 250 ml of ethanol was added to the phosphoric acid solution within 3 to 5 minutes under stirring. The result clear solution was cooled to -40 °C within 1 hour without seeding. The obtained crystal suspension was slowly stirred at -40 °C over night. The suspension was filtered and washed with 240 ml of acetone and 300 ml of n-heptane. The crystal was then dried in vacuum under maximal temperature of 50 °C. 53 g of fine white crystal form B was obtained, correspond to a yield of 88.6%.

Characterization of crystal form B

Form B can be characterized:

-by an X-ray powder diffraction pattern obtained with a Cu K α radiation having characteristic peaks expressed in degrees 2Theta at approximately: approximately 5.3, 6.0, 7.4, 12.1, 12.8, 13.6, 16.1, 18.0, 18.7, 21.4, 23.8 and 24.3. The term "approximately" means in this context that there is an uncertainty in the measurements of the degrees 2Theta of ± 0.2 (expressed in degrees 2Theta).

-by an infrared spectrum having sharp bands at approximately: 3347, 3172, 2719, 1728, 1713, 1661, 1619, 1552, 1377, 1335, 1293, 1262, 1245, 1199, 1132, 1072, 1031, 968, 953, 938, 875, 851, 730 cm⁻¹. The term "approximately" means in this context that there is an uncertainty in the measurements of the wavenumbers of ± 3 cm⁻¹.

Example 3Preparation of crystalline form C of the compound of formula (I)

The bulk solution was prepared by dissolution of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate into water for injection followed by pH adjustment with 0.1 N hydrochloric acid (HCl) to pH 4.0.

Before freeze-drying the bulk solution is sterile filtered through a sterilized 0.22 μ m membrane filter using a nitrogen pressure of approx. 0.5 bar (maximum 0.7 bar). The filtrate is collected into a sterile depyrogenated vessel, for example consisting of borosilicate glass.

Under aseptic conditions, the sterile bulk solution is filled into sterile depyrogenated vials which are then stoppered with sterile stoppers in lyo-position and subsequently lyophilized in a steam-sterilized freeze-dryer.

After freeze-drying the vial headspace is overlaid with sterile filtered nitrogen, the vials are fully stoppered and finally sealed with aluminum flip-off caps.

The following lyophilisation cycle was developed.

	Shelf temperature (°C)	Ramp temperature (°C/min)	Ramp time (min)	Holding time (min)	Vacum (mTorr)
Pre-cooling	+5	0	-	60	-
Freezing/Annealing	-40	1	45	180	-
	-5	1	35	240	
	-40	1	30	120	
Primary drying	-5	0.5	70	1100	200

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	Secondary drying optimal by -8°C product temperature				
Secondary drying	+30	0.5	54	300	100
			234	2000	
Total process time	2234 min = 37.2 hrs				

Characterization of crystallin form C

Form C can be characterized:

- 5 -by an X-ray powder diffraction pattern obtained with a Cu K α radiation having characteristic peaks expressed in degrees 2Theta at approximately: approximately 4.5, 9.1 and 13.6. The term “approximately” means in this context that there is an uncertainty in the measurements of the degrees 2Theta of ± 0.2 (expressed in degrees 2Theta).

Example 4

Crystallin form C for use in pharmaceutical formulations

60 mg	declared	filled (incl. 10%)
Form C of compound of formula (I)	60 – 100 – 120	66 – 110 – 132 mg
HCl 0.1N ad pH 4.0	q.s.	q.s.
Water for injection solutions	ad 1 mL	ad 1.2 mL

10

Container: 3 mL flint glass, type I, 13 mm tubing glass vials

Closure: butyl rubber (D777-1), FPE laminated stopper, Aluminium flip-off 13 mm

The lyophilisate was dissolved with 1.1 mL sterile water for injection. The reconstituted solution contains 60, 100 and 120 mg/mL.

15

Example 5

Preparation of the amorphous form of the compound of formula (I)

A crystalline sample of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate was milled for 45 minutes in a agate ball mill and then analyzed.

20

Characterization of the amorphous form

The amorphous form can be characterized:

- by the lack of a Bragg diffraction peak in its XRPD pattern.
- by an infrared spectrum having bands at approximately: approximately 3257, 3180, 3070, 2401, 1717, 1658, 1555, 1301, 1246, 1199, 1127, 1063, 1030, 943, 875, 735 cm⁻¹. The term

“approximately” means in this context that there is an uncertainty in the measurements of the wavenumbers of $\pm 3 \text{ cm}^{-1}$.

Claims

1. Crystalline form C of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-
1-enecarboxylic acid ethyl ester phosphate, which is characterized by an X ray powder
diffraction pattern comprising at least one X-ray diffraction peaks (expressed in degrees 2-
5 theta) selected from the group consisting of 4.5 ± 0.2 , 9.1 ± 0.2 and 13.6 ± 0.2 .
2. Crystalline form C according to claim 1, wherein the X ray powder diffraction pattern
comprises three X-ray diffraction peaks (expressed in degrees 2-theta) selected from the
group consisting of 4.5 ± 0.2 , 9.1 ± 0.2 and 13.6 ± 0.2 .

3. The crystalline form according to claim 1 or 2 for use as therapeutic active substance.
4. The crystalline form according to claim 1 or 2 for use as therapeutic active substance for the treatment and /or prophylaxis of diseases which are associated with virus neuraminidase.
5. Use of the crystalline form according to claim 1 or 2 for the preparation of medicaments for the therapeutic and/or prophylactic treatment of diseases which are associated with virus neuraminidase.
6. Pharmaceutical compositions comprising the crystalline form according to claim 1 or 2 and a pharmaceutically acceptable carrier.
7. An injectable pharmaceutical formulation comprising a pharmaceutically effective amount of crystalline form C according to claim 1 or 2 and a pharmaceutically acceptable carrier.
8. An injectable pharmaceutical formulation according to claim 7, which formulation contains 60 to 120 mg of form C of compound of formula (I), said formulation being reconstituted in an aqueous solution at a pH of 3.0 to 7.0
9. An injectable pharmaceutical formulation according to claim 8, the aqueous solution having a pH of 3.5 to 4.5.
10. A method for preparing the crystalline form C of (3R,4R,5S)-4-Acetylamino-5-amino-3-(1-ethyl-propoxy)-cyclohex-1-enecarboxylic acid ethyl ester phosphate, comprising

Step a)

Dissolving compound of formula (I) into water and adjusting pH to 4.0;

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Step b)

Sterile filtering the solution through a sterilized 0.22 μm membrane;

Step c)

5 Aseptic filling the solution into sterile depyrogenated vial and stoppering the vial with a sterile stopper;

Step d)

Lyophilizing the solution in a steam-sterilized freeze-dryer.