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(54) **Tenofovir-alafenamid-hemifumarát**

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(54) **TENOFOVIR ALAFENAMIDE HEMIFUMARATE**

TENOFOVIR-ALAFENAMID-HEMIFUMARAT

HÉMIFUMARATE DE TÉNOFOVIR ALAFÉNAMIDE

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- **CHAPMAN H ET AL: "PURIFICATION OF PMPA AMIDATE PRODRUGS BY SMB CHROMATOGRAPHY AND X-RAY CRYSTALLOGRAPHY OF THE DIASTEREOMERICALLY PURE GS-7340", NUCLEOSIDES, NUCLEOTIDES AND NUCLEIC ACIDS, TAYLOR & FRANCIS, PHILADELPHIA, PA, vol. 20, no. 4-07, 1 January 2001 (2001-01-01), pages 1085-1090, XP009032140, ISSN: 1525-7770, DOI: 10.1081/NCN-100002495**

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Description

BACKGROUND OF THE INVENTION

Description of Related Art

[0001] U.S. Patent Nos. 7,390,791 and 7,803,788 describe certain prodrugs of phosphonate nucleotide analogs that are useful in therapy. One such prodrug is 9-[(R)-2-[[(S)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine. This compound is also known by the Chemical Abstract name L-alanine, N-[(S)-[[(1R)-2-(6-amino-9H-purin-9-yl)-1-methylethoxy]methyl]phenoxyphosphinyl]-, 1-methylethyl ester. U.S. Patent Nos. 7,390,791 and 7,803,788 also disclose a monofumarate form of this compound and its preparation method (see, e.g.,

Example 4).

SUMMARY OF THE INVENTION

[0002] Described is a hemifumarate form of 9-[(R)-2-[[(S)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine. The name for 9-[(R)-2-[[(S)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine is tenofovir alafenamide. The hemifumarate form of tenofovir alafenamide is also referred to herein as tenofovir alafenamide hemifumarate.

[0003] In one embodiment of the invention is provided tenofovir alafenamide hemifumarate.

[0004] In another embodiment is provided tenofovir alafenamide hemifumarate, wherein the ratio of fumanic acid to tenofovir alafenamide is 0.5 ± 0.1, or 0.5 ± 0.05, or 0.5 ± 0.01, or 0.5.

[0005] In one embodiment is provided tenofovir alafenamide hemifumarate in a solid form.

[0006] In one embodiment is provided tenofovir alafenamide hemifumarate that has an X-ray powder diffraction (XRPD) pattern having 2theta values of 6.9 ± 0.2° and 8.6 ± 0.2°. In another embodiment is provided tenofovir alafenamide hemifumarate wherein the XRPD pattern comprises 2theta values of 6.9 ± 0.2°, 8.6 ± 0.2°, 11.0 ± 0.2°, 15.9 ± 0.2°, and 20.2 ± 0.2°.

[0007] In one embodiment is provided tenofovir alafenamide hemifumarate that has a differential scanning calorimetry (DSC) onset endotherm of 131 ±2 °C, or 131 ± 1 °C.

[0008] In one embodiment is provided a pharmaceutical composition comprising tenofovir alafenamide hemifumarate and a pharmaceutically acceptable excipient. In another embodiment is provided the pharmaceutical composition, further comprising an additional therapeutic agent. In a further embodiment, the additional therapeutic agent is selected from the group consisting of human immunodeficiency virus (HIV) protease inhibiting compounds, HIV nonnucleoside inhibitors of reverse transcriptase, HIV nucleoside inhibitors of reverse transcriptase, HIV nucleotide inhibitors of reverse transcriptase, HIV integrase inhibitors, and CCR5 inhibitors.

[0009] In one embodiment is provided tenofovir alafenamide hemifumarate for use in a method for treating a human immunodeficiency virus (HIV) infection. In another embodiment is provided a pharmaceutical composition comprising tenofovir alafenamide hemifumarate for use in a method for treating an HIV infection. A further embodiment provides a pharmaceutical composition comprising tenofovir alafenamide hemifumarate further comprising one or more additional therapeutic agents selected from the group consisting of HIV protease inhibiting compounds, HIV nonnucleoside inhibitors of reverse transcriptase, HIV nucleoside inhibitors of reverse transcriptase, HIV nucleotide inhibitors of reverse transcriptase, HIV integrase inhibitors, and CCR5 inhibitors, for use in treating an HIV infection.

[0010] In one embodiment is provided tenofovir alafenamide hemifumarate for use in treating a hepatitis B virus (HBV) infection. In another embodiment is provided a pharmaceutical composition comprising tenofovir alafenamide hemifumarate for use in a method for treating an HBV infection.

[0011] In one embodiment is provided a method for preparing a pharmaceutical composition comprising combining tenofovir alafenamide hemifumarate and a pharmaceutically acceptable excipient to provide the pharmaceutical composition.

[0012] In one embodiment is provided a method for preparing tenofovir alafenamide hemifumarate comprising subjecting a solution comprising a suitable solvent; fumaric acid; tenofovir alafenamide; and, optionally, one or more seeds of tenofovir alafenamide hemifumarate to conditions that provide for the crystallization of the fumaric acid and the tenofovir alafenamide. In one embodiment, the solvent comprises acetonitrile. In another embodiment, the solution is subjected to a temperature in the range of from about 0 °C to about 75 °C.

[0013] In one embodiment is provided tenofovir alafenamide hemifumarate for use in medical therapy.

[0014] In one embodiment is provided tenofovir alafenamide hemifumarate for use in the prophylactic or therapeutic treatment of an HIV infection. In another embodiment is provided tenofovir alafenamide hemifumarate for use to treat an HIV infection. Disclosed is the use of tenofovir alafenamide hemifumarate for the preparation or manufacture of a

medicament for the treatment of an HIV infection. In another further embodiment is provided tenofovir alafenamide hemifumarate for use in treating an HIV infection.

[0015] In one embodiment is provided tenofovir alafenamide hemifumarate for use in the prophylactic or therapeutic treatment of an HBV In another embodiment is provided tenofovir alafenamide hemifumarate for use to treat an HBV infection. Disclosed is the use of tenofovir alafenamide hemifumarate for the preparation or manufacture of a medicament for the treatment of an HBV infection. In another further embodiment is provided tenofovir alafenamide hemifumarate for use in treating an HBV infection.

[0016] In some embodiments of the invention, the compounds and compositions for use in the methods of treating comprise administration of multiple daily doses. Other embodiments comprise administration of a single daily dose.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0017]

FIG. 1 shows the X-ray powder diffraction (XRPD) pattern of tenofovir alafenamide hemifumarate.
FIG. 2 shows a graph of the DSC analysis of tenofovir alafenamide hemifumarate.
FIG. 3 shows a graph of the thermogravimetric analysis (TGA) data for tenofovir alafenamide hemifumarate.
FIG. 4 shows a graph of the dynamic vapor sorption (DVS) analysis of tenofovir alafenamide hemifumarate.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Specific values listed within the present description for radicals, substituents, and ranges are for illustration only; they do not exclude other defined values or other values within defined ranges for the radicals and substituents.

[0019] In one embodiment, there is provided a hemifumarate form of tenofovir alafenamide (i.e., tenofovir alafenamide hemifumarate). This form may have a ratio (i.e., a stoichiometric ratio or mole ratio) of fumaric acid to tenofovir alafenamide of 0.5 ± 0.1, 0.5 ± 0.05, 0.5 ± 0.01, or 0.5, or the like.

[0020] In one embodiment, tenofovir alafenamide hemifumarate consists of fumaric acid and tenofovir alafenamide in a ratio of 0.5 ± 0.1.

[0021] In one embodiment, tenofovir alafenamide hemifumarate consists essentially of fumaric acid and tenofovir alafenamide in a ratio of 0.5 ± 0.1.

[0022] In one embodiment, tenofovir alafenamide hemifumarate has an XRPD pattern comprising 2theta values of 6.9 ± 0.2°, 8.6 ± 0.2°, 10.0 ± 0.2°, 11.0 ± 0.2°, 12.2 ± 0.2°, 15.9 ± 0.2°, 16.3 ± 0.2°, 20.2 ± 0.2°, and 20.8 ± 0.2°.

[0023] In one embodiment, tenofovir alafenamide hemifumarate has an XRPD pattern comprising at least four 2theta values selected from 6.9 ± 0.2°, 8.6 ± 0.2°, 10.0 ± 0.2°, 11.0 ± 0.2°, 12.2 ± 0.2°, 15.9 ± 0.2°, 16.3 ± 0.2°, 20.2 ± 0.2°, and 20.8 ± 0.2°.

[0024] In one embodiment, tenofovir alafenamide hemifumarate has a DSC onset endotherm of 131 ± 2 °C, or 131 ± 1 °C.

[0025] In one embodiment, a tenofovir alafenamide hemifumarate composition comprises less than about 5% by weight of tenofovir alafenamide monofumarate.

[0026] In one embodiment, a tenofovir alafenamide hemifumarate composition comprises less than about 1% by weight of tenofovir alafenamide monofumarate.

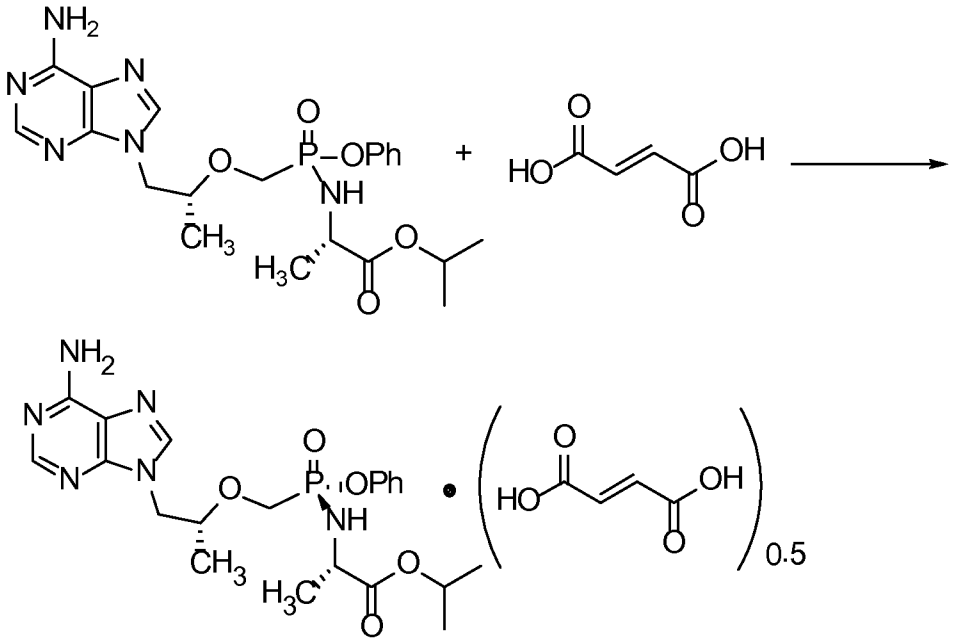
[0027] In one embodiment, a tenofovir alafenamide hemifumarate composition comprises less than about 0.5% by weight of tenofovir alafenamide monofumarate.

[0028] In one embodiment, a tenofovir alafenamide hemifumarate composition comprises no detectable tenofovir alafenamide monofumarate.

[0029] Tenofovir alafenamide (i.e., the compound 9-[(R)-2-[[(S)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxy-phosphinyl]methoxy]propyl]adenine) can be prepared as described in U.S. Patent No. 7,390,791.

Selective Crystallization

[0030] In one embodiment, tenofovir alafenamide hemifumarate can be prepared using selective crystallization. An example of a scheme for this preparation method is as follows.



[0031] The method can be carried out by subjecting a solution comprising: a) a suitable solvent; b) fumaric acid; c) tenofovir alafenamide; and, optionally, d) one or more seeds comprising tenofovir alafenamide hemifumarate, to conditions that provide for the crystallization of fumaric acid and tenofovir alafenamide. The starting solution can contain the single diastereomer of tenofovir alafenamide or a mixture of tenofovir alafenamide and one or more of its other diastereomers (e.g., GS-7339, as described in U.S. Patent No. 7,390,791).

[0032] The selective crystallization can be carried out in any suitable solvent. For example, it can be carried out in a protic solvent or in an aprotic organic solvent, or in a mixture thereof. In one embodiment, the solvent comprises a protic solvent (e.g., water or isopropyl alcohol). In another embodiment, the solvent comprises an aprotic organic solvent (e.g., acetone, acetonitrile (ACN), toluene, ethyl acetate, isopropyl acetate, heptane, tetralrydrofuran (THF), 2-methyl THF, methyl ethyl ketone, or methyl isobutyl ketone, or a mixture thereof). In one embodiment, the solvent comprises ACN or a mixture of ACN and up to about 50% methylene chloride (by volume). The selective crystallization also can be carried out at any suitable temperature, for example, a temperature in the range of from about 0 °C to about 70 °C. In one specific embodiment, the resolution is carried out at a temperature of about 0 °C.

[0033] One major advantage of the hemifumarate form of tenofovir alafenamide over the monofumarate form is its exceptional capability to purge GS-7339 (i.e., 9-[(R)-2-[[(R)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine; described in, e.g., U.S. Patent No. 7,390,791), which is the major diastereomeric impurity in the active pharmaceutical ingredient. Thus, the hemifumarate form of tenofovir alafenamide can be more readily and easily separated from impurities than the monofumarate form. Other major advantages of tenofovir alafenamide hemifumarate over the monofumarate form include improved thermodynamic and chemical stability (including long-term storage stability), superior process reproducibility, superior drug product content uniformity, and a higher melting point.

[0034] Tenofovir alafenamide hemifumarate is useful in the treatment and/or prophylaxis of one or more viral infections in man or animals, including infections caused by DNA viruses. RNA viruses, herpesviruses (e.g., CMV, HSV 1, HSV 2, VZV), retroviruses, hepadnaviruses (e.g., HBV), papillomavirus, hantavirus, adenoviruses and HIV. U.S. Patent No. 6,043,230 and other publications describe the antiviral specificity of nucleotide analogs, such as tenofovir disoproxil. Like tenofovir disoproxil, tenofovir alafenamide is another prodrug form of tenofovir, and can be used in the treatment and/or prophylaxis of the same conditions.

[0035] Tenofovir alafenamide hemifumarate can be administered by any route appropriate to the condition to be treated. Suitable routes include oral, rectal, nasal, topical (including ocular, buccal, and sublingual), vaginal, and parenteral (including subcutaneous, intramuscular, intravenous, intradermal, intrathecal, and epidural). Generally, tenofovir alafenamide hemifumarate is administered orally, but it can be administered by any of the other routes noted herein.

[0036] Accordingly, pharmaceutical compositions include those suitable for topical or systemic administration, including oral, rectal, nasal, buccal, sublingual, vaginal, or parenteral (including subcutaneous, intramuscular, intravenous, intradermal, intrathecal, and epidural) administration. The formulations are in unit dosage form and are prepared by any of the methods well known in the art of pharmacy.

[0037] For oral therapeutic administration, the tenofovir alafenamide hemifumarate may be combined with one or more excipients and used in the form of ingestible tablets, buccal tablets, troches, capsules, elixirs, suspensions, syrups,

wafers, and the like. Such pharmaceutical compositions and preparations will typically contain at least 0.1% of tenofovir alafenamide hemifumarate. The percentage of this active compound in the compositions and preparations may, of course, be varied and may conveniently be between about 2% to about 60% or more of the weight of a given unit dosage form. The amount of active compound in such therapeutically useful pharmaceutical compositions is preferably such that an effective dosage level will be obtained upon administration of a single-unit dosage (e.g., tablet). Other dosage formulations may provide therapeutically effective amounts of tenofovir alafenamide hemifumarate upon repeated administration of subclinically effective amounts of the same. Preferred unit dosage formulations include those containing a daily dose (e.g., a single daily dose), as well as those containing a unit daily subclinical dose, or an appropriate fraction thereof (e.g., multiple daily doses), of tenofovir alafenamide hemifumarate.

[0038] Pharmaceutical compositions suitable for oral administration may be presented as discrete units such as capsules, cachets, or tablets, each containing a predetermined amount of tenofovir alafenamide hemifumarate; as a powder or granules; as a solution or a suspension in an aqueous liquid or a nonaqueous liquid; or as an oil-in-water liquid emulsion or a water-in-oil liquid emulsion. Tenofovir alafenamide hemifumarate may also be presented as a bolus, electuary, or paste.

[0039] Tenofovir alafenamide hemifumarate is preferably administered as part of a pharmaceutical composition or formulation. Such pharmaceutical composition or formulation comprises tenofovir alafenamide hemifumarate together with one or more pharmaceutically acceptable carriers / excipients, and optionally other therapeutic ingredients. The excipient(s) / carrier(s) must be "acceptable" in the sense of being compatible with the other ingredients of the formulation and not deleterious to the patient. Excipients include, but are not limited to, substances that can serve as a vehicle or medium for tenofovir alafenamide hemifumarate (e.g., a diluent carrier). They may be enclosed in hard or soft shell gelatin capsules, may be compressed into tablets, or may be incorporated directly with the food of the patient's diet.

[0040] Accordingly, the tablets, troches, pills, capsules, and the like may also contain, without limitation, the following: a binder(s), such as hydroxypropyl cellulose, povidone, or hydroxypropyl methylcellulose; a filler(s), such as microcrystalline cellulose, pregelatinized starch, starch, mannitol, or lactose monohydrate; a disintegrating agent(s), such as croscarmellose sodium, crosslinked povidone, or sodium starch glycolate; a lubricant(s), such as magnesium stearate, stearic acid, or other metallic stearates; a sweetening agent(s), such as sucrose, fructose, lactose, or aspartame; and/or a flavoring agent(s), such as peppermint, oil of wintergreen, or a cherry flavoring. When the unit dosage form is a capsule, it may contain, in addition to materials of the above types, a liquid carrier, such as a vegetable oil or a polyethylene glycol. Various other materials may be present as coatings or to otherwise modify the physical form of the solid unit dosage form. For instance, tablets, pills, or capsules may be coated with gelatin, polymers, wax, shellac, or sugar and the like. Of course, any material used in preparing any unit dosage form typically will be pharmaceutically acceptable and substantially nontoxic in the amounts employed. In addition, tenofovir alafenamide hemifumarate may be incorporated into sustained-release preparations and devices.

[0041] For infections of the eye or other external tissues, e.g., mouth and skin, the pharmaceutical compositions are preferably applied as a topical ointment or cream containing tenofovir alafenamide hemifumarate in an amount of, for example, 0.01 to 10% w/w (including active ingredient in a range between 0.1% and 5% in increments of 0.1% w/w such as 0.6% w/w, 0.7% w/w, etc.), preferably 0.2 to 3% w/w and most preferably 0.5 to 2% w/w. When formulated in an ointment, the active ingredient may be employed with either a paraffinic or a water-miscible ointment base. Alternatively, the active ingredient may be formulated in a cream with an oil-in-water cream base.

[0042] Pharmaceutical compositions suitable for topical administration in the mouth include lozenges comprising tenofovir alafenamide hemifumarate in a flavored basis, for example, sucrose and acacia or tragacanth; pastilles comprising the active ingredient in an inert basis such as gelatin and glycerin, or sucrose and acacia; and mouthwashes comprising the active ingredient in a suitable liquid carrier.

[0043] Formulations for rectal administration may be presented as a suppository with a suitable base comprising, for example, cocoa butter or a salicylate.

[0044] Pharmaceutical formulations suitable for parenteral administration are sterile and include aqueous and nonaqueous injection solutions that may contain antioxidants, buffers, bacteriostats, and solutes that render the formulation isotonic with the blood of the intended recipient; and aqueous and nonaqueous sterile suspensions that may include suspending agents and thickening agents. The formulations may be presented in unit-dose or multi-dose containers, for example, sealed ampoules and vials with elastomeric stoppers, and may be stored in a freeze-dried (lyophilized) condition requiring only the addition of the sterile liquid carrier (e.g., water for injections) immediately prior to use. Injection solutions and suspensions may be prepared from sterile powders, granules, and tablets of the kind previously described.

[0045] In addition to the ingredients particularly mentioned above, the pharmaceutical compositions / formulations may include other ingredients conventional in the art, having regard to the type of formulation in question.

[0046] In another embodiment, there is provided veterinary compositions comprising tenofovir alafenamide hemifumarate together with a veterinary carrier therefor. Veterinary carriers are materials useful for the purpose of administering the composition to cats, dogs, horses, rabbits, and other animals, and may be solid, liquid, or gaseous materials that are otherwise inert or acceptable in the veterinary art and are compatible with the active ingredient. These veterinary

compositions may be administered orally, parenterally, or by any other desired route.

[0047] The tenofovir alafenamide hemifumarate can be used to provide controlled release pharmaceutical formulations containing a matrix or absorbent material and an active ingredient of the invention, in which the release of the active ingredient can be controlled and regulated to allow less frequent dosing or to improve the pharmacokinetic or toxicity profile of the compound. Controlled release formulations adapted for oral administration, in which discrete units comprising a compounds of the invention, can be prepared according to conventional methods.

[0048] Useful dosages of tenofovir alafenamide hemifumarate can be determined by comparing *in vitro* activities, and the *in vivo* activities in animal models. Methods for the extrapolation of effective amounts / dosages in mice and other animals to therapeutically effective amounts / dosages in humans are known in the art.

[0049] The amount of tenofovir alafenamide hemifumarate required for use in treatment will vary with several factors, including but not limited to the route of administration, the nature of the condition being treated, and the age and condition of the patient; ultimately, the amount administered will be at the discretion of the attendant physician or clinician. The therapeutically effective amount / dose of tenofovir alafenamide hemifumarate depends, at least, on the nature of the condition being treated, any toxicity or drug interaction issues, whether the compound is being used prophylactically (e.g., sometimes requiring lower doses) or against an active disease or condition, the method of delivery, and the pharmaceutical formulation, and will be determined by the clinician using conventional dose escalation studies.

[0050] In one embodiment, the oral dose of tenofovir alafenamide hemifumarate may be in the range from about 0.0001 to about 100 mg/kg body weight per day, for example, from about 0.01 to about 10 mg/kg body weight per day, from about 0.01 to about 5 mg/kg body weight per day, from about 0.5 to about 50 mg/kg body weight per day, from about 1 to about 30 mg/kg body weight per day, from about 1.5 to about 10 mg/kg body weight per day, or from about 0.05 to about 0.5 mg/kg body weight per day. As a nonlimiting example, the daily candidate dose for an adult human of about 70 kg body weight will range from about 0.1 mg to about 1000 mg, or from about 1 mg to about 1000 mg, or from about 5 mg to about 500 mg, or from about 1 mg to about 150 mg, or from about 5 mg to about 150 mg, or from about 5 mg to about 100 mg, and may take the form of single or multiple doses.

[0051] The pharmaceutical compositions described herein may further include one or more therapeutic agents in addition to tenofovir alafenamide hemifumarate. In one specific embodiment of the invention, the additional therapeutic agent can be selected from the group consisting of HIV protease inhibiting compounds, HIV nonnucleoside inhibitors of reverse transcriptase, HIV nucleoside inhibitors of reverse transcriptase, HIV nucleotide inhibitors of reverse transcriptase, HIV integrase inhibitors, and CCR5 inhibitors.

[0052] Therapeutic methods include administering tenofovir alafenamide hemifumarate to a subject / patient in need of the same as a therapeutic or preventative treatment. Thus, tenofovir alafenamide hemifumarate may be administered to a subject / patient having a medical disorder or to a subject who may acquire the disorder. One of ordinary skill will appreciate that such treatment is given in order to ameliorate, prevent, delay, cure, and/or reduce the severity of a symptom or set of symptoms of a disorder (including a recurring disorder). The treatment may also be given to prolong the survival of a subject, e.g., beyond the survival time expected in the absence of such treatment. The medical disorders that may be treated with tenofovir alafenamide hemifumarate include those discussed herein, including without limitation, HIV infection and HBV infection.

[0053] The following are nonlimiting, illustrative Examples.

Example 1

[0054] Tenofovir alafenamide monofumarate solids (5.0 g) and 9-[(R)-2-[[(R)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino] phenoxyphosphinyl]methoxy]propyl]adenine (GS-7339) monofumarate solids (0.75 g) were charged into 35 g MTBE at 22 °C and the mixture was stirred for 1 hour. A slurry was formed and was dried in a rotary evaporator. 58 g acetonitrile (ACN) was charged into the solids and the mixture was heated to reflux to dissolve the solids. The resulting solution was allowed to cool naturally while agitated. A slurry was formed, and the slurry was further cooled by ice-water-bath. The solids were isolated by filtration and washed with 5 g ACN. The solids were dried in a vacuum oven at 40 °C overnight. 5.52 g off-white solids were obtained. The solids were analyzed by XRPD and found to contain tenofovir alafenamide monofumarate, GS-7339 monofumarate, and tenofovir alafenamide hemifumarate.

Example 2: Preparation of Tenofovir Alafenamide Hemifumarate via Selective Crystallization

[0055] 9-[(R)-2-[[[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine as a slurry in ACN (9.7 kg slurry, 13.8 wt%, a diastereomeric mixture of 1.0 kg (2.10 mol, 1 mol equiv) of 9-[(R)-2-[[(S)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine and 0.35 kg of 9-[(R)-2-[[(R)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine was charged into a reactor and rinsed forward with dichloromethane (5 kg). The mixture was concentrated under vacuum to about 3 L with jacket temperature below 40 °C. The concentrate was then coevaporated with ACN (6 kg) under vacuum to about 3 L with jacket temperature

below 40 °C. The concentrate was diluted with ACN (8.5 kg) and warmed to 40-46 °C. The warm mixture was filtered into a second reactor and the filtrate was cooled to 19-25 °C.

[0056] To the above solution was charged fumaric acid (0.13 kg, 1.12 mol, 0.542 mole equiv) followed by ACN (1 kg), and the mixture was heated to 67-73 °C. The hot mixture was transferred into a reactor via a polishing filter, and then adjusted to 54-60 °C. Seed crystals (5 g) of the hemifumarate form of tenofovir alafenamide were charged (for example, the mixture can be seeded with tenofovir alafenamide hemifumarate formed in Example 1 or a subsequent production), and the resulting mixture was agitated at 54-60 °C for about 30 minutes. The mixture was cooled over a minimum of 4 hours to 0-6 °C, and then agitated at 0-6 °C for a minimum of 1 hour. The resulting slurry was filtered and rinsed with chilled (0-6 °C) ACN (2 kg). The product was dried under vacuum below 45 °C until loss on drying (LOD) and organic volatile impurities (OVI) limits were met (LOD ≤ 1.0%, dichloromethane content ≤ 0.19%, acetonitrile content ≤ 0.19%) to afford the final compound of the hemifumarate form of tenofovir alafenamide as a white to off-white powder (typical yield is about 0.95 kg). ^{1}H NMR (400 MHz, d6 DMSO): δ 1.06 (d, J = 5.6 Hz, 3H), 1.12-1.16 (m, 9H), 3.77 (dd, J = 10.4, 11.6 Hz, 1H), 3.84-3.90 (m, 2H), 3.94 (m, 1H), 4.14 (dd, J = 6.8, 14.8 Hz, 1H), 4.27 (m, 1H), 4.85 (heptet, J = 6.0 Hz, 1H), 5.65 (t, J = 11.2 Hz, 1H), 6.63 (s, 1H), 7.05 (d. J = 7.6 Hz, 2H), 7.13 (t, J = 7.2 Hz, 1H), 7.24 (s, 2H), 7.29 (t, J = 7.6 Hz, 2H), 8.13 (t, J = 13.6 Hz, 2H),
^{31}P NMR (162 MHz, d6 DMSO): δ 23.3.

Example 3: Preparation of Tenofovir Alafenamide Hemifumarate

[0057] To a jacketed reactor equipped with overhead agitator, was charged 9-[(R)-2-[[(S)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine (10 g), fumaric acid (1.22 g), and ACN (100 mL). The mixture was heated to 70-75 °C to dissolve the solids. Any undissolved particulates were removed by filtration through a cartridge filter. The filtered solution was cooled to 60-65 °C, and seeded with 1% (by weight) of tenofovir alafenamide hemifumarate. The slurry was aged for 30 minutes and cooled to 0-5 °C over 2 hours. The temperature was maintained for 1-18 hours, and the resulting slurry was filtered and washed with 2 ml of cold ACN (0-5 °C). The solids were dried under vacuum at 50 °C to provide the hemifumarate form of tenofovir alafenamide, which was characterized as described below.

Characterization of Tenofovir Alafenamide Hemifumarate from Example 3

[0058] Tenofovir alafenamide hemifumarate from Example 3 consists of 9-[(R)-2-[[(S)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine and one-half an equivalent of fumaric acid. Tenofovir alafenamide hemifumarate is anhydrous, nonhygroscopic, and has a DSC onset endotherm of about 131 °C.

X-ray Powder Diffraction

[0059] The XRPD pattern of tenofovir alafenamide hemifumarate was obtained in the following experimental setting: 45 KV, 45 mA, Kα1=1.5406 Å, scan range 2. - 40°, step size 0.0084°, counting time: 8.25 s. The XRPD pattern for tenofovir alafenamide hemifumarate is shown in **FIG. 1.** The characteristic peaks include: 6.9 ± 0.2°, 8.6 ± 0.2°, 10.0 ± 0.2°, 11.0 ± 0.2°, 12.2 ± 0.2°, 15.9 ± 0.2°, 16.3 ± 0.2°, 20.2 ± 0.2°, and 20.8 ± 0.2°.

Single-Crystal X-ray Diffraction

[0060] The crystal size was 0.32 x 0.30 x 0.20 mm^3. The sample was held at 123 K and the data was collected using a radiation source with a wavelength of 0.71073 Å in the theta range of 1.59 to 25.39°. Conditions of, and data collected from the single-crystal X-ray diffraction are shown in Table 1.

Table 1. Single-Crystal X-ray Diffraction

Empirical formula	$C_{23}H_{31}N_6O_7P$
Formula weight	534.50
Temperature	123(2) K
Crystal size	0.32 x 0.30 x 0.20 mm ^{3}
Theta range for data collection	1.59 to 25.39°
Wavelength	0.71073 Å

(continued)

Crystal system	Tetragonal
Space group	P4(2)2(1)2
Unit cell dimensions	a = 18.1185(12) Å α = 90° b = 18.1185(12) Å β=90° c = 17.5747(11) Å γ = 90°
Volume	5769.4(6) $Å^3$
Z	8
Density (calculated)	1.231 g/cm^3

DSC Analysis

[0061] The DSC analysis was conducted using 2.517 mg of tenofovir alafenamide hemifumarate. It was heated at 10 °C/min over the range of 40-200 °C. The onset endotherm was found to be about 131 °C (**FIG. 2**).

TGA Data

[0062] The TGA data were obtained using 4.161 mg of tenofovir alafenamide hemifumarate. It was heated at 10 °C/min over the range of 25-200 °C. The sample lost 0.3% weight before melting (**FIG. 3**). It was determined to be an anhydrous form.

DVS Analysis

[0063] DVS analysis was conducted using 4.951 mg of tenofovir alafenamide hemifumarate. The material was kept at 25 °C in nitrogen at humidities ranging from 10% to 90% relative humidity; each step was equilibrated for 120 minutes. The sorption isotherm is shown at **FIG. 4.** The material was found to be nonhygroscopic, and to absorb 0.65% water at a relative humidity of 90%.

Purging of Diastereomeric Impurity

[0064] In the prior syntheses of tenofovir alafenamide, one of the major impurities is typically the diastereomer 9-[(R)-2-[[(R)-[[(S)-1-(isopropoxycarbonyl)ethyl]amino]phenoxyphosphinyl]methoxy]propyl]adenine. The hemifumarate form of tenofovir alafenamide from Example 3 has an exceptional capability to purge this diastereomeric impurity, as compared with the capability of the monofumarate form (described in U.S. Patent No. 7,390,791). The data in Table 2 (below) demonstrates that tenofovir alafenamide hemifumarate (Batch 2) purged the diastereomeric impurity to less than one-tenth of the starting concentration, whereas the monofumarate form of tenofovir alafenamide (Batch 1) only slightly purged the diastereomeric impurity.

Table 2. Purging Capability Comparison

Batch	Diastereomeric Impurity in Starting Material	Solvent	Fumaric acid charge (mole equivalent)	Product obtained	Diastereomeric Impurity in Product
1	9.3%	ACN	0.9	Monofumarate form	7.6%
2	10.0%	ACN	0.5	Hemifumarate form	0.65%

Chemical Stability

[0065] Chemical stability of the hemifumarate form of tenofovir alafenamide was compared with the monofumarate form. As shown in Table 3 (below), under identical conditions, the hemifumarate form of tenofovir alafenamide was chemically more stable and exhibited better long-term storage stability, with significantly less degradation (% Total Deg.

Products) than the monofumarate form. Conditions evaluated include temperature, relative humidity (RH), and the open or closed state of the container cap.

Table 3. Chemical Stability Comparison

Storage Condition	Time Points (weeks)	Monofumarate form		Hemifumarate form	
		% TA* Area Normalized	% Total Deg. Products	% TA Area Normalized	% Total Deg. Products
40°C / 75% RH Cap Closed	0	97.1	0.69	98.4	0.05
	1	97.0	0.87	98.4	0.14
	2	96.6	1.18	98.5	0.14
	4	96.4	1.49	98.4	0.25
	8	95.4	2.36	98.0	0.49
40°C / 75% RH Cap Open	0	97.1	0.69	98.4	0.05
	1	96.9	0.90	98.5	0.15
	2	96.6	1.10	98.5	0.14
	4	96.2	1.67	98.4	0.26
	8	95.0	2.74	98.1	0.50
70°C Cap Closed	0	97.1	0.69	98.4	0.05
	2	96.2	1.83	98.5	0.22
	4	93.3	4.78	98.4	0.33
TA is tenofovir alafenamide					

Thermodynamic Stability

[0066] Stable form screening of tenofovir alafenamide hemifumarate showed that it is thermodynamically stable in most solvents, such as ACN, toluene, ethyl acetate, methyl *tert*-butyl ether (MTBE), acetone, THF, and 2-methyl THF. A similar stable form screening of the monofumarate form showed that this form is not thermodynamically stable in the above-listed solvents. When suspended in these solvents, the monofumarate form of tenofovir alafenamide fully converts to the hemifumarate form in THF and 2-methyl THF, and partially converts to the hemifumarate form in ACN, ethyl acetate, MTBE, and acetone, as well as at ambient temperatures.

Thermal Stability

[0067] As shown by the DSC data, the hemifumarate form of tenofovir alafenamide has a melting point that is about 10 °C higher than that of the monofumarate form, indicating that the hemifumarate form has improved thermal stability as compared with the monofumarate form.

[0068] The invention has been described with reference to various specific and preferred embodiments and techniques. However, it should be understood that many variations and modifications may be made while remaining within the scope of the claims.

Claims

1. Tenofovir alafenamide hemifumarate.

2. The tenofovir alafenamide hemifumarate of claim 1, wherein the ratio of fumaric acid to tenofovir alafenamide is: 0.5 ± 0.1.

3. The tenofovir alafenamide hemifumarate of claim 2, wherein the ratio of fumaric acid to tenofovir alafenamide is: 0.5 ± 0.05.

4. The tenofovir alafenamide hemifumarate of claim 2, wherein the ratio of fumaric acid to tenofovir alafenamide is: 0.5 ± 0.01.

5. The tenofovir alafenamide hemifumarate of claim 1, wherein an X-ray powder diffraction (XRPD) pattern comprises 2theta values of 6.9 ± 0.2° and 8.6 ± 0.2°, when measured using radiation of wavelength 1.5406 Å.

6. The tenofovir alafenamide hemifumarate of claim 5, wherein an X-ray powder diffraction (XRPD) pattern comprises 2theta values of 6.9 ± 0.2°, 8.6 ± 0.2° 11.0 ± 0.2°, 15.9 ± 0.2°, and 20.2 ± 0.2°, when measured using radiation of wavelength 1.5406 Å.

7. The hemifumarate of claim 1 that has a differential scanning calorimetry (DSC) onset endotherm of: 131 ± 2 °C.

8. The hemifumarate of claim 7 that has a differential scanning calorimetry (DSC) onset endotherm of: 131 ± 1 °C.

9. A pharmaceutical composition comprising the hemifumarate of any one of claims 1-8 and a pharmaceutically acceptable excipient.

10. The pharmaceutical composition of claim 9, further comprising an additional therapeutic agent; optionally, wherein the additional therapeutic agent is selected from the group consisting of human immunodeficiency virus (HIV) protease inhibiting compounds, HIV nonnucleoside inhibitors of reverse transcriptase, HIV nucleoside inhibitors of reverse transcriptase, HIV nucleotide inhibitors of reverse transcriptase, HIV integrase inhibitors, and CCR5 inhibitors.

11. A method for preparing a pharmaceutical composition comprising combining the hemifumarate of any one of claims 1-8 and a pharmaceutically acceptable excipient to provide the pharmaceutical composition.

12. A method for preparing tenofovir alafenamide hemifumarate comprising subjecting a solution comprising: a) a suitable solvent; b) fumaric acid; c) tenofovir alafenamide; and d) one or more seeds of tenofovir alafenamide hemifumarate, to conditions that provide for the crystallization of the fumaric acid and the tenofovir alafenamide; optionally, wherein the solvent comprises acetonitrile; and/or, wherein the solution is subjected to a temperature in the range of from about 0 °C to about 75 °C.

13. The hemifumarate of any one of claims 1-8, or the composition of any one of claims 9-10 for use in medical therapy.

14. The hemifumarate of any one of claims 1-8, or the composition of any one of claims 9-10, for use in: the prophylactic or therapeutic treatment of an HIV infection; optionally, wherein the HIV infection is in a human.

15. The hemifumarate of any one of claims 1-8, or the composition of any one of claims 9-10, for use in: the prophylactic or therapeutic treatment of an HBV infection; optionally, wherein the HBV infection is in a human.

Patentansprüche

1. Tenofovir-Alafenamid-Hemifumarat.

2. Tenofovir-Alafenamid-Hemifumarat nach Anspruch 1, wobei das Verhältnis von Fumarsäure zu Tenofovir-Alafenamid 0,5 ± 0,1 beträgt.

3. Tenofovir-Alafenamid-Hemifumarat nach Anspruch 2, wobei das Verhältnis von Fumarsäure zu Tenofovir-Alafenamid 0,5 ± 0,05 beträgt.

4. Tenofovir-Alafenamid-Hemifumarat nach Anspruch 2, wobei das Verhältnis von Fumarsäure zu Tenofovir-Alafenamid 0,5 ± 0,01 beträgt.

5. Tenofovir-Alafenamid-Hemifumarat nach Anspruch 1, wobei ein XRPD(X-Ray Powder Diffraction)-Muster 2theta-Werte von 6,9 ± 0,2° und 8,6 ± 0,2° bei Messung unter Verwendung einer Strahlung der Wellenlänge 1,5406 Å umfasst.

6. Tenofovir-Alafenamid-Hemifumarat nach Anspruch 5, wobei ein XRPD(X-Ray Powder Diffraction)-Muster 2theta-Werte von 6,9 ± 0,2°, 8,6 ± 0,2°, 11,0 ± 0,2°, 15,9 ± 0,2° und 20,2 ± 0,2° bei Messung unter Verwendung einer Strahlung der Wellenlänge 1,5406 Å umfasst.

7. Hemifumarat nach Anspruch 1, das eine DSC(Differential Scanning Calorimetry)-Onset-Endotherme von 131 ± 2 °C aufweist.

8. Hemifumarat nach Anspruch 7, das eine DSC(Differential Scanning Calorimetry)-Onset-Endotherme von 131 ± 1 °C aufweist.

9. Pharmazeutische Zusammensetzung, umfassend das Hemifumarat nach einem der Ansprüche 1-8 und einen pharmazeutisch unbedenklichen Hilfsstoff.

10. Pharmazeutische Zusammensetzung nach Anspruch 9, ferner umfassend ein zusätzliches Therapeutikum; gegebenenfalls wobei das zusätzliche Therapeutikum aus der aus HIV(Human Immunodeficiency Virus)-Protease hemmenden Verbindungen, HIV-Nicht-nukleosid-Inhibitoren von reverser Transkriptase, HIV-Nukleosid-Inhibitoren von reverser Transkrip-tase, HIV-Nukleotid-Inhibitoren von reverser Transkriptase, HIV-Integrase-Inhibitoren und CCR5-Inhibitoren bestehenden Gruppe ausgewählt ist.

11. Verfahren zur Herstellung einer pharmazeutischen Zusammensetzung, bei dem das Hemifumarat nach einem der Ansprüche 1-8 und ein pharmazeutisch unbedenklicher Hilfsstoff zum Bereitstellen der pharmazeutischen Zusammensetzung kombiniert werden.

12. Verfahren zur Herstellung von Tenofovir-Alafenamid-Hemifumarat, bei dem eine Lösung, die a) ein geeignetes Lösungsmittel; b) Fumarsäure; c) Tenofovir-Alafenamid; und d) einen oder mehrere Animpfkristalle von Tenofovir-Alafenamid-Hemifumarat umfasst, Bedingungen ausgesetzt wird, die für die Kristallisation der Fumarsäure und des Tenofovir-Alafenamid sorgen; gegebenenfalls wobei das Lösungsmittel Acetonitril umfasst; und/oder wobei die Lösung einer Temperatur im Bereich von etwa 0 °C bis etwa 75 °C ausgesetzt wird.

13. Hemifumarat nach einem der Ansprüche 1-8 oder Zusammensetzung nach einem der Ansprüche 9-10 zur Verwendung in der medizinischen Therapie.

14. Hemifumarat nach einem der Ansprüche 1-8 oder Zusammensetzung nach einem der Ansprüche 9-10 zur Verwendung bei der prophylaktischen oder therapeutischen Behandlung einer HIV-Infektion; gegebenenfalls wobei es sich um eine HIV-Infektion beim Menschen handelt.

15. Hemifumarat nach einem der Ansprüche 1-8 oder Zusammensetzung nach einem der Ansprüche 9-10 zur Verwendung bei der prophylaktischen oder therapeutischen Behandlung einer HBV-Infektion; gegebenenfalls wobei es sich um eine HBV-Infektion beim Menschen handelt.

Revendications

1. Ténofovir alafénamide hémifumarate.

2. Ténofovir alafénamide hémifumarate de la revendication 1, dans lequel le rapport de l'acide fumarique au ténofovir alafénamide est : 0,5 ± 0,1.

3. Ténofovir alafénamide hémifumarate de la revendication 2, dans lequel le rapport de l'acide fumarique au ténofovir alafénamide est : 0,5 ± 0,05.

4. Ténofovir alafénamide hémifumarate de la revendication 2, dans lequel le rapport de l'acide fumarique au ténofovir alafénamide est : 0,5 ± 0,01.

5. Ténofovir alafénamide hémifumarate de la revendication 1, dans lequel un diagramme de diffraction des rayons X sur poudre (XRPD) comprend des valeurs 2thêta de 6,9 ± 0,2° et 8,6 ± 0,2°, mesurées en utilisant un rayonnement ayant une longueur d'onde de 1,5406 Å.

6. Ténofovir alafénamide hémifumarate de la revendication 5, dans lequel un diagramme de diffraction des rayons X sur poudre (XRPD) comprend des valeurs 2thêta de 6,9 ± 0,2°, 8,6 ± 0,2° 11,0 ± 0,2°, 15,9 ± 0,2°, et 20,2 ± 0,2°, mesurées en utilisant un rayonnement ayant une longueur d'onde de 1,5406 Å.

7. Hémifumarate de la revendication 1 qui a un début d'endothermie en analyse calorimétrique différentielle (ACD) de : 131 ± 2 °C.

8. Hémifumarate de la revendication 7 qui a un début d'endothermie en analyse calorimétrique différentielle (ACD) de : 131 ± 1 °C.

9. Composition pharmaceutique comprenant l'hémifumarate de l'une quelconque des revendications 1 à 8 et un excipient pharmaceutiquement acceptable.

10. Composition pharmaceutique de la revendication 9, comprenant en outre un agent thérapeutique additionnel ; facultativement, dans laquelle l'agent thérapeutique additionnel est choisi dans le groupe constitué de composés inhibiteurs de protéase du virus d'immunodéficience humaine (VIH), inhibiteurs non nucléosidiques de transcriptase inverse du VIH, inhibiteurs nucléosidiques de transcriptase inverse du VIH, inhibiteurs nucléotidiques de transcriptase inverse du VIH, inhibiteurs d'intégrase du VIH, et inhibiteurs de CCR5.

11. Procédé de préparation d'une composition pharmaceutique comprenant la combinaison de l'hémifumarate de l'une quelconque des revendications 1 à 8 et un excipient pharmaceutiquement acceptable pour produire la composition pharmaceutique.

12. Procédé de préparation de ténofovir alafénamide hémifumarate comprenant la soumission d'une solution comprenant : a) un solvant adapté ; b) l'acide fumarique ; c) ténofovir alafénamide ; et d) un ou plusieurs germes de ténofovir alafénamide hémifumarate, à des conditions qui permettent la cristallisation de l'acide fumarique et du ténofovir alafénamide ; facultativement, dans lequel le solvant comprend l'acétonitrile ; et/ou, dans lequel la solution est soumise à une température dans la plage d'environ 0 °C à environ 75 °C.

13. Hémifumarate de l'une quelconque des revendications 1 à 8, ou composition de l'une quelconque des revendications 9 à 10 pour utilisation en thérapie médicale.

14. Hémifumarate de l'une quelconque des revendications 1 à 8, ou composition de l'une quelconque des revendications 9 à 10, pour utilisation dans : le traitement prophylactique ou thérapeutique d'une infection par le VIH ; facultativement, où l'infection par le VIH est chez un humain.

15. Hémifumarate de l'une quelconque des revendications 1 à 8, ou composition de l'une quelconque des revendications 9 à 10, pour utilisation dans : le traitement prophylactique ou thérapeutique d'une infection par le VHB ; facultativement, où l'infection par le VHB est chez un humain.

Figure 1

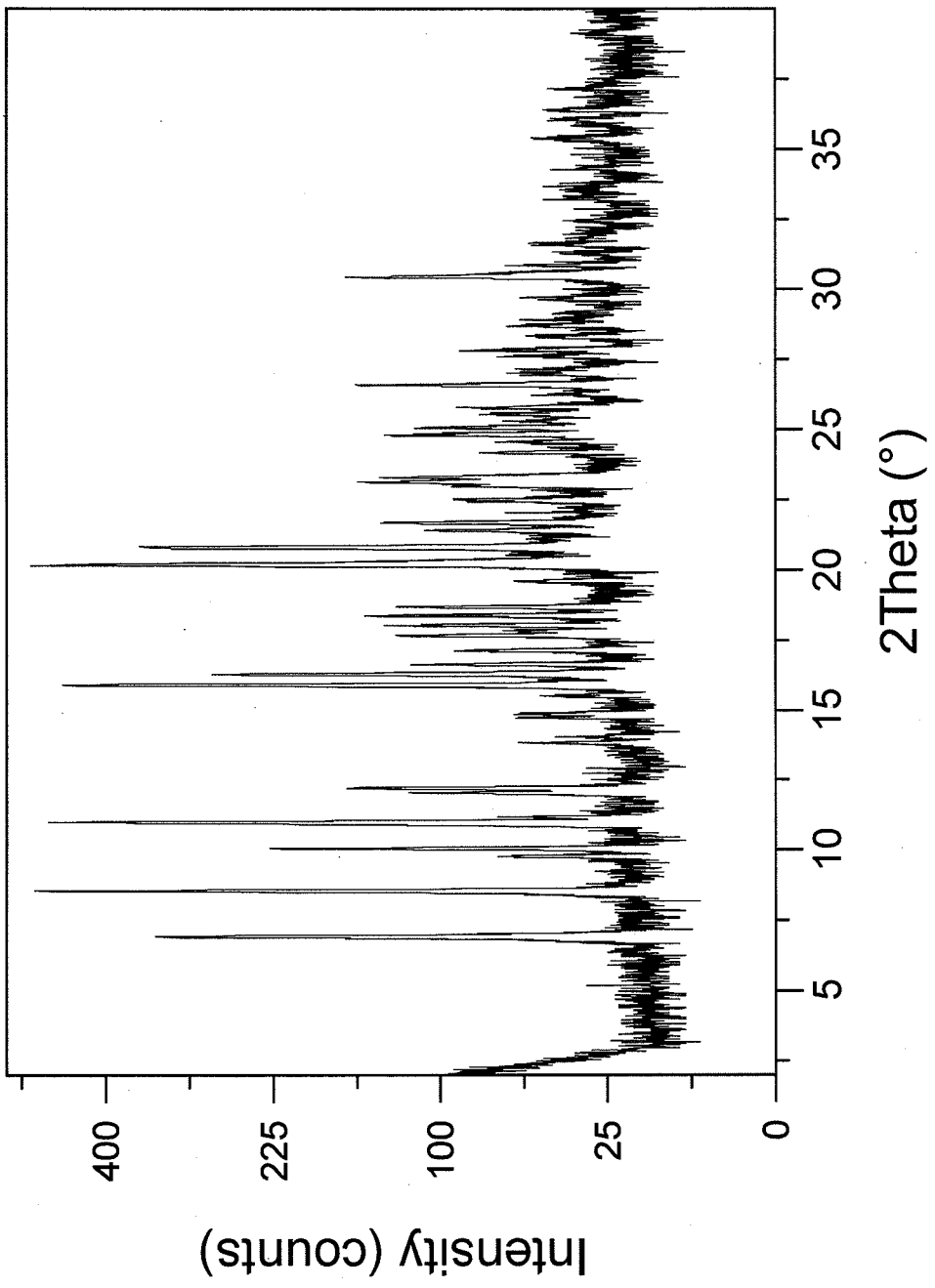
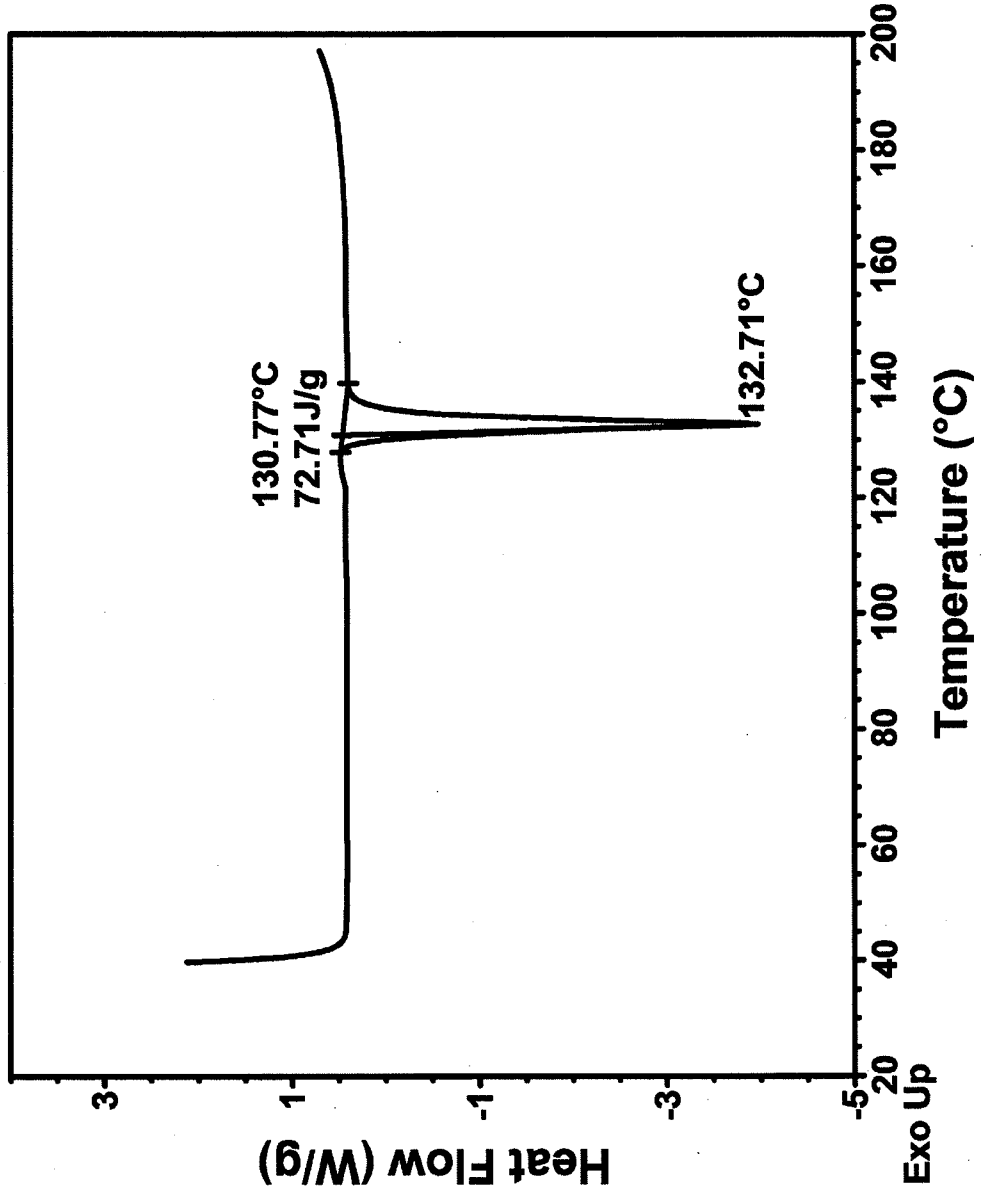


Figure 2


130.77°C
72.71J/g
132.71°C
Heat Flow (W/g)
Exo Up
Temperature (°C)
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1
-1
-3
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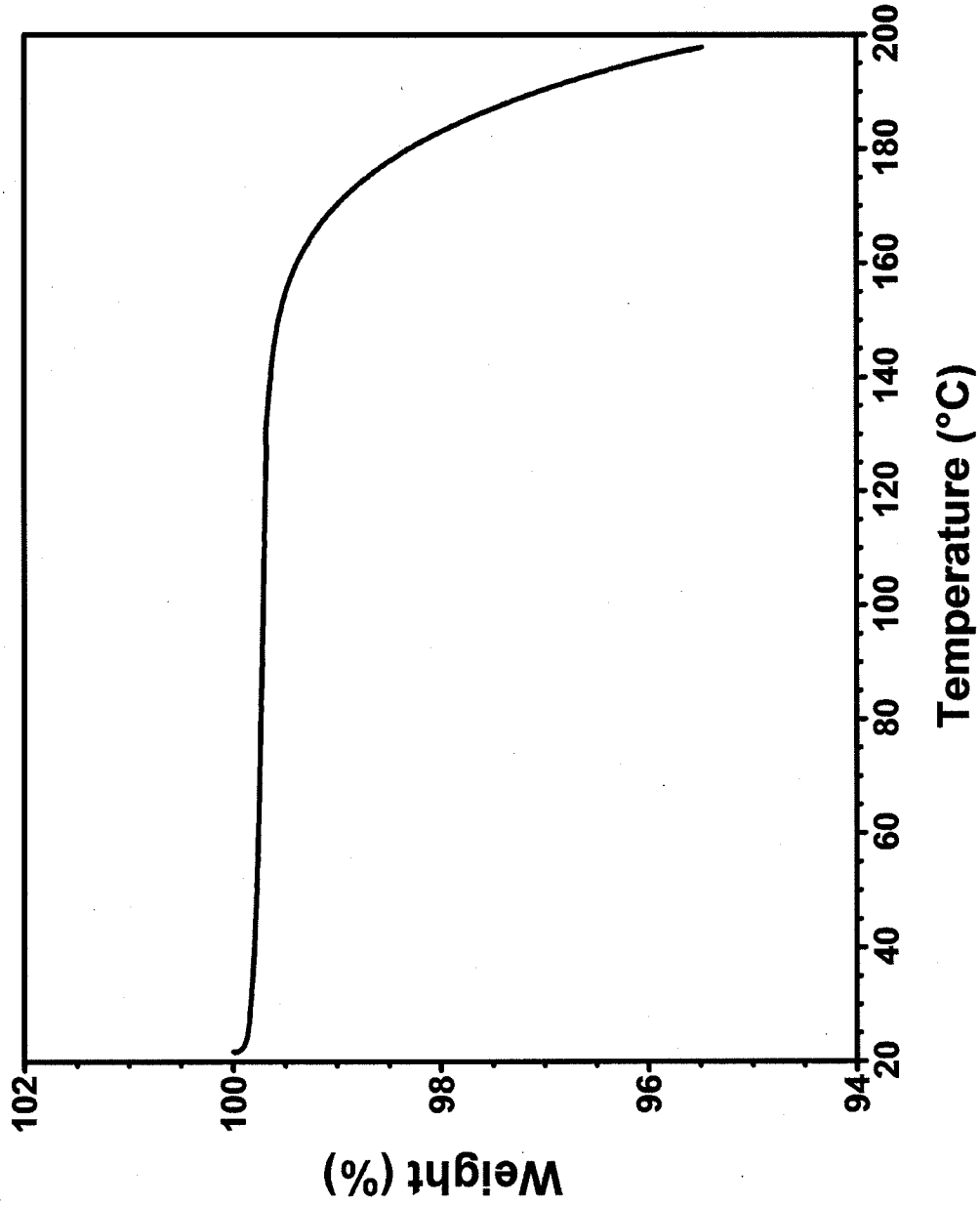
20
40
60
80
100
120
140
160
180
200


Weight (%)
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100
98
96
94
Temperature (°C)
20
40
60
80
100
120
140
160
180
200

Figure 3

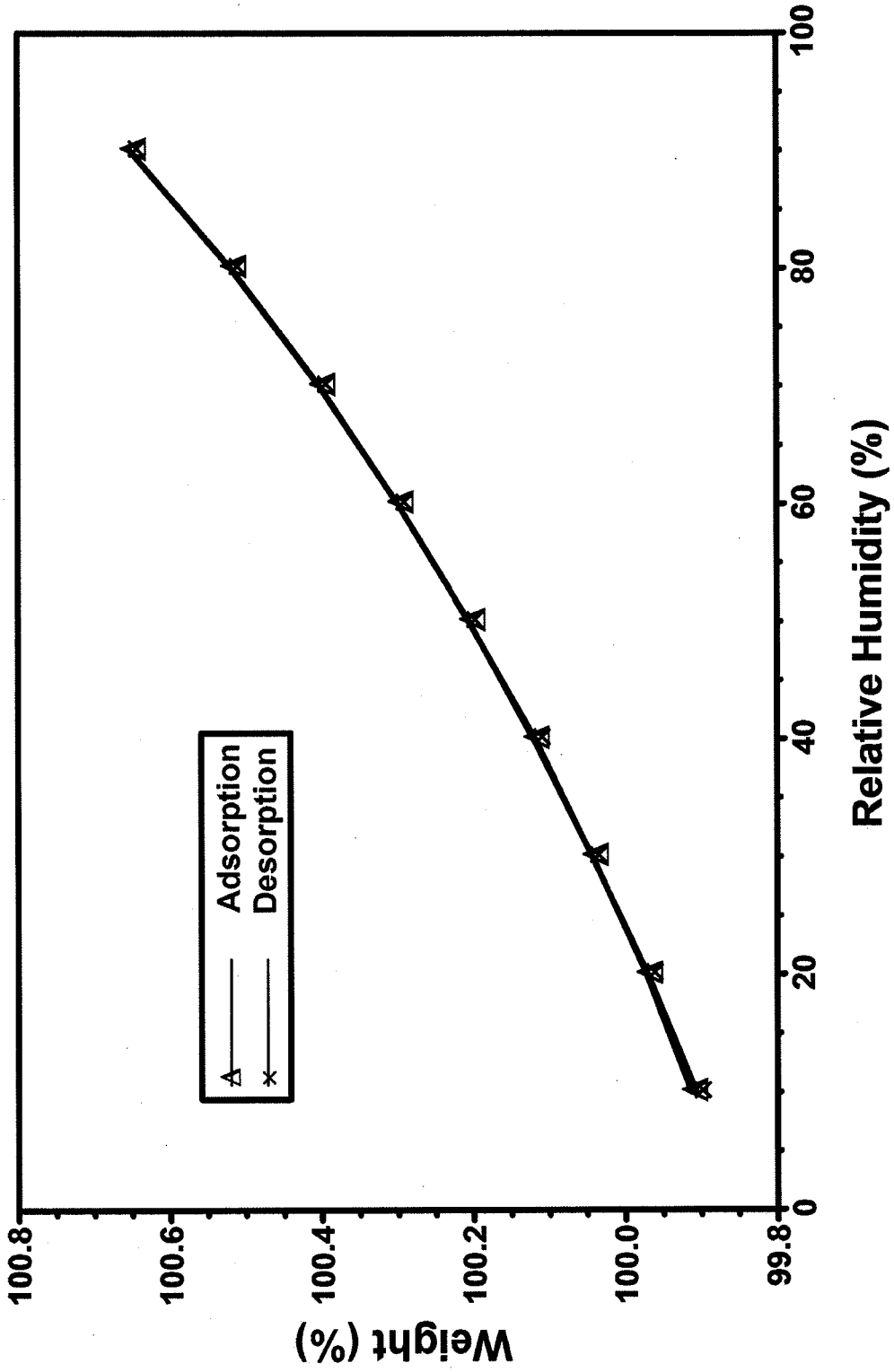
Weight (%)
100.8
100.6
100.4
100.2
100.0
99.8
Relative Humidity (%)
0
20
40
60
80
100
Adsorption
Desorption

Figure 4

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 7390791 B **[0001] [0029] [0031] [0033] [0064]**
- US 7803788 B **[0001]**
- US 6043230 A **[0034]**

Szabadalmi igénypontok

1. Tenofovir-alafenamid-hemifumarát.

2. Az 1. igénypont szerinti tenofovir-alafenamid-hemifumarát, ahol a fumársavnak a tenofovir-alafenamidhoz mért aránya 0,5 ± 0,1.

3. A 2. igénypont szerinti tenofovir-alafenamid-hemifumarát, ahol a fumársavnak a tenofovir-alafenamidhoz mért aránya 0,5 ± 0,05.

4. A 2. igénypont szerinti tenofovir-alafenamid-hemifumarát, ahol a fumársavnak a tenofovir-alafenamidhoz mért aránya 0,5 ± 0,01.

5. Az 1. igénypont szerinti tenofovir-alafenamid-hemifumarát, ahol a röntgen pordiffrakciós (XRPD) mintázat tartalmazza a következő 2-teta értékeket: 6,9 ± 0,2° és 8,6 ± 0,2°, ahol a mérés során 1,5406 Å hullámhosszúságú sugárzást alkalmazunk.

6. Az 5. igénypont szerinti tenofovir-alafenamid-hemifumarát, ahol a röntgen pordiffrakciós (XRPD) mintázat tartalmazza a következő 2-teta értékeket: 6,9 ± 0,2°, 8,6 ± 0,2°, 11,0 ± 0,2°, 15,9 ± 0,2° és 20,2 ± 0,2°, ahol a mérés során 1,5406 Å hullámhosszúságú sugárzást alkalmazunk.

7. Az 1. igénypont szerinti hemifumarát, amelynek differenciális pásztázó kalorimetriás (DSC) endotermáján 131 ± 2 °C-nál van a kezdőpont (onset).

8. Az 1. igénypont szerinti hemifumarát, amelynek differenciális pásztázó kalorimetriás (DSC) endotermáján 131 ± 1 °C-nál van a kezdőpont (onset).

9. Gyógyszerészeti készítmény, amely tartalmazza az 1-8. igénypontok bármelyike szerinti hemifumarátot és gyógyszerészetileg elfogadható segédanyagot.

10. A 9. igénypont szerinti gyógyszerészeti készítmény, amely tartalmaz további kiegészítő terápiás szereket; adott esetben ahol a további terápiás szer a következő csoportból választott: humán immunhiányosságot okozó vírus (HIV) proteázt gátló vegyületek, reverz transzkriptáznak HIV non-nukleozid gátlói, reverz transzkriptáznak HIV nukleozid inhibitorai, reverz transzkriptáznak HIV nukleotid inhibitorai, HIV integráz inhibitorok és CCR5 inhibitorok.

11. Eljárás gyógyszerészeti készítmény előállítására, amely tartalmazza az 1-8. igénypontok bármelyike szerinti hemifumarát és gyógyszerészetileg elfogadható segédanyag kombinálását egy gyógyszerészeti készítmény előállítására.

12. Eljárás tenofovir-alafenamid-hemifumarát előállítására, amely tartalmazza a) megfelelő oldószert; b) fumársavat; c) tenofovir-alafenamidet és d) egy vagy több tenofovir-alafenamid-hemifumarát oltókristályt tartalmazó oldat alávetését olyan körülményeknek, amelyek a fumársav és a tenofovir-alafenamid kristályosodását eredményezik; adott esetben ahol az oldószer tartalmaz acetonitrilt; és/vagy az oldószert kb. 0-kb. 75 °C tartományba eső hőmérsékletnek tesszük ki.

13. Az 1-8. igénypontok bármelyike szerinti hemifumarát vagy a 9-10. igénypontok bármelyike szerinti készítmény gyógyászati terápiában való alkalmazásra.

14. Az 1-8. igénypontok bármelyike szerinti hemifumarát vagy a 9-10. igénypontok bármelyike szerinti készítmény gyógyászati terápiában való alkalmazásra HIV-fertőzés profilaktikus vagy terápiás kezelésében; adott esetben ahol a HIV fertőzés egy emberben történt.

15. Az 1-8. igénypontok bármelyike szerinti hemifumarát vagy a 9-10. igénypontok bármelyike szerinti készítmény gyógyászati terápiában való alkalmazásra HBV-fertőzés profilaktikus vagy terápiás kezelésében, adott esetben ahol a HBV-fertőzés emberben történt.