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(54) **N4-(2,2-dimetil-4-[(dihidrogén-foszfonoxi)metil]-3-oxo-5-pirido[1,4]oxazin-6-il)-5-fluoro-N2-(3,4,5-trimetoxifenil)-2,4-pirimidindiamin-dinátriumsó szintézise**

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(54) **SYNTHESIS OF N4-(2,2-DIMETHYL-4-[(DIHYDROGEN PHOSPHONOXY)METHYL]-3-OXO-5-PYRIDO[1,4]OXAZIN-6-YL)-5-FLUORO-N2-(3,4,5-TRIMETHOXYPHENYL)-2,4-PYRIMIDINEDIAMINE DISODIUM SALT**

SYNTHESE EINES N4- (2, 2-DIMETHYL-4- [(DIHYDROGEN PHOSPHONOXY]-3-OXO-5-PYRIDO [1, 4]OXAZIN-6-YL)-5-FLUOR-N2- (3, 4, 5,-TRIMETHOXYPHENYL) -2, 4- PYRIMIDIN-DIAMIN-DINATRIUMSALZES

SYNTHÈSE DE SEL DE N4- (2, 2-DIMETHYL-4- [(DIHYDROGEN PHOSPHONOXY]-3-OXO-5-PYRIDO [1, 4]OXAZIN-6-YL)-5-FLUORO-N2- (3, 4, 5,-TRIMETHOXYPHENYL) -2, 4-PYRIMIDINEDIAMINES DISODIUM

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- **OSLOB J D ET AL: "Water-soluble prodrugs of an Aurora kinase inhibitor", BIOORGANIC & MEDICINAL CHEMISTRY LETTERS, vol. 19, no. 5, 1 March 2009 (2009-03-01), pages 1409-1412, XP025994282, ISSN: 0960-894X, DOI: 10.1016/J.BMCL.2009.01.043**
- **CHASSAING C ET AL: "Highly water-soluble prodrugs of anthelmintic benzimidazole carbamates: synthesis, pharmacodynamics, and pharmacokinetics", JOURNAL OF MEDICINAL CHEMISTRY, vol. 51, no. 5, 13 March 2008 (2008-03-13) , pages 1111-1114, XP009135085, ISSN: 0022-2623, DOI: 10.1021/JM701456R**

EP 2 448 950 B1

Description

I. BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to the field of pharmaceutical/process chemistry. Disclosed herein are methods for synthesizing 2,4-pyrimidinediamines as well as intermediates used therein. As an embodiment, provided herein is a process for preparing N4-(2,2-dimethyl-4-[(dihydrogen phosphonoxy)methyl]-3-oxo-5-pyrido[1,4]oxazin-6-yl)-5-fluoro-N2-(3,4,5-trimethoxyphenyl)-2,4-pyrimidinediamine disodium salt (compound of formula I), particularly hydrates (such as a hexahydrate) of the compound of formula I, a 2,4-pyrimidinediamine that is useful in the treatment and prevention of various diseases.

Summary of the Related Art

[0002] Various-classes of 2,4-pyrimidinediamine compounds have been discovered that have myriad therapeutic uses. See, for example, U.S. application Ser. No. 10/355,543 filed Jan. 31, 2003 (US 2004/0029902A1), international application Ser. No. PCT/US03/03022 filed Jan. 31, 2003 (WO 03/063794), U.S. application Ser. No. 10/631,029 filed Jul. 29, 2003 (U.S.2007/0060603), international application Ser. No. PCT/US03/24087 (WO 2004/014382), U.S. application Ser. No. 10/903,263 filed Jul. 30, 2004 (US2005/0234049), and international application Ser. No. PCT/US2004/24716 (WO/2005/016893).

[0003] One of the process for preparing the 2,4-pyrimidinediamine compounds is described in U.S. Application Ser. No. 11/539,074, filed October 5, 2006.

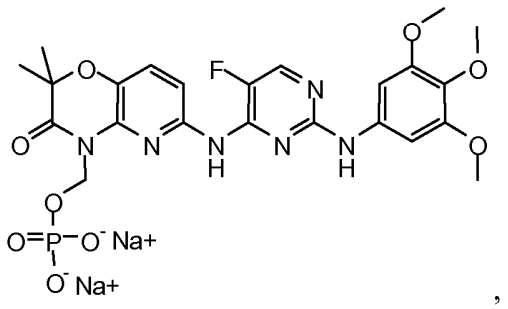
[0004] WO 2008/064274 discloses prodrugs of biologically active 2,4- pyrimidinediamine compounds, salts and hydrates of the prodrugs, compositions. comprising the prodrugs, intermediates and methods for synthesizing the prodrugs and methods of using the prodrugs in a variety of applications.

[0005] Oslob J D et al. (Bioorganic & Medicinal Chemistry Letters, vol. 19, no. 5, 1 March 2009) discloses water-soluble prodrugs of an aurora kinase inhibitor.

[0006] Chassaing C et al. (Journal Of Medicinal Chemistry, vol. 51, no. 5, 13 March 2008) discloses the synthesis, pharmacodynamics, and pharmacokinetics of highly water-soluble prodrugs of anthelmintic benzimidazole carbamates.

II. SUMMARY OF THE INVENTION

[0007] The invention comprises a processes for preparing N4-(2,2-dimethyl-4-[(dihydrogen phosphonoxy)methyl]-3-oxo-5-pyrido[1,4]oxazin-6-yl)-5-fluoro-N2-(3,4,5-trimethoxyphenyl)-2,4-pyrimidinediamine disodium salt (compound of formula I):



I

as well as hydrates (such as a hexahydrate) thereof. The comound of formula I (and hydrates thereof) is a 2,4-pyrimidinediamine that is useful in the treatment and prevention of various diseases. The invention further comprises solvate intermediates useful in the process.

[0008] It will be appreciated by one of skill in the art that the embodiments summarized above may be used together in any suitable combination to generate embodiments not expressely recited above and that such embodiments are considered to be part of the present invention.

III. BRIEF DESCRIPTION OF THE FIGURES

[0009]

Figure 1 illustrates a dynamic differential scanning calorimetry experiment (DSC) in closed cup of neat di-*tert*-butylchloromethyl phosphate (3.834 mg).

Figure 2 illustrates a Thermo-Graphic-Analysis (TGA) experiment with neat di-*tert*-butylchloromethyl phosphate (7.7 mg).

Figure 3 illustrates a dynamic differential scanning calorimetry experiment in closed cup of a 36% solution of di-*tert*-butylchloromethyl phosphate (5.6 mg) in DMAc.

Figure 4 illustrates a isotherm differential scanning calorimetry experiment in closed cup of a 36% di-*tert*-butylchloromethyl phosphate (10.9 mg) solution in DMAc at 80°C.

IV. DETAILED DESCRIPTION OF THE INVENTION

1. Definitions

[0010] As used herein, the following definitions shall apply unless otherwise indicated.

[0011] Unless defined otherwise, all technical, and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this invention belongs. Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, the preferred methods, devices, and materials are now described.

[0012] "Amide" refers to the group $R^{20}CON(R^{21})_2$ wherein R^{20} is selected from hydrogen or optionally substituted alkyl; and each R^{21} is independently hydrogen or optionally substituted alkyl, or both of R^{21} and the nitrogen with which they are attached form a 4 to 6 membered aliphatic ring; or R^{20} and one of the R^{21} join together with the carbon and nitrogen to which they are attached, respectively, combine to form a 4 to 6 membererd nitrogen containing ring, and the other R^{21} is hydrogen or optionally substituted alkyl. Amides include primary amides, secondary amides (such as, but not limited to, alkyl formamides and acetamides, such as N-methyl acetamide), and tertiary amides (such as, but not limited to, N,N-dialkylacetamides, N,N-dialkylformamides, N-alkylpyrrolidones, and N-alkylpiperidones). Particular examples of tertiary amides suitable for use in the presently disclosed solvates include, without limitation N,N-dimethylacetamide, N,N-dimethylformamide, N-methylpyrrolidinone, N-methylpiperidinone.

[0013] "Alkyl" refers to monovalent saturated aliphatic hydrocarbyl groups having from 1 to 8 carbon atoms, such as, 1 to 6 carbon atoms or 1 to 4 carbon atoms. This term includes, by way of example, linear and branched hydrocarbyl groups such as methyl (CH_3-), ethyl (CH_3CH_2-), n-propyl ($CH_3CH_2CH_2$-), isopropyl ($(CH_3)_2CH$-), n-butyl ($CH_3CH_2CH_2CH_2$-), isobutyl ($(CH_3)_2CHCH_2$-), sec-butyl ($(CH_3)(CH_3CH_2)CH$-), t-butyl ($(CH_3)_3C$-), n-pentyl ($CH_3CH_2CH_2CH_2CH_2$-), and neopentyl ($(CH_3)_3CCH_2$-). Also by way of example, a methyl group, an ethyl group, an n-propyl, an isopropyl group, a n-butyl group, an isobutyl group, sec-butyl group, and t-butyl are all represented by the term C_1-C_4 alkyl. Likewise terms indicating larger numerical ranges of carbon atoms are representative of any linear or branched hydrocarbyl falling within the numerical range. This inclusiveness applies to other hydrocarbyl terms bearing such numerical ranges.

[0014] "Base" refers to substance that can accept protons. Examples of bases include, but are not limited to, carbonates, such as cesium carbonate, sodium carbonate, sodium bicarbonate, potassium carbonate, hydroxides, such as, sodium hydroxide, potassium hydroxide, lithium hydroxide, and ammonia.

[0015] "Halo" or "halogen" refers to fluoro, chloro, bromo, and iodo.

[0016] "Solvate" refers to a complex formed by combination of at least one solvent molecule with at least one molecule or ion of the solute. One of ordinary skill in the art will appreciate that the stoichiometry of the solvent to the solute in a solvated may be greater than one, equal to one or less than one. The solvent can be an organic compound, an inorganic compound, or a mixture of both. Some examples of solvents include, but are not limited to, methanol, acetic acid, N,N-dimethylformamide, tetrahydrofuran, dimethylsulfoxide, and water. When used herein, the term "solvate" is not intended to restrict the solvate compounds described herein to any particular sort of bonding (such as ionic or coordinate covalent bonds).

[0017] The term "substituted," when used to modify a specified group or radical, means that one or more hydrogen atoms of the specified group or radical are each, independently of one another, replaced with the same or different substituent groups as defined below.

[0018] Substituent groups on optionally substituted alkyls are alkyl, halo, haloalkyl, nitroso, and cyano.

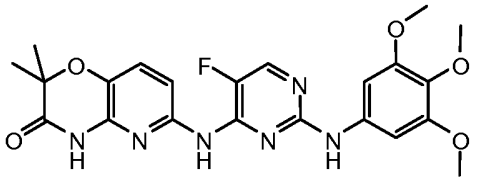
[0019] Similarly, it is understood that the above definitions are not intended to include impermissible substitution patterns (such as carbon substituted with five groups, i.e., pentavalent carbon). Such impermissible substitution patterns are easily recognized by a person having ordinary skill in the art.

2. Compositions and Process

[0020] Disclosed herein are methods for synthesizing 2,4-pyrimidinediamines as well as intermediates used therein. As an embodiment, provided herein is a process for preparing N4-(2,2-dimethyl-4-[(dihydrogen phosphonoxy)methyl]-3-oxo-5-pyrido[1,4]oxazin-6-yl)-5-fluoro-N2-(3,4,5-trimethoxyphenyl)-2,4-pyrimidinediamine disodium salt (Compound of formula I) (including hydrates thereof, particularly a hexahydrate), a 2,4-pyrimidinediamine that is useful in the treatment and prevention of various diseases.

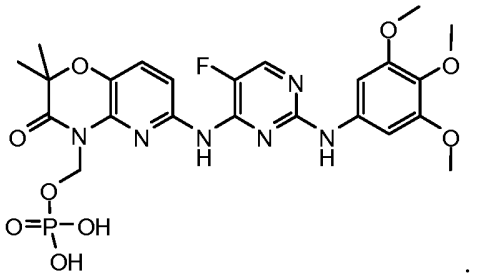
[0021] The compound of formula I has been described in U.S. Patent No. 7,449,458, filed January 19, 2006. The phosphate containing progroups such as in the compounds of formulae I, II, III, and VI may increase the solubility of the 2,4-pyrimidinediamine compounds that exhibit poor solubility under physiological conditions (for example, solubilities of less than about 10 μg/mL). The phosphate-containing progroups may aid the solubility of the underlying active 2,4-pyrimidinediamine compound, which in turn may increase its bioavailability when administered orally. The phosphate progroups may be metabolized by phosphatase enzymes found in the digestive tract, permitting uptake of the underlying active drug.

[0022] The U.S. Patent No. 7,449,458, filed January 19, 2006, discloses that the water solubility and oral bioavailability of a particular biologically active 2,4-pyrimidinediamine compound, such as compound of formula IV:



IV

increased dramatically when formulated to include a progroup at the ring nitrogen atom as in compound of formula II:

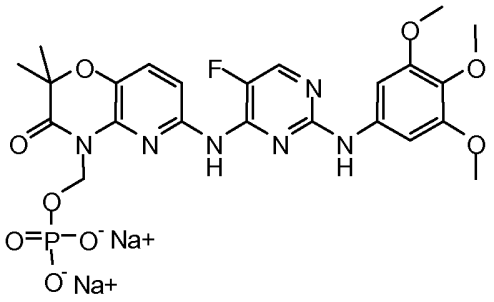


II

[0023] Where the water solubility of the compound of formula IV was found to be in the range of about 1-2 μg/mL in aqueous buffer under physiological conditions, the solubility of the corresponding phosphate prodrug (compound of formula II) was found to be greater than 5 mg/mL under the same conditions, or approximately 2000 times greater. This increased water-solubility allows for better dissolution in the gut, thereby facilitating oral administration.

[0024] A process for preparing the compound of formula I has been described in U.S. Application Ser. No. 11/539,074, filed October 5, 2006, which is incorporated herein by reference in its entirety in the present disclosure.

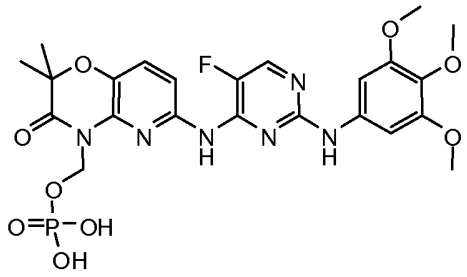
[0025] The invention includes a process for preparing a compound of formula I:



I

comprising:

a) contacting an acid solvate of a compound of formula II:

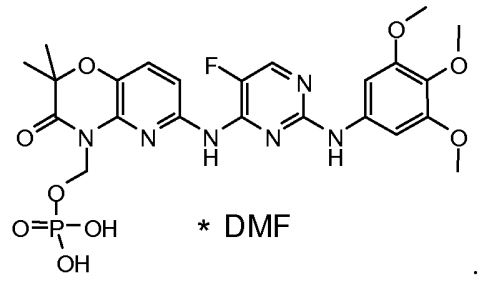


II

with an amide under conditions suitable for forming an amide solvate of the compound of formula II; and
b) contacting the amide solvate with an aqueous base comprising sodium ions under conditions suitable for forming the compound of formula I. In a particular embodiment, the compound of formula I is a hydrate, such as a hexahydrate.

[0026] In some embodiments, the acid solvate of the compound of formula II is a carboxylic acid. In some embodiments, the carboxylic acid is R^1COOH wherein R^1 is -H or a C_1-C_4 alkyl optionally substituted with up to three halo substituents.

[0027] In another aspect the invention comprises the novel amide solvate intermediate of formula III:



III

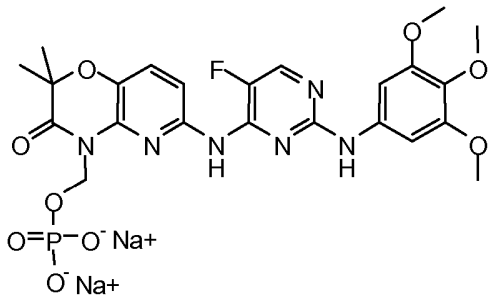
[0028] The amide solvate III can be synthesized by conversion of an acid solvate of the compound for formula II to the amide solvate III. One of ordinary skill in the art will recognize in view of the present disclosure that the amide solvates of formula III can be made via other forms of II, not only acid solvates of II. In some embodiments, the conditions suitable for forming the amide solvate of the compound of formula II comprise contacting the acid solvate with the tertiary amide at a temperature of between about 20 °C and about 50 °C. In some embodiments, the conditions suitable for forming the amide solvate comprise re-slurrying the acid solvate in N,N-dimethyl formamide (DMF) at a temperature of about 40 °C.

[0029] In some embodiments, the aqueous base in step b) above comprises sodium hydroxide (NaOH) and an alcohol, and the conditions suitable for forming the compound of formula I comprise a temperature of between about 40 °C about 80 °C and a pH of about 9 to about 10.5. In some embodiments, the alcohol includes, but is not limited to, methanol,

ethanol, iso-propanol, butanol, t-butanol, pentanol.

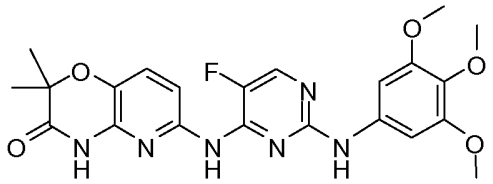
[0030] In some embodiments, the aqueous base in step b) above comprises sodium hydroxide (NaOH) and isopropyl alcohol (IPA), and the conditions suitable for forming the compound of formula I comprise a temperature of about 80 °C and a pH of about 10.2.

[0031] In another aspect, the invention comprises a process for preparing a precursor (VI) of the compound of formula I:



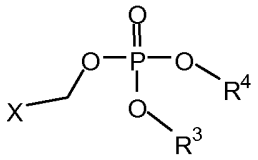
I

comprising contacting a compound of formula IV:



IV

with a compound of formula V:

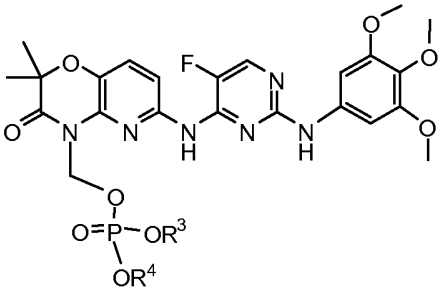


V

in the presence of an amide, wherein:

R^3 and R^4 are each independently C_1-C_6 alkyl; and
X is halogen;

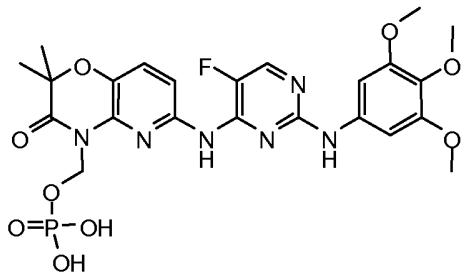
under conditions suitable for forming a compound of formula VI:



VI

[0032] In another embodiment, the invention comprises a method of converting the precursor VI into the compound of formula I, the method comprising:

a) contacting the compound of formula VI with an acid under conditions suitable for forming an acid solvate of a compound of formula II:



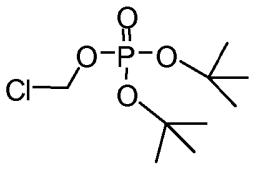
II

b) contacting the acid solvate of the compound of formula II with an amide under conditions suitable for forming an amide solvate of the compound of formula II; and
c) contacting the amide solvate of the compound of formula II with an aqueous base comprising sodium ions under conditions suitable for forming the compound of formula I.

In a particular embodiment, the compound of formula I produced by this method is a hydrate, such as a hexahydrate.

[0033] In another embodiment, the invention comprises the sequential combination of the two previous methods (i.e., a method comprising the method of making precursor VI followed by the method of converting VI to the compound of formula I).

[0034] In some embodiments, the compound of formula V is di-*tert*-butyl chloromethyl phosphate:



[0035] The conditions suitable for producing the compound of formula VI can comprise:

(i) combining the compound of formula IV with the compound of formula V with a base in a polar solvent; and
(ii) washing the product obtained from step (i) in an aqueous base solution.

[0036] Examples of bases suitable for use in steps (i), (ii) or both include, but are not limited to, carbonates, such as cesium carbonate, sodium carbonate, sodium bicarbonate, potassium carbonate, hydroxides, such as, sodium hydroxide, potassium hydroxide, lithium hydroxide, and 1°, 2° and 3° amines such as triethylamine, N,N-dimethylaniline, N,N-diethylaniline and ammonia, as well as metal alkoxides e.g. potassium t-butoxide.

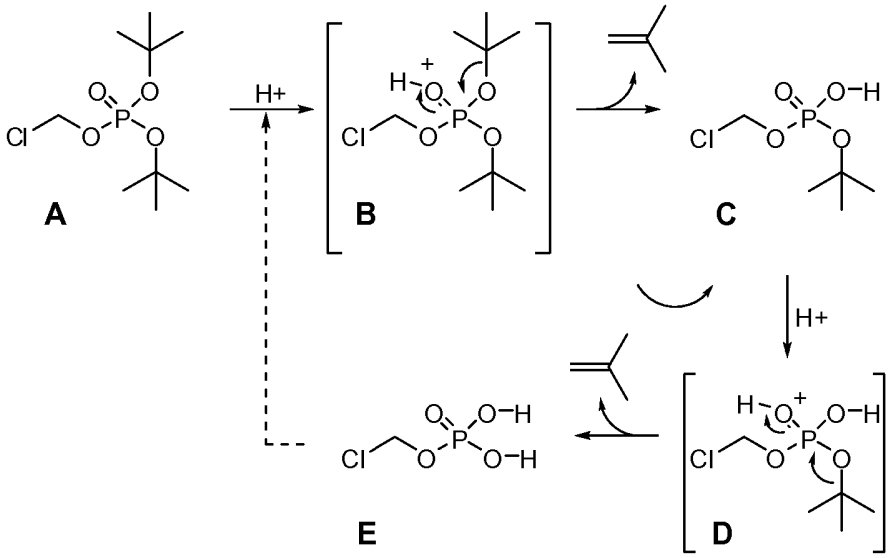
[0037] Examples of polar solvent include, but are not limited to, N,N-dimethylformamide (DMF), N,N-dimethylacetamide, tetrahydrofuran, dichloromethane, acetone, acetonitrile, dimethylsulfoxide. Mixtures of such solvents also can be used as is known to those of skill in the art. Moreover, those of skill in the art also would understand that such polar solvents can include non-polar components in a mixture with one or more polar solvents so long as the resultant solvent mixture is polar. Solvents typically considered to be polar include those having a dielectric constant, ε, of at least about 5 and typically greater than about 7 or 8. For example, tetrahydrofuran has a dielectric constant, ε of 7.6, whereas DMF has a dielectric constant of 37.

[0038] In some embodiments, the base in step (i) above comprises at least one of cesium carbonate (Cs_2CO_3) and potassium carbonate (K_2CO_3); the polar solvent comprises at least one of DMF and N,N-dimethylacetamide (DMAc); and the aqueous base in step (ii) above comprises at least one of sodium bicarbonate ($NaHCO_3$) and sodium hydroxide (NaOH).

[0039] In some embodiments, the compound of formula VI is not isolated.

[0040] In some embodiments, the compound of formula V is stabilized with N,N-dimethylacetamide (DMAc) solvent.

[0041] Generally, the compound of formula V, such as, di-*tert*-butyl chloromethyl phosphate, is an unstable product. As an example, di-*tert*-butyl chloromethyl phosphate undergoes decomposition upon storage to give off heat and isobutene gas. With reference to the scheme below, and while not intending to be bound by theory, it is believed that the presence of trace amounts of acid catalyzes the cleavage of an *O-tert*-butyl group on di-*tert*-butyl chloromethyl phosphate **A** to give mono-*tert*-butyl species C with the release of isobutene. Species **C** can act as an acid source further driving autocatalytic decomposition to phosphate **E.** As indicated by the dotted line in the scheme below, phosphate **E** can also provide protons to feed into the autocatalytic decomposition of **A**. Decomposition of **A** is exothermic and produces two moles of isobutene per mole of **A**.



[0042] When stored under adiabatic conditions, the heat and pressure build-up from decomposition can be significant. Figure 1 illustrates that storage of di-*tert*-butyl chloromethyl phosphate under adiabatic conditions can result in decomposition whereby the pressure and temperature increase dramatically. Figure 1 illustrates a dynamic differential scanning calorimetry experiment (DSC) in closed cup of neat di-*tert*-butylchloromethyl phosphate (heating from 0 °C to 300 °C at a rate of 5 °C/min under a N_2 flow of 50 mL/min.). Referring to Figure 1, after an endothermic signal (start of isobutene release under upon formation of acidic by products; extrapolated peak at 99.10 °C with a peak width of 0.33 °C and an integrated area of -108.45 mJ) a very sharp exothermic signal at about 100°C is observable (extrapolated peak at 100.57 °C with a peak width of 3.99 °C and a integrated area of 2717.05 mJ), which is typical for an autocatalytic decomposition. Figure 2 illustrates a Thermo-Graphic-Analysis (TGA) experiment with neat di-*tert*-butylchloromethyl phosphate, showing that continuous decomposition is observed with isobutene offgassing. In Figure 2, the sample was heated from 20 °C to 300 °C at a rate of 5 °C/min under N_2 at a flow rate of 80 mL/min. The sample showed a 41.465% (3.189 mg) mass loss between about 21 °C and 119 °C; and a 19.526 % (1.502 mg) mass loss between about 119 °C and 300 °C. Most of the isobutene is sharply split off at 110°C; after 1 h at 300°C the weight of the sample corresponds to acid **E** as depicted above. Further tests have shown the pressure increase due to isobutene release can be as great as 80 bar. Also, isobutene is a flammable gas therefore venting large quantities of iso-butene can be dangerous.

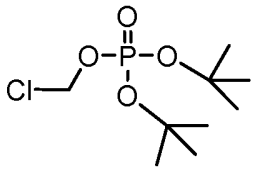
[0043] Therefore, it is normally critical to design equipment for the storage of the compound of formula V that can

withstand the pressure build up. Various other safety measures need to be taken as well, such as temperature control, distillation time, and safety valve dimension, to avoid equipment damage during the unwanted decomposition reaction.

[0044] However, it was unexpectedly found that the addition of N,N-dimethylacetamide (DMAc) stabilizes di-*tert*-butyl chloromethyl phosphate such that the compound may be stored at about 60°C with no autocatalytic decomposition and no gas being formed (see Figures 3-4). Figure 3 illustrates a dynamic differential scanning calorimetry experiment in closed cup of a 36% solution of di-*tert*-butylchloromethyl phosphate in DMAc (heating from 0 °C to 300 °C at a rate of 5 °C/min. under a N_2 flow of 50 mL/min.). After an endothermic signal (some isobutene loss due to trace acid; extrapolated peak at 116.42 °C with a peak width of 6.19 °C and an integrated area of -70.78 mJ) a smooth exothermic signal at 120°C is observable (no sharp exothermic signal at 99 to 100°C is observable; extrapolated peak at 129.74 °C with a peak width of 42.52 °C and an integrated area of 1362.40 mJ). This indicates that the system is not undergoing autocatalytic decomposition. Figure 4 illustrates an isothermic differential scanning calorimetry (DSC) experiment in closed cup of a 36% di-*tert*-butylchloromethyl phosphate solution in DMAc at 80°C (under a N_2 flow of 50 mL/min.). No endothermic or exothermic decomposition of a 36% di-*tert*-butylchloromethyl phosphate solution in DMAc is observed at storage temperatures (45, 60 and even 80°C) over 15 hours, thus the di-*tert*-butylchloromethyl phosphate is stabilized. In fact, isothermal heating at 60°C of a solution from 68.7g of a 36% solution of di-*tert*-butylchloromethyl phosphate in DMAc for over 96 hours generated no gas (isobutene).

[0045] It is to be understood that any amide, such as, but not limited to, DMAc, may be used to stabilize the compound of formula V, including di-*tert*-butyl chloromethyl phosphate. Such amides are well known to a person of ordinary skill in the art. Examples of such amides include, but are not limited to, N,N-dimethylacetamide, N,N-dimethylformamide, N-methylpyrrolidinone. In some embodiments, a solvent may be optionally added to a combination of the amide and di-*tert*-butyl chloromethyl phosphate. In some embodiments, the amide may also be a solvent. For example, DMAc can be used as the amide as well as the solvent.

[0046] Accordingly, in one aspect, there is provided a composition consisting essentially of di-*tert*-butyl chloromethyl phosphate:



and an amide optionally in a solvent.

[0047] In some embodiments, the amide is also the solvent.

[0048] In some embodiments, the amide is a tertiary amide.

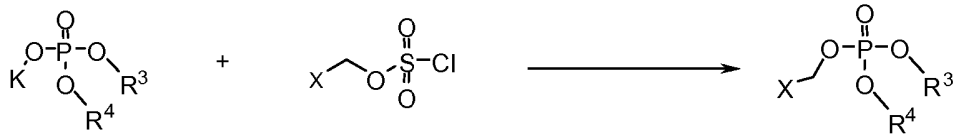
[0049] In some embodiments, the tertiary amide is N,N-dimethylacetamide (DMAc).

[0050] The improved process for the synthesis of the compound of formula I is as illustrated in Schemes I-VII below.

3. Synthetic Schemes

[0051] Starting materials used in the synthesis described herein are available commercially. The synthesis of the compound of formula V is as shown in Scheme I below:

Scheme I



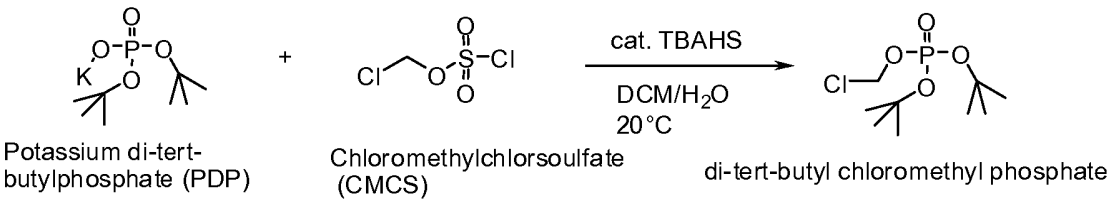
V

[0052] According to Scheme I, compound of formula V is obtained by the reaction of potassium dialkyl phosphate group (R^3 and R^4 as defined hereinabove) with an alkylating agent (X as defined hereinabove), such as a halomethyl-chlorosulfate in the presence of a phase transfer catalyst (PTC). Numerous examples of phase transfer catalysts are known to those of skill in the art. Examples of such phase transfer catalysts include, without limitation tetraalkyl ammonium salts, such as tetrabutyl ammonium salts. For example, di-*tert*-butyl chloromethyl phosphate can be obtained by the

reaction of potassium or sodium di-*tert*-butyl phosphate (PDP) with chloromethylchlorosulfate (CMCS) in the presence of tetrabutylamonium bisulfate (TBAHS).

[0053] Scheme Ia below (as well as **Figures 1-4** and the Examples below), shows that the pH adjustment and the addition of N,N-dimethylacetamide (DMAc) stabilizes di-*tert*-butyl chloromethyl phosphate such that the compound may be kept at about 60°C with no gas being formed.

Scheme Ia

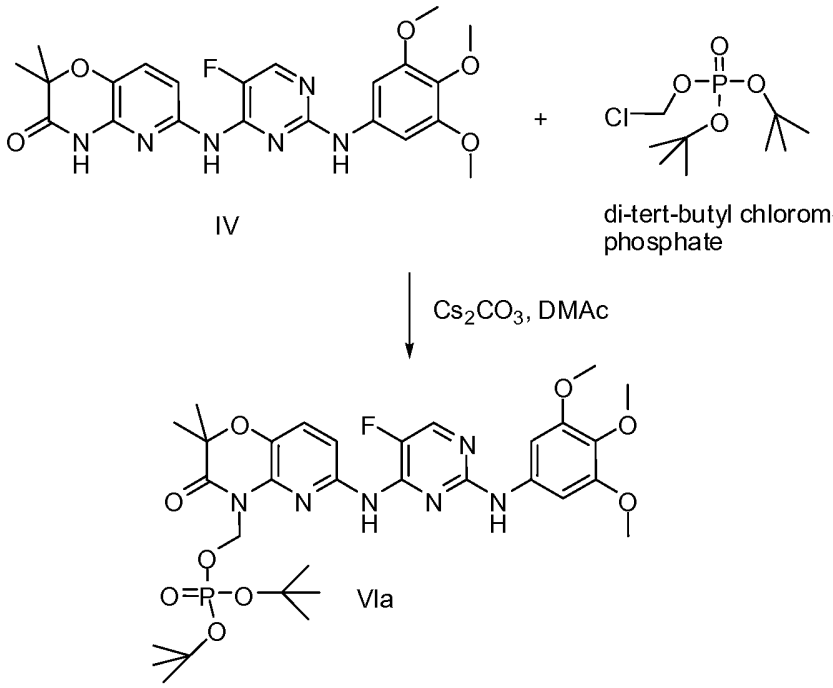


Potassium di-tert-butylphosphate (PDP) + Chloromethylchlorsoulfate (CMCS) → di-tert-butyl chloromethyl phosphate

[0054] It is to be understood that the synthesis of di-*tert*-butyl chloromethyl phosphate in Scheme Ia is for illustration purposes only. Synthesis of other phosphates of the compound of formula V by following Scheme Ia can be carried out by routine adaptation of the method. In addition, sodium or other salts of di-*tert*-butyl phosphate and other reaction conditions can be used to make di-*tert*-butyl chloromethyl phosphate.

[0055] The synthesis of the compound of formula VIa from compound of formula IV is as illustrated in Scheme II below:

Scheme II



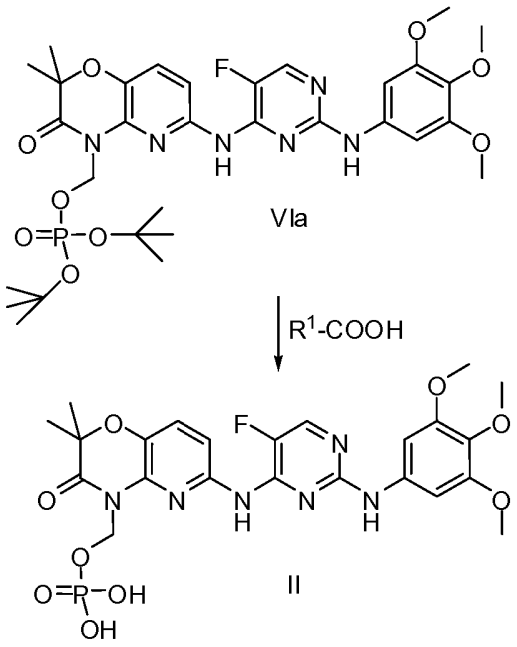
[0056] According to Scheme II, the compound of formula IV is treated with di-*tert*-butyl chloromethyl phosphate to result in the compound of formula VIa (such as step B of Example 1 herein). It is to be understood that reaction of a compound of formula IV with di-*tert*-butyl chloromethyl phosphate is for illustration purposes only. Other phosphates, such as compound of formula V described herein, may be reacted with the compound of formula IV to result in the compound of formula VI using routine adaptation of the method. The steps described further below for the compound of formula VIa may also be applied to the compound of formula VI.

[0057] In some embodiments, Cs_2CO_3 as a base and DMAc as the solvent in the synthesis of the compound of formula VIa. Base Cs_2CO_3 may be substituted with K_2CO_3 or KOtBu, each alone or in combination with each other or Cs_2CO_3. The compound of formula VIa can be isolated as a solid but can also be obtained as solution in methyl *tert*-butyl ether (MtBE).

[0058] Synthesis of the acid solvate of the compound of formula II from a compound of formula VIa is as illustrated in

Scheme III and exemplified in step C of Example 1 below:

Scheme III

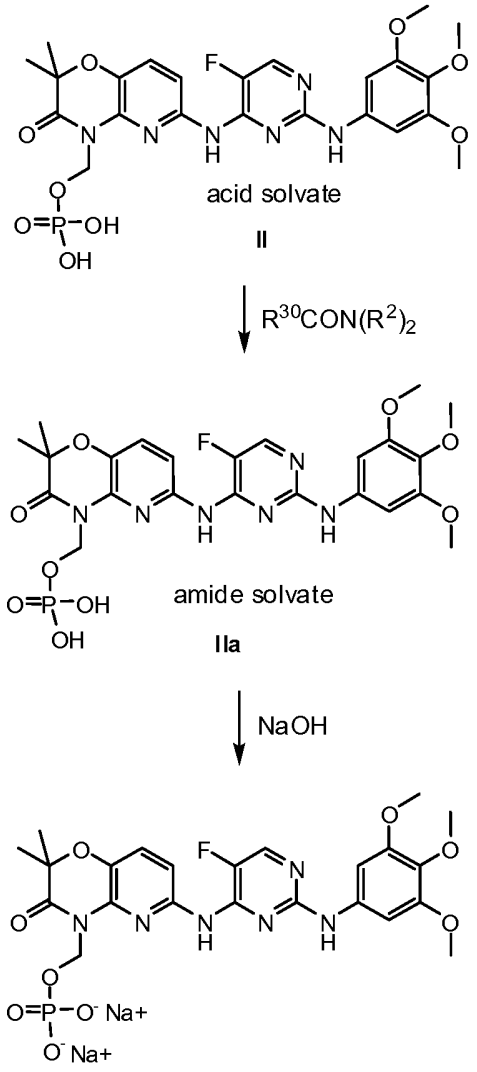


acid solvate

[0059] According to Scheme III, the compound of formula VIa is dissolved in a mixture of an acid R^1-COOH (R^1 is as defined hereinabove) and water and heated to about 55-70°C. For example, as described in step C of Example 1, the compound of formula VIa is dissolved in acetic acid and water (4:1 AcOH:H_2O) and heated to 67°C to yield an acetic acid solvate of the compound of formula II.

[0060] The synthesis of the amide solvate of the compound of formula II from the acid solvate of the compound of formula II is as illustrated in Scheme IV and exemplified in step C of Example 1:

Scheme IV



I

wherein the compound of formula I is optionally in the form of a hydrate, such as a hexahydrate.

[0061] The conversion of the acid solvate of the compound of formula II to the amide solvate of the compound of formula II comprises reslurrying the acid solvate of the compound of formula II in a tertiary amide, such as $R^{30}CON(R^2)_2$ (where R^2 and R^{30} are as defined hereinabove) between about 20°C-50°C. For example, as described in step C of Example 1, the acetic acid solvate of the compound of formula II is reslurried in DMF at about 40°C to yield a DMF solvate of the compound of formula II.

[0062] This step of reslurrying of the acid solvate to obtain the DMF solvate of the compound of formula II results in a higher quality product with less starting material and byproducts, such as, depletion of the compound of formula IV to < 1 mole % and of p-dimer to < 0.1 mole %. The product is stable at 40°C for about 24h. This improved process results in improved filterability of the product. This improved process further results in increased yield by about 10%.

[0063] A synthesis of the compound of formula I from the amide solvate of the compound of formula II is as exemplified in step D of Example 1. The amide solvate of the compound of formula II is taken in an alcohol, such as, isopropylalcohol/water where the pH is adjusted between about 9 to about 10.5 by adding a base, such as, NaOH. The solution is heated between about 40°C to about 80°C. In one embodiment, the DMF solvate of the compound of formula II is treated with isopropylalcohol/water at a temperature of about 80°C and a pH of about 8 - 10.2 to result in the compound of formula I.

IV. EXAMPLES

[0064] The invention is further understood by reference to the following examples, which are intended to be purely

exemplary of certain aspects of the invention and are not intended to limit the scope.

[0065] In the examples below as well as throughout the application, the following abbreviations have the following meanings. If not defined, the terms have their generally accepted meanings.

cm	= centimeter
CMCS	= chloromethylchlorsulfate
Cs_2CO_3	= cesium carbonate
DCM	= dichloromethane
DMAc	= dimethylacetamide
h	= hours
HCl	= hydrochloric acid
IPA	= isopropylalcohol
mbar	= millibar
MeOH	= methanol
MtBE	= methyl- *tert*-butyl ether
mol	= molar
mL	= milliliter
g	= gram
mg	= milligram
rpm	= revolutions per minute
min	= minute
mm	= millimeter
N	= normal
Na_2CO_3	= sodium carbonate
$NaHCO_3$	= sodium bicarbonate
NaOH	= sodium hydroxide
NMP	= N-methylpyrrolidinone
NMR	= nuclear magnetic resonance
PDP	= di-*t*-butylphosphate
PTC	= phase transfer catalyst
TBAHS	= tetrabutylamoniumhydrogehsulfate
v/v	= volume/volume
°C	= degree Celsius
$POCl_3$	= Phosphorus oxychloride

Example 1

A. Preparation of di-*tert*-butyl chloromethyl phosphate:

Procedure I:

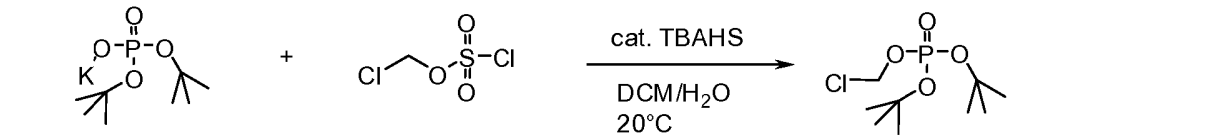
Preparation of stabilized di-*tert*-butyl chloromethyl phosphate

[0066] Preparation of di-*tert*-butyl chloromethyl phosphate, has been described in the literature, such as in Mantyla, et al. Tetrahedron Letters, 43(2002), 3793-3794 and Chadwick, et al. US 2006/0047135. We have found improvements to these processes whereby the yield is increased, with high purity, and the di-*tert*-butyl chloromethyl phosphate is stabilized via exposure to an amide. The specific example below illustrates this aspect of the invention.

[0067] Surprisingly, it was found that di-*tert*-butyl chloromethyl phosphate could be synthesized in excellent yield (>90%) and purity (>99%) by dosing 2.5 eq. CMCS to a two phase mixture of PDP and phase transfer catalyst TBAHS in DCM/water and adjusting pH value to 8 at the same time by addition of 20% aqueous NaOH. Additionally it was found, that the stability of di-*tert*-butyl chloromethyl phosphate was tremendously enhanced and no auto catalytic decomposition behaviour was observed by preparation of a 30 w% solution in dimethylacetamide (DMAc).

Description of the process:

[0068] Di-*tert*-butyl chloromethyl phosphate was synthesized using a TBAHS phase transfer catalysed reaction of PDP in DCM/H_2O with 2.5 eq. CMCS at 18°C. The pH was monitored and adjusted to 8 by addition of 20% aqueous NaOH.



Potassium di-tert-butylphosphate (PDP)

Chlormethylchlorsulfate (CMCS)

di-tert-butyl chloromethyl phosphate

[0069] The DCM was removed at 20°C and a pH > 7 at reduced pressure (recycling of DCM). To the crude di-*tert*-butyl chloromethyl phosphate was added MtBE, and the TBASHS was removed by washing the MtBE layer with 2% aqueous bicarbonate solution. To stabilize the di-*tert*-butyl chloromethyl phosphate, DMAc was added, and then the MtBE was distilled off. The yield was > 90% based on PDP starting material. The purity of di-*tert*-butyl chloromethyl phosphate in DMAc according to ^{1}H-NMR > 99%

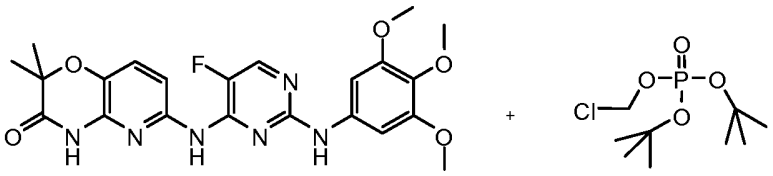
[0070] This procedure has at least the following advantages: 1) a liquid base (aqueous NaOH) instead of an excess of solid base such as $NaHCO_3$, Na_2HPO_4 or Na_2CO_3 can be used; 2) the reaction can be performed in a more concentrated state because an excess of less soluble bicarbonates or phosphates are replaced by soluble chlorides, thereby minimizing volume requirements and reaction time while improving yield. Also, the stability of the di-*tert*-butyl chloromethyl phosphate is enhanced, up to 40°C, by preparation of, for example, a 30 w% solution in DMAc.

[0071] In a specific example, 56.3 g of PDP (1.0 mol equivalent: 91.2 w%) was mixed with 3.53 g of TBAHS (0.05 eq.), 60 g of water and 300 g of DCM. At room temperature, 86.6 g of CMCS (2.5 eq.) was dosed to the reaction mixture over 4 h. During the dosing of CMCS, the pH was adjusted to 8 by addition of 227 g of 20% aqueous NaOH. The resulting two phase reaction mixture was stirred overnight at 20°C. The DCM was distilled off at 20°C under reduced pressure (500→300 mbar) from the two phase mixture. After addition of 200 mL MtBE to the residue, layers were separated. The water layer was discarded and the organic layer was washed once with 300 mL 2% aqueous $NaHCO_3$ to remove phase transfer catalyst. After addition of 90 mL DMAc, MtBE was distilled off at 40°C and reduced pressure. Liquid nitrogen was bubbled through the resulting mixture for 1 hour to remove traces of DCM and MtBE. The di-*tert*-butyl chloromethyl phosphate (128 g of an oil) was obtained and analysed by ^{1}H-NMR, showing a yield of di-*tert*-butyl chloromethyl phosphate of 90.7%. (di-*tert*-butyl chloromethyl phosphate: 36.4%; DMAc: 63.4 w%; DCM: 0.03 w%; MtBE: 0.01 w%; PTC: 0.01 w%; Water: 0.6 w%).

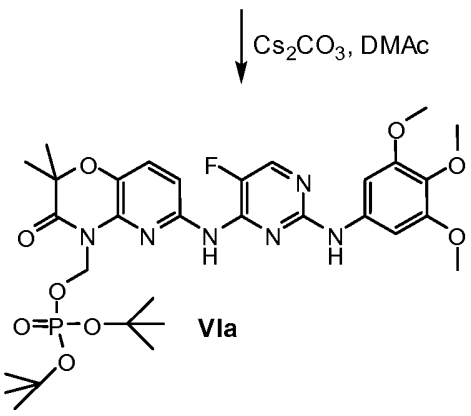
[0072] Additional advantages include: 1) DCM can be recycled, 2) PTC can be removed in a single extraction, 3) only 5 mol% of PTC is needed, and 4) all but minute traces of DCM and MtBE are remove by bubbling N_2.

B. Preparation of compound of formula VIa in MtBE

[0073]



IV



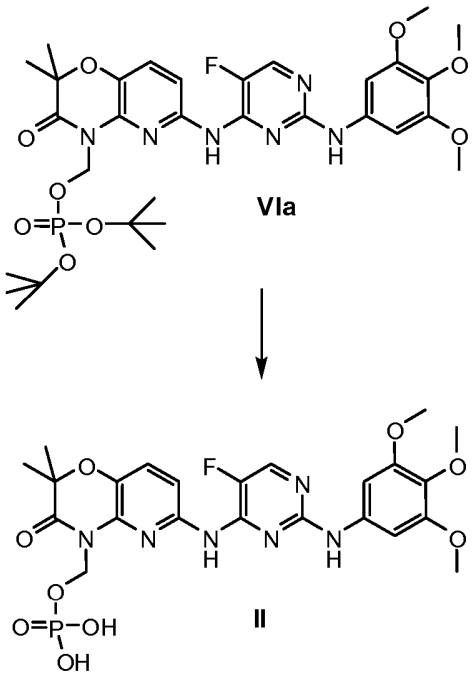
VIa

Description of synthesis of compound of formula VIa:

[0074] Cesium carbonate, 27.3 g (1.2 eq.), 185 g of N,N-Dimethylacetamide, 33.5g of compound of formula IV (1 eq., 70mmol) and 74g of 30.6w% di-*tert*-butyl chloromethyl phosphate (1.25 eq.) in DMAc were charged and stirred at 40°C overnight. A beige suspension resulted. The suspension was cooled to room temperature and 118mL each of MTBE and water were added. The phases were separated and the aqueous layer washed with 94mL MTBE. The organic layers were each washed with 94mL water. The organic layers yielded 187.9 g of compound VIa in MTBE, (yield 74% based on 70 mmol compound of formula IV).

C. Preparation of compound of formula IIa (amide solvate):

[0075]



Description:

[0076] Acetic acid (168.6 g, 160.6mL) was combined with an equal amount of water and the mixture heated to 67°C. The compound of formula VIa (187g, 170mL) of the solution in MTBE obtained as described above was added to the aqueous acetic acid. Most of the MTBE was distilled off at atmospheric pressure and the resulting solution stirred for 2h, resulting in a yellow suspension. The remaining MTBE was distilled off at 300mbar and the suspension cooled to 20°C and filtered to give an off-white solid. The filter cake was washed with cold acetone (2 x 160 mL) and dried overnight at 30°C to yield 29.8 g of the compound of formula II as an acetic acid solvate.

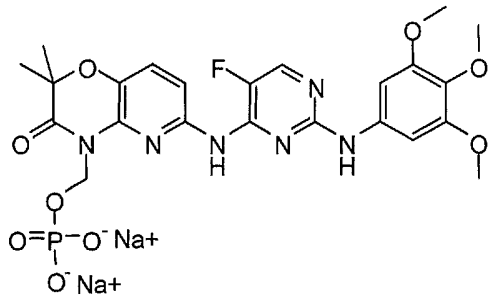
[0077] A suspension of 29.8 g of the compound of formula II as an acetic acid solvate at or about 1:1 stoichiometry) and 150mL DMF were heated to 50°C and stirred for 2 h. The suspension was then cooled to room temperature and filtered. The filter cake was washed three times with 98 mL of MTBE and dried under vacuum overnight at 30°C. The amide solvate of the compound of formula II (26.7g) was obtained (yield 55% based on 70 mmol of compound IV).

D. Preparation of a hexahydrate of the compound of formula I:

[0078] The amide solvate (10 g, 15 mmol) was suspended in 100 mL water and stirred for 1 hour. Subsequently, 50 mL IPA were added and the pH was adjusted from 3.3 to 8.5 by addition of 31.9 g of 1M NaOH. The reaction mixture was heated to 82°C, stirred for 1 hour, filtered through a 10 micron filter, cooled to 20°C, and stirred over night. The resulting suspension was filtered and the filter cake washed twice with 40 mL acetone and dried under vacuum over night at 40°C to give 8.6 g of a hexahydrate of the compound of formula I (77% yield).

Claims

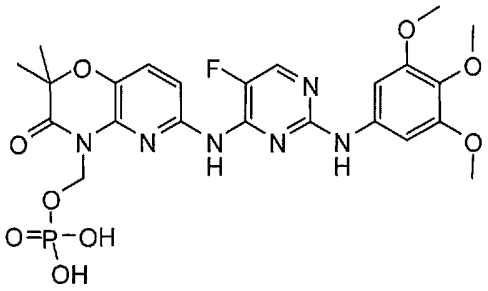
1. A process for preparing a compound of formula I:



I

comprising:

a) contacting an acid solvate of a compound of formula II:



II

with an amide under conditions suitable for forming an amide solvate of the compound of formula II; and
b) contacting the amide solvate with an aqueous base comprising sodium ions under conditions suitable for forming the compound of formula I.

2. The process of Claim 1, wherein the acid component of the acid solvate of the compound of formula II is a carboxylic acid, preferably wherein the carboxylic acid is R^1COOH wherein R^1 is -H or a C_1-C_4 alkyl optionally substituted with up to three halo.

3. The process of Claim 1, wherein the amide is a secondary amide or a tertiary amide.

4. The process of claim 3, wherein the amide is $R^{30}CON(R^2)_2$ where each R^2 is independently -H or C_1-C_4 alkyl or both R^2 together with the nitrogen to which they are attached form a 4 to 6 membered aliphatic ring, and R^{30} is -H or C_1-C_4 alkyl; or R^{30} and one of the R^2 together with the carbon and nitrogen to which they are attached, respectively, combine to form a 4 to 6-membered aliphatic ring and the other R^2 is independently -H or C_1-C_4 alkyl.

5. The process of claim 4, wherein the amide is a N,N-dialkylformamide, N,N-dialkylacetamide, N-alkylpyrrolidinone, or N-alkylpiperidone.

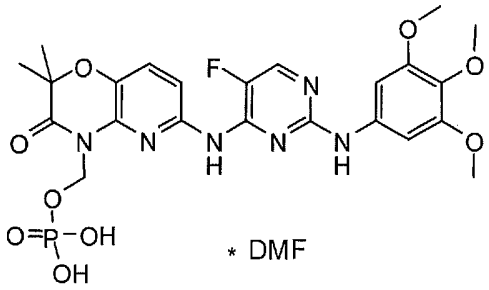
6. The process of Claim 5, wherein the amide is the N,N-dialkylformamide; and the conditions suitable for forming the amide solvate of the compound of formula II comprise a temperature of between about 20 °C and about 70 °C; preferably wherein:

the amide is N,N-dimethylformamide (DMF); and the conditions suitable for forming the amide solvate comprise

re-slurrying of the acid solvate in the DMF at a temperature of about 50 °C.

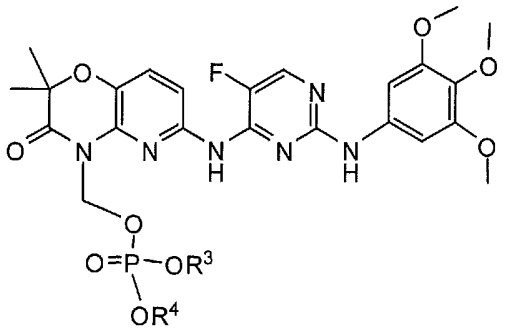
7. The process of Claim 1, wherein the aqueous base in part b) comprises sodium hydroxide and an alcohol, and the conditions suitable for forming the compound of formula I comprise a temperature of between about 40 °C about 80 °C and a pH of about 8 to about 10.5; preferably wherein;
the aqueous base in step b) comprises sodium hydroxide (NaOH) and isopropyl alcohol (IPA), and the conditions suitable for forming the compound of formula I comprise a temperature of about 80 °C and a pH of about 9.

8. A compound of formula III:



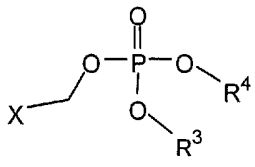
III

9. A process for preparing a compound of formula VI:



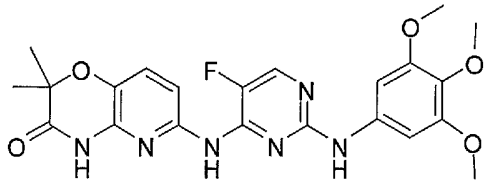
VI

comprising
providing a combination of a compound of formula V:



V

stabilised with an amide; and then
contacting a compound of formula IV:



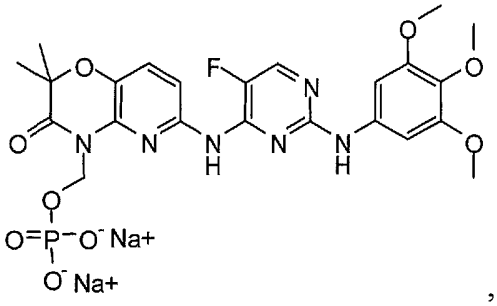
IV

with the combination of the compound of formula V in the presence of the amide, wherein:

R^3 and R^4 are each independently C_1-C_6 alkyl; and
X is halogen;

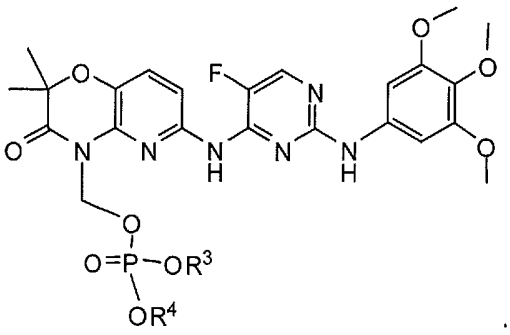
under conditions suitable for forming a compound of formula VI.

10. A method for preparing a compound for formula I,



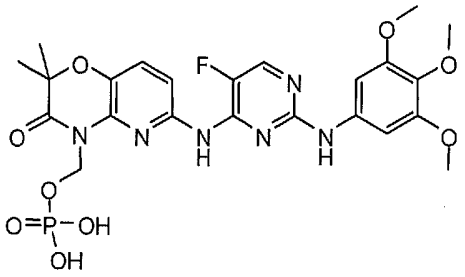
I

comprising contacting a compound of formula VI,



VI

with an acid under conditions suitable for forming an acid solvate of a compound of formula II:

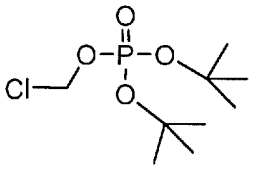


II

contacting the acid solvate of the compound of formula II with an amide under conditions suitable for forming an amide solvate of the compound of formula II; and
contacting the amide solvate of the compound of formula II with an aqueous base comprising sodium ions under conditions suitable for forming the compound of formula I.

11. The process of Claim 9, wherein:

(a) the compound of formula V is di-*tert*-butyl chloromethyl phosphate:



;

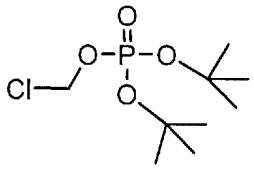
or
(b) the conditions sufficient to produce the compound of formula VI comprise:

(i) combining the compound of formula IV with the compound of formula V with a base in a polar solvent; and
(ii) washing a product obtained from (i) in an aqueous base solution; preferably wherein:

the base in (i) comprises at least one of cesium carbonate (Cs_2CO_3) and potassium carbonate (K_2CO_3); the polar solvent comprises at least one of DMF and N,N-dimethylacetamide (DMAc); and the aqueous base in (ii) comprises at least one of sodium bicarbonate ($NaHCO_3$) and sodium hydroxide (NaOH); or

(c) the compound of formula VI is not isolated; or
(d) the amide is N,N-dimethylacetamide (DMAc), N,N-dimethylformamide (DMF), or N-methylpyrrolidinone (NMP).

12. A composition consisting essentially of di-*tert*-butyl chloromethyl phosphate:



and an amide, optionally in a solvent.

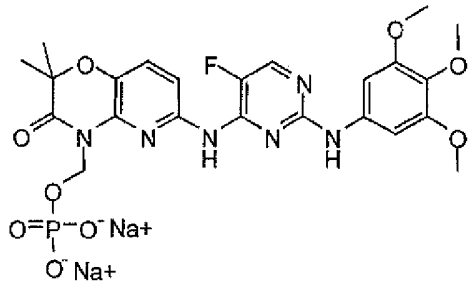
13. The composition of claim 12, wherein the amide is also a solvent; preferably wherein the amide is a tertiary amide, more preferably N,N-dimethylacetamide (DMAc).

14. The process according to claim 1 or 10 wherein the compound of formula I is in the form of a hydrate, preferably a hexahydrate.

15. Use of an amide to stabilize a compound of formula V as defined in claim 9.

Patentansprüche

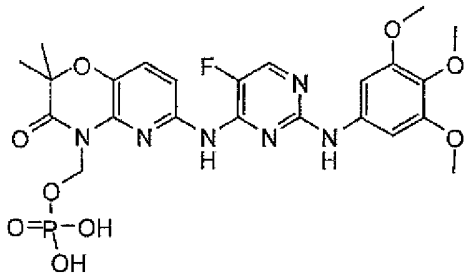
1. Verfahren zur Herstellung einer Verbindung der Formel I:



I

umfassend:

a) Inkontaktbringen eines Säuresolvats einer Verbindung der Formel II:



II

mit einem Amid unter geeigneten Bedingungen zur Bildung eines Amidsolvats der Verbindung der Formel II; und
b) Inkontaktbringen des Amidsolvats mit einer wässrigen Base, umfassend Natriumionen, unter geeigneten Bedingungen zur Bildung der Verbindung der Formel I.

2. Verfahren nach Anspruch 1, wobei die Säurekomponente des Säuresolvats der Verbindung der Formel II eine Carbonsäure ist, wobei vorzugsweise die Carbonsäure R^1COOH ist, wobei R^1 -H oder ein gegebenenfalls mit bis zu drei Halogenatomen substituierter C_1-C_4-Alkylrest ist.

3. Verfahren nach Anspruch 1, wobei das Amid ein sekundäres Amid oder ein tertiäres Amid ist.

4. Verfahren nach Anspruch 3, wobei das Amid $R^{30}CON(R^2)_2$ ist, wobei jedes R^2 unabhängig -H oder C_1-C_4-Alkyl ist, oder beide R^2 zusammen mit dem Stickstoff, an den sie gebunden sind, einen 4- bis 6-gliedrigen aliphatischen Ring bilden, und R^{30} -H oder C_1-C_4-Alkyl ist; oder R^{30} und eines von den R^2 zusammen mit dem Kohlenstoff bzw. Stickstoff, an den sie gebunden sind, gemeinsam einen 4- bis 6-gliedrigen aliphatischen Ring bilden und der andere Rest R^2 unabhängig - H oder C_1-C_4-Alkyl ist.

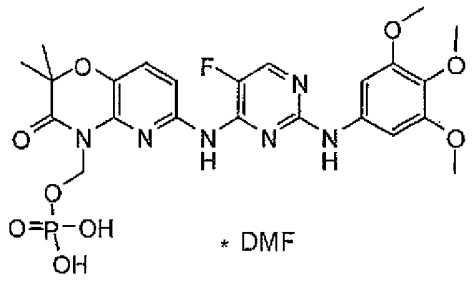
5. Verfahren nach Anspruch 4, wobei das Amid ein N,N-Dialkylformamid, N,N-Dialkylacetamid, N-Alkylpyrrolidinon oder N-Alkylpiperidon ist.

6. Verfahren nach Anspruch 5, wobei das Amid das N,N-Dialkylformamid ist; und die geeigneten Bedingungen zur Bildung des Amidsolvats der Verbindung der Formel II umfassen eine Temperatur zwischen etwa 20°C und etwa 70°C; wobei vorzugsweise:

das Amid N,N-Dimethylformamid (DMF) ist; und die geeigneten Bedingungen zur Bildung des Amidsolvats umfassen Wiederaufschlämmen des Säuresolvats in dem DMF bei einer Temperatur von etwa 50°C.

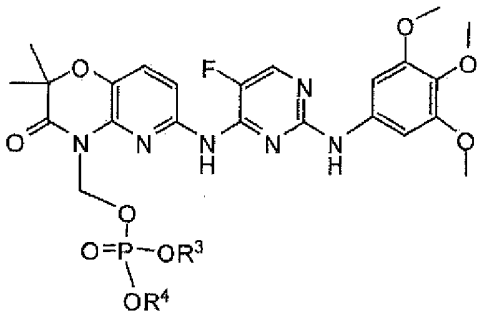
7. Verfahren nach Anspruch 1, wobei die wässrige Base in Schritt b) Natriumhydroxid und einen Alkohol umfasst, und die geeigneten Bedingungen zur Bildung der Verbindung der Formel I umfassen eine Temperatur zwischen etwa 40°C und etwa 80°C und einen pH von etwa 8 bis etwa 10,5; wobei vorzugsweise die wässrige Base in Schritt b) Natriumhydroxid (NaOH) und Isopropylalkohol (IPA) umfasst, und die geeigneten Bedingungen zur Bildung der Verbindung der Formel I umfassen eine Temperatur von etwa 80°C und einen pH von etwa 9.

8. Verbindung der Formel III:



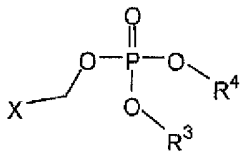
III

9. Verfahren zur Herstellung einer Verbindung der Formel VI:



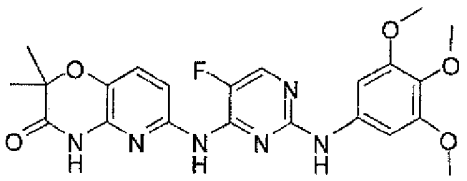
VI

umfassend
Bereitstellen einer Kombination einer Verbindung der Formel V:



V

stabilisiert mit einem Amid; und anschließendes Inkontaktbringen einer Verbindung der Formel IV:



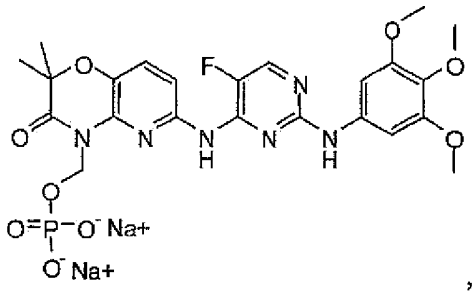
IV

mit der Kombination der Verbindung der Formel V in Gegenwart des Amids, wobei:

R^3 und R^4 jeweils unabhängig C_1-C_6-Alkyl sind; und
X Halogen ist;

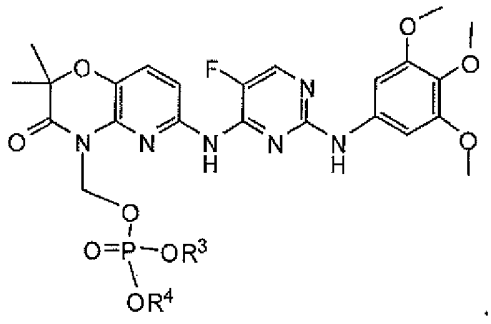
unter geeigneten Bedingungen zur Bildung einer Verbindung der Formel VI.

10. Verfahren zur Herstellung einer Verbindung der Formel I,



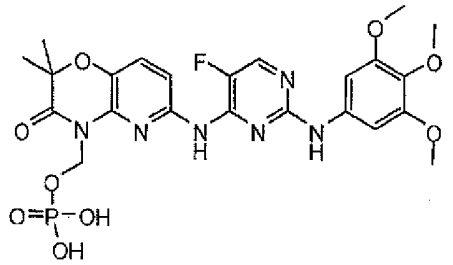
I

umfassend das Inkontaktbringen einer Verbindung der Formel VI,



VI

mit einer Säure unter geeigneten Bedingungen zur Bildung eines Säuresolvats einer Verbindung der Formel II:

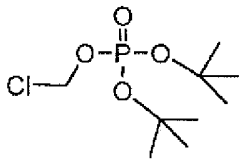


II

Inkontaktbringen des Säuresolvats der Verbindung der Formel II mit einem Amid unter geeigneten Bedingungen zur Bildung eines Amidsolvats der Verbindung der Formel II; und
Inkontaktbringen des Amidsolvats der Verbindung der Formel II mit einer wässrigen Base, umfassend Natriumionen, unter geeigneten Bedingungen zur Bildung der Verbindung der Formel I.

11. Verfahren nach Anspruch 9, wobei:

(a) die Verbindung der Formel V Di-*tert*-butylchlormethylphosphat ist:



;

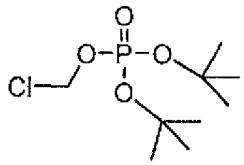
oder
(b) die ausreichenden Bedingungen zur Bildung der Verbindung der Formel IV umfassen:

(i) Kombinieren der Verbindung der Formel IV mit der Verbindung der Formel V mit einer Base in einem polaren Lösungsmittel; und
(ii) Waschen eines aus (i) erhaltenen Produkts in einer wässrigen Basenlösung;
wobei vorzugsweise:

die Base in (i) mindestens eines von Cäsiumcarbonat (Cs_2CO_3) und Kaliumcarbonat (K_2CO_3) umfasst;
das polare Lösungsmittel mindestens eines von DMF und N,N-Dimethylacetamid (DMAc) umfasst; und
die wässrige Base in (ii) mindestens eines von Natriumbicarbonat ($NaHCO_3$) und Natriumhydroxid (NaOH) umfasst; oder

(c) die Verbindung der Formel VI nicht isoliert wird; oder
(d) das Amid N,N-Dimethylacetamid (DMAc), N,N-Dimethylformamid (DMF) oder N-Methylpyrrolidinon (NMP) ist.

12. Zusammensetzung, bestehend im Wesentlichen aus Di-*tert*-butylchlormethylphosphat:



und einem Amid, gegebenenfalls in einem Lösungsmittel.

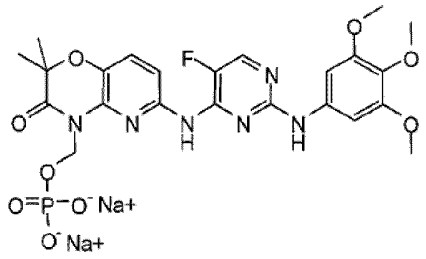
13. Zusammensetzung nach Anspruch 12, wobei das Amid auch ein Lösungsmittel ist; wobei vorzugsweise das Amid ein tertiäres Amid ist, insbesondere N,N-Dimethylacetamid (DMAc).

14. Verfahren nach Anspruch 1 oder 10, wobei die Verbindung der Formel I in der Form eines Hydrats, vorzugsweise eines Hexahydrats vorliegt.

15. Verwendung eines Amids zur Stabilisierung einer Verbindung der Formel V wie in Anspruch 9 definiert.

Revendications

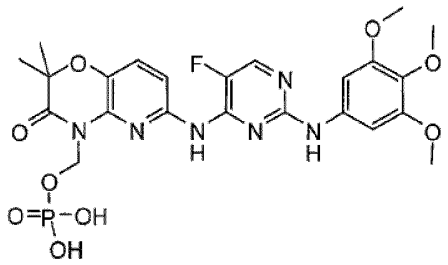
1. Procédé pour la préparation d'un composé de formule I :



I

comprenant :

a) la mise en contact d'un produit de solvatation par un acide d'un composé de formule II :



II

avec un amide dans des conditions appropriées à la formation d'un produit de solvatation par un amide du composé de formule II ; et
b) la mise en contact du produit de solvatation par un amide avec une base aqueuse comprenant des ions sodium, dans des conditions appropriées à la formation du composé de formule I.

2. Procédé selon la revendication 1, dans lequel le composant acide du produit de solvatation par un acide du composé de formule II est un acide carboxylique, de préférence dans lequel l'acide carboxylique est de formule R^1COOH, R^1 étant -H ou un groupe alkyle en C_1-C_4 en option substitué par jusqu'à trois atomes d'halogène.

3. Procédé selon la revendication 1, dans lequel l'amide est un amide secondaire ou un amide tertiaire.

4. Procédé selon la revendication 3, dans lequel l'amide est de formule $R^{30}CON(R^2)_2$, où chaque radical R^2 représente indépendamment -H ou un groupe alkyle en C_1-C_4 ou les deux radicaux R^2 forment ensemble avec l'atome d'azote auquel ils sont liés un cycle aliphatique à 4 ou 6 chaînons, et R^{30} est -H ou un groupe alkyle en C_1-C_4 ; ou R^{30} et l'un des radicaux R^2 forment ensemble avec l'atome de carbone et l'atome d'azote auxquels ils sont respectivement liés, un cycle aliphatique à 4 à 6 chaînons et l'autre radical R^2 est indépendamment -H ou un groupe alkyle en C_1-C_4.

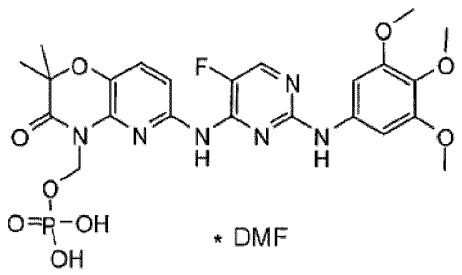
5. Procédé selon la revendication 4, dans lequel l'amide est un N,N-dialkylformamide, un N,N-dialkylacétamide, une N-alkylpyrrolidinone ou une N-alkylpipéridone.

6. Procédé selon la revendication 5, dans lequel l'amide est un N,N-dialkylformamide et les conditions appropriées à la formation du produit de solvatation par un amide du composé de formule II comprennent une température comprise entre environ 20 °C et environ 70 °C ; de préférence dans lequel :

l'amide est le N,N-diméthylformamide (DMF) ; et les conditions appropriées à la formation du produit de solvatation par un amide comprennent la remise en suspension du produit de solvatation par un acide dans le DMF à une température d'environ 50 °C.

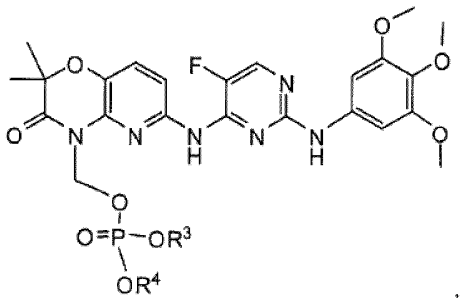
7. Procédé selon la revendication 1, dans lequel la base aqueuse dans la partie b) comprend de l'hydroxyde de sodium et un alcool, et les conditions appropriées à la formation du composé de formule I comprennent une température comprise entre environ 40 °C et environ 80 °C et un pH d'environ 8 à environ 10,5 ; de préférence dans lequel la base aqueuse dans l'étape b) comprend de l'hydroxyde de sodium (NaOH) et de l'alcool isopropyliqe (IPA), et les conditions appropriées à la formation du composé de formule I comprennent une température d'environ 80 °C et un pH d'environ 9.

8. Composé de formule III :



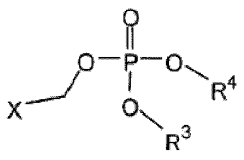
III

9. Procédé pour la préparation d'un composé de formule VI :



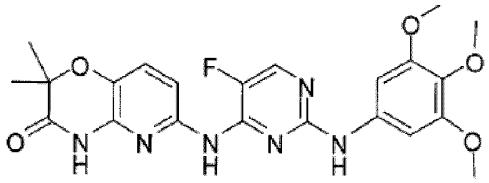
VI

comprenant
la disposition d'une combinaison d'un composé de formule V :



V

stabilisé par un amide ; et ensuite
la mise en contact d'un composé de formule IV :



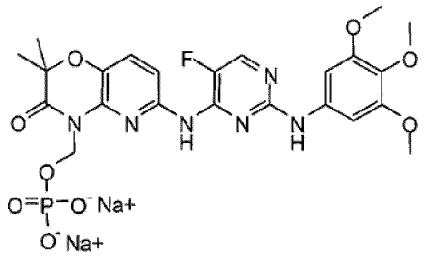
IV

avec la combinaison du composé de formule V en présence de l'amide,
où

R^3 et R^4 représentent chacun indépendamment un groupe alkyle en C_1-C_6 ; et
X est un atome d'halogène ;

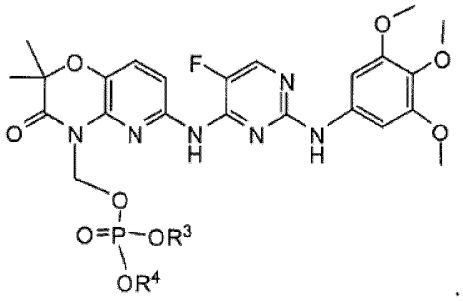
dans des conditions appropriées à la formation d'un composé de formule VI.

10. Procédé pour la préparation d'un composé de formule I,



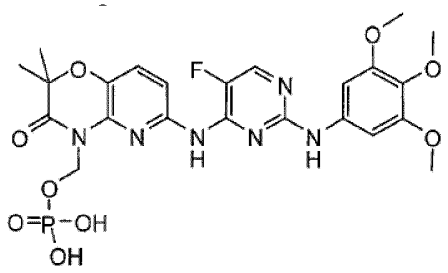
I

comprenant la mise en contact d'un composé de formule VI,



VI

avec un acide dans des conditions appropriées à la formation d'un produit de solvatation par un acide d'un composé de formule II :

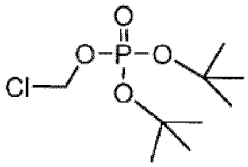


II

la mise en contact du produit de solvatation par un acide du composé de formule II avec un amide dans des conditions appropriées à la formation d'un produit de solvatation par un amide du composé de formule II ; et
la mise en contact du produit de solvatation par un amide du composé de formule II avec une base aqueuse comprenant des ions sodium, dans des conditions appropriées à la formation du composé de formule II.

11. Procédé selon la revendication 9, dans lequel :

(a) le composé de formule V est le phosphate de chlorométhyle et de di-tert-butyle :



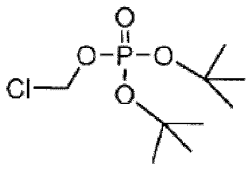
;

ou
(b) les conditions suffisantes pour produire le composé de formule VI comprennent :

(i) la combinaison du composé de formule IV avec le composé de formule V avec une base dans un solvant polaire ; et
(ii) le lavage d'un produit obtenu à partir de (i) dans une solution aqueuse d'une base ;

de préférence dans lequel :
la base en (i) comprend au moins un parmi le carbonate de césium ($CsCO_3$) et le carbonate de potassium (K_2CO_3) ; le solvant polaire comprend au moins un parmi le DMF et le N,N-diméthylacétamide (DMAc) ; et la base aqueuse en (ii) comprend au moins un parmi le bicarbonate de sodium ($NaHCO_3$) et l'hydroxyde de sodium (NaOH) ; ou
(c) le composé de formule VI n'est pas isolé ; ou
(d) l'amide est le N,N-diméthylacétamide (DMAc), le N,N-diméthylformamide (DMF) ou la N-méthylpyrrolidone (NMP).

12. Composition consistant essentiellement en phosphate de chlorométhyle et de di-tert-butyle :



et un amide, en option dans un solvant.

13. Composition selon la revendication 12, dans laquelle l'amide est également un solvant ; de préférence dans laquelle

l'amide est un amide tertiaire, de façon plus particulièrement préférée le N,N-diméthylacétamide (DMAc).

14. Procédé selon la revendication 1 ou 10, dans lequel le composé de formule I est sous la forme d'un hydrate, de préférence d'un hexahydrate.

15. Utilisation d'un amide pour stabiliser un composé de formule V tel que défini dans la revendication 9.

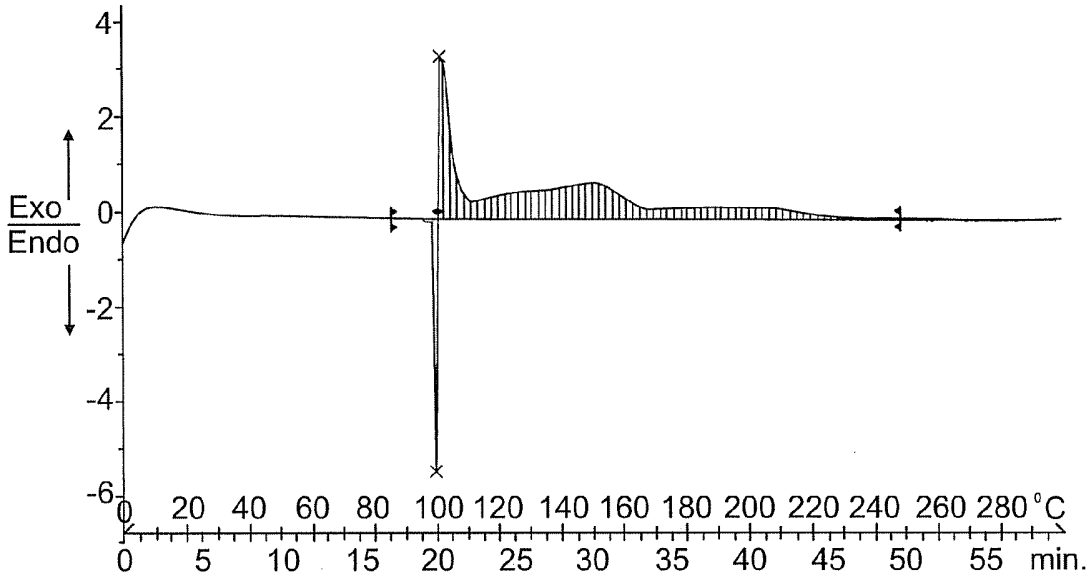

4
2
0
-2
-4
-6
Exo
Endo
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 °C
0 5 10 15 20 25 30 35 40 45 50 55 min.

FIG. 1

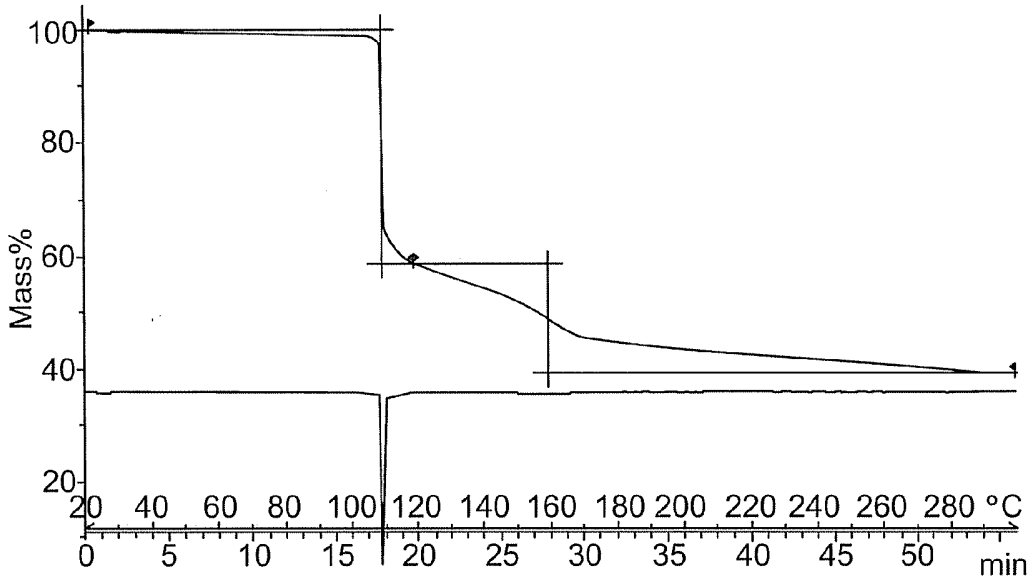

100
80
60
40
20
Mass%
20 40 60 80 100 120 140 160 180 200 220 240 260 280 °C
0 5 10 15 20 25 30 35 40 45 50 min

FIG. 2

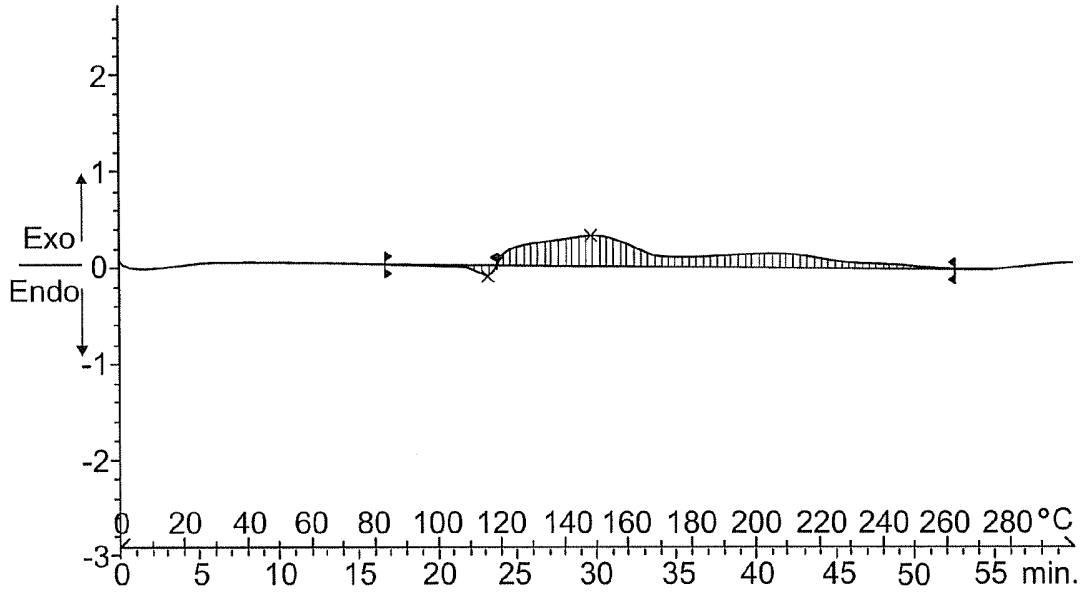

2
1
Exo
0
Endo
-1
-2
-3
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 °C
0 5 10 15 20 25 30 35 40 45 50 55 min.

FIG. 3

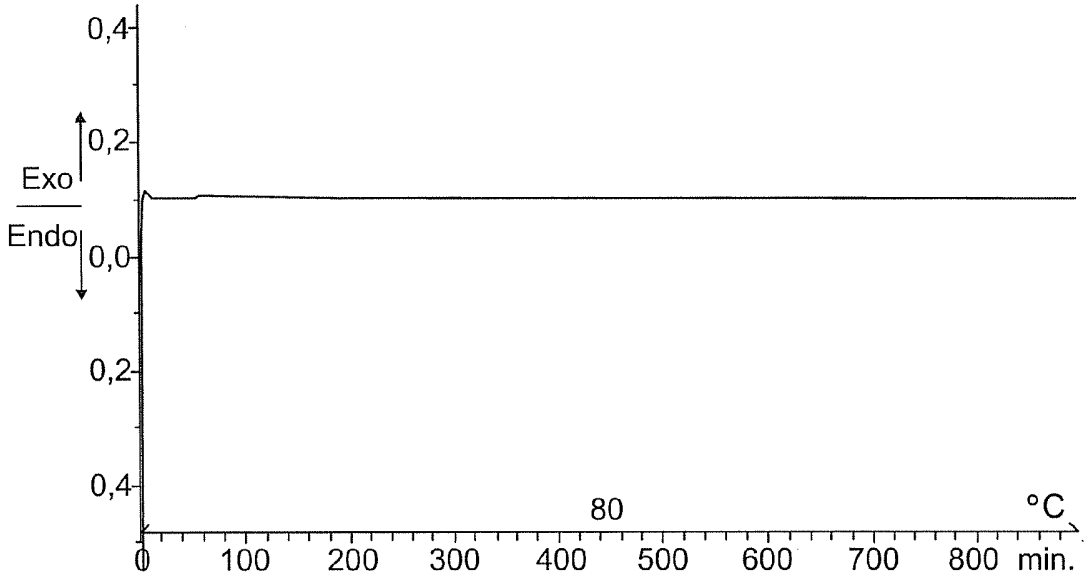

0,4
0,2
Exo
Endo
0,0
0,2
0,4
80
°C
0 100 200 300 400 500 600 700 800 min.

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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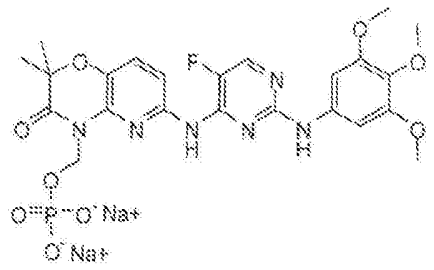
- **CHASSAING C et al.** *Journal Of Medicinal Chemistry,* 13 March 2008, vol. 51 (5 **[0006]**
- **MANTYLA et al.** *Tetrahedron Letters,* 2002, vol. 43, 3793-3794 **[0066]**

Szabadalmi igénypontok

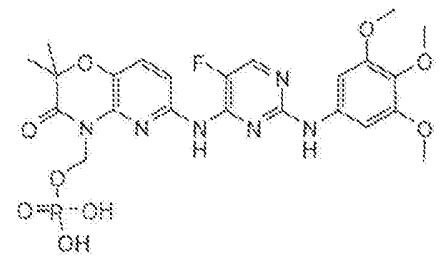
1. Eljárás az I képletű vegyület előállítására:



I

amely tartalmazza

a) II képletű vegyület sav szolvátjának érintkezésbe hozását



II

egy amiddal II képletű vegyület amid szolvátjának képzésére alkalmas körülmények között; és

b) az amid szolvát nátriumionokat tartalmazó vizes bázissal történő érintkezésbe hozását I képletű vegyület képzésére alkalmas körülmények között.

2. Az 1. igénypont szerinti eljárás, ahol a II képletű vegyület sav szolvátjának savkomponense egy karbonsav, előnyösen ahol a karbonsav R^1COOH, ahol R^1 jelentése -H vagy C_1-C_4 alkil, amely adott esetben legfeljebb három halogénnel szubsztituált.

3. Az 1. igénypont szerinti eljárás, ahol az amid szekunder amid vagy tercier amid.

4. A 3. igénypont szerinti eljárás, ahol az amid jelentése $R^{30}CON(R^2)_2$, ahol minden egyes R^2 jelentése egymástól függetlenül -H vagy C_1-C_4 alkil vagy mindkét R^2 a nitrogénatommal együtt, amelyhez kapcsolódnak, 4-6-tagú alifás gyűrűt alakít ki, és R^{30} jelentése -H vagy C_1-C_4 alkil; vagy R^{30} és az egyik R^2 a szénatommal és nitrogénatommal együtt, amelyekhez rendre kapcsolódnak, 4-6-tagú alifás gyűrűt alakít ki, és a másik R^2 jelentése függetlenül -H vagy C_1-C_4 alkil.

5. A 4. igénypont szerinti eljárás, ahol az amid jelentése N,N-dialkilformamid, N,N-dialkilacetamid, N-alkilpirrolidinon vagy N-alkilpiperidon.

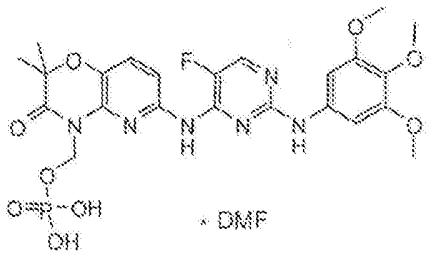
6. Az 5. igénypont szerinti eljárás, ahol az amid jelentése N,N-dialkilformamid; és a II képletű vegyület amid szolvátjának képzésére alkalmas körülmények tartalmazzák a kb. 20°C és kb. 70°C közötti hőmérsékletet, előnyösen ahol

az amid jelentése N,N-dimetilformamid (DMF); és az amid szolvát képzésére alkalmas körülmények tartalmazzák a sav szolvát újraszuszpendálását DMF-ben kb. 50 °C hőmérsékleten.

7. Az 1. igénypont szerinti eljárás, ahol a b) lépés szerinti vizes bázis tartalmaz nátrium-hidroxidot és egy alkoholt, és az I képletű vegyület képzésére alkalmas körülmények tartalmazzák a kb. 40°C és kb. 80°C közötti hőmérsékletet és a kb. 8 és kb. 10,5 közötti pH-t, előnyösen ahol:

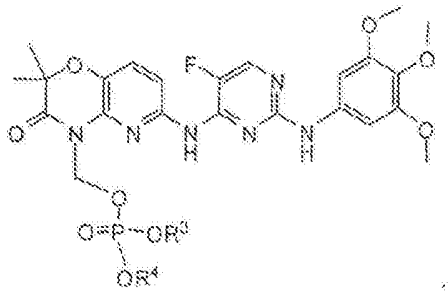
a b) lépés szerinti vizes bázis tartalmaz nátrium-hidroxidot (NaOH) és izopropil-alkoholt (IPA), és az I képletű vegyület képzésére alkalmas körülmények tartalmazzák a kb. 80°C hőmérsékletet és a kb. 9 értékű pH-t.

8. III képletű vegyület:



III

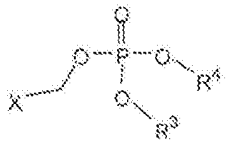
9. Eljárás VI képletű vegyület előállítására:



VI

amely tartalmazza

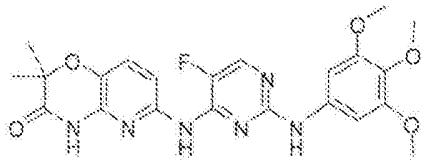
V képletű vegyület kombinációjának biztosítását:



V

amely vegyület amiddal stabilizált; majd

IV képletű vegyület érintkezésbe hozását.



IV

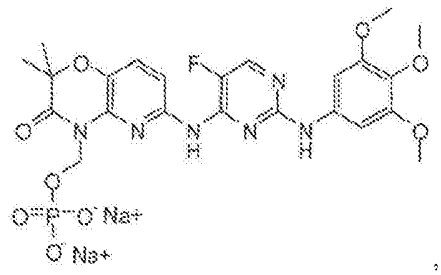
az V képletű vegyület kombinációjával amid jelenlétében, ahol:

R^3 és R^4 jelentése egymástól függetlenül C_1-C_6 alkil; és

X jelentése halogén;

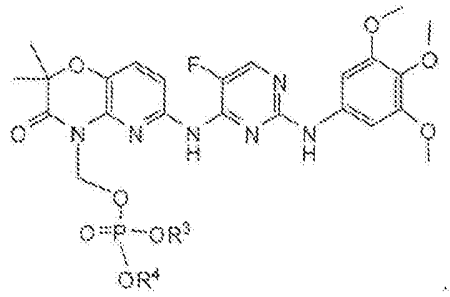
VI képletű vegyület képzésére alkalmas körülmények között.

10. Eljárás I képletű vegyület előállítására,



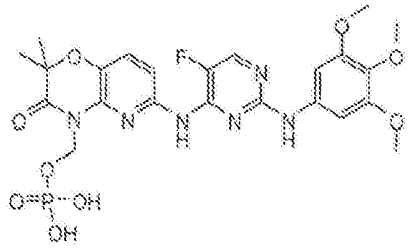
I

amely tartalmazza VI képletű vegyület érintkezésbe hozását



VI

egy savval, II képletű vegyület sav szolvátjának képzésére alkalmas körülmények között:



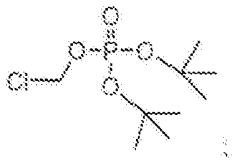
II

II képletű vegyület sav szolvátjának amiddal történő érintkezésbe hozását II képletű vegyület amid szolvátjának képzésére alkalmas körülmények között; és

II képletű vegyület amid szolvátjának érintkezésbe hozását nátriumionokat tartalmazó vizes bázissal I képletű vegyület képzésére alkalmas körülmények között.

11. A 9. igénypont szerinti eljárás, ahol

(a) az V képletű vegyület jelentése di-*terc*-butil-klórmetil-foszfát:



vagy

(b) a VI képletű vegyület előállítására alkalmas körülmények tartalmazzák:

(i) a IV képletű vegyület kombinálását az V képletű vegyülettel és bázissal egy poláris oldószerben; és

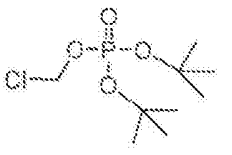
(ii) az (i) lépésben kapott termék mosását egy vizes bázis oldatban, előnyösen ahol:

az (i) lépés szerinti bázis tartalmazza a következők legalább egyikét: cézium-karbonát (Cs_2CO_3) és kálium-karbonát (K_2CO_3); a poláris oldószer tartalmazza a következők legalább egyikét: DMF és N,N-dimetilacetamid (DMAc); és a (ii) lépés szerinti vizes bázis tartalmazza a következők legalább egyikét: nátrium-bikarbonát ($NaHCO_3$) és nátrium-hidroxid (NaOH); vagy

(c) a VI képletű vegyületet nem izoláljuk; vagy

(d) az amid jelentése N,N-dimetilacetamid (DMAc), N,N-dimetilformamid (DMF) vagy N-metilpirrolidinon (NMP).

12. Készítmény, amely alapvetően di-*terc*-butil-klórmetil-foszfátból



és amidból áll, adott esetben oldószerben.

13. A 12. igénypont szerinti készítmény, ahol az amid egyben az oldószer; előnyösen ahol az amid egy tercier amid, még előnyösebben N,N-dimetilacetamid (DMAc).

14. Az 1-10. igénypontok bármelyike szerinti eljárás, ahol az I képletű vegyület hidrát, előnyösen hexahidrát formában van.

15. Amid alkalmazása a 9. igénypont szerinti V képletű vegyület stabilizálására.