



(51) International Patent Classification:  
**C07H 17/08** (2006.01)

(21) International Application Number:  
PCT/US2011/029424

(22) International Filing Date:  
22 March 2011 (22.03.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
61/316,063 22 March 2010 (22.03.2010) US

(71) Applicant (for all designated States except US): **CEMPRA PHARMACEUTICALS, INC.** [US/US]; 6340 Quadrangle Drive, Suite 100, Chapel Hill, NC 27517 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **PEREIRA, David, E.** [US/US]; 103 Lansbrooke Lane, Apex, NC 27502 (US).

(74) Agent: **MCLAREN, Kevin, L.**; Barnes & Thornburg LLP, 11 South Meridian Street, Indianapolis, IN 46204 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))
- of inventorship (Rule 4.17(iv))

[Continued on next page]

(54) Title: CRYSTALLINE FORMS OF A MACROLIDE, AND USES THEREFOR

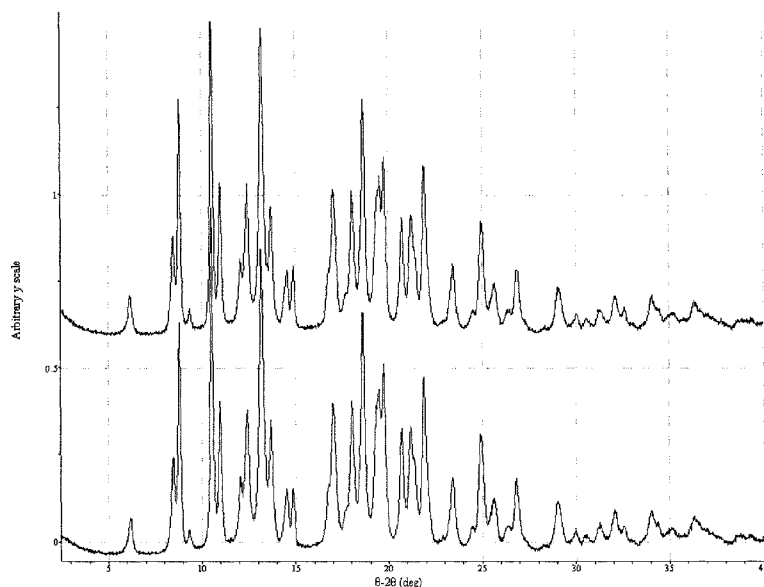


FIG. 1

(57) Abstract: New crystalline forms of macrolide compounds, and pharmaceutical compositions thereof, are described herein. In addition, processes for preparing the crystalline forms are described herein.



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**Published:**

— *with international search report (Art. 21(3))*

## CRYSTALLINE FORMS OF A MACROLIDE, AND USES THEREFOR

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of United States provisional application 61/316,063, filed 22 March 2010, which is incorporated by reference herein.

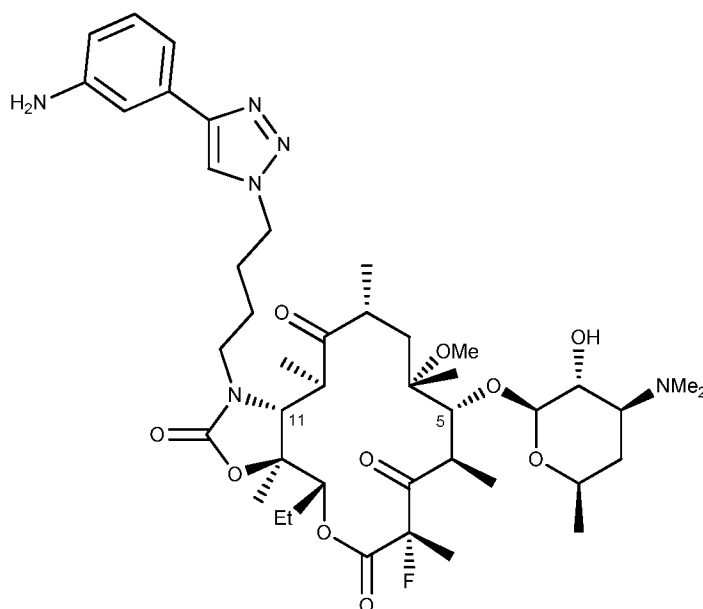
## 5 TECHNICAL FIELD

The invention described herein relates to a macrolide compound. More particularly, it relates to new crystalline forms of the macrolide compound, to processes for the preparation of the crystalline forms, and to pharmaceutical compositions containing the forms.

## BACKGROUND AND SUMMARY OF THE INVENTION

10 It is appreciated that compounds considered as candidates for further development as pharmaceuticals advantageously possess desirable biological properties, but also physical properties that adapt them for use in the manufacture of pharmaceutical products. For example, compounds that form stable solids, including crystalline solids may be more readily manufactured and formulated. It is further appreciated that individual physical forms of  
15 the compound that are stable and additionally that may be prepared substantially free of other physical forms may also be more readily manufactured and formulated. It is to be understood herein that different physical forms may have markedly different physical properties, such as different solubility characteristics, different bioavailabilities and/or biological exposure, different stability, and the like.

20 In US patent application publication number US 2006/0100164, there are disclosed certain macrolide antibiotic compounds. The foregoing publication, and each additional publication cited herein is incorporated herein by reference. One of these macrolides is a fluoroketolide having Chemical Abstracts Registry Number 760981-83-7, which is also known as CEM-101 and solithromycin. The preparation of an amorphous form of CEM-101 is  
25 described therein. An alternative preparation of CEM-101 is described in WO 2009/055557. CEM-101 has the following chemical structure:



It has been discovered herein that CEM-101 can be isolated in a variety of crystalline forms which provide illustrative embodiments of the invention. CEM-101 can be isolated in crystalline form as a material having a range of different physical properties, depending upon the method of isolation. This is because CEM-101 can exist in more than one crystalline form, i.e., it exhibits polymorphism. CEM-101 can be isolated in at least two crystalline forms, denoted herein as Form I and Form II, each of which is pure or substantially pure and/or free of or substantially free of the other form. Various mixtures of Form I and Form II can also be isolated. In addition, solids which are mixtures of one or more crystalline materials and also include amorphous solids can be obtained.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Illustrative examples of X-ray powder diffraction (XRPD) spectra for each of Form I and Form II are given in FIG. 1 and FIG. 2, respectively, showing degrees  $2\theta$  on the X-axis and relative intensity on the Y-axis.

More detailed listings of the peaks for each of Form I and Form II are provided below in Tables 1-4 in the Examples, in which peaks are denoted as % relative intensity ( $I/I_0 \times 100$ ). It is to be understood that in the X-ray powder diffraction spectra the exact values measured for  $2\theta$  (or the corresponding d-spacings) may vary depending upon the particular sample analyzed and the particular analysis procedure used. A range of values of at least  $\pm 0.1^\circ 2\theta$ , and in some cases at least  $\pm 0.2^\circ 2\theta$ , may be typical. Measurements on independently prepared samples on different instruments may lead to variability which is greater than  $\pm 0.1^\circ 2\theta$  and/or  $\pm 0.2^\circ 2\theta$ .

## DETAILED DESCRIPTION

The new physical form, Form I of CEM-101 is a crystalline form which may be described by its X-ray powder diffraction pattern. Peaks at approximate positions of about  $2\theta = 8.8, 10.5, 13.2$  and  $18.6$  are representative of this crystalline form. An example of an X-ray powder diffraction spectrum for Form I is shown in FIG. 1. A more detailed analysis of the peaks is described in Tables 1-2 below. Form I of CEM-101 demonstrates minimal weight loss by thermogravimetric analysis (TGA). Water determination by Karl Fisher titration in typical lots is 0.6 to 1.1%. Dynamic vapor sorption indicates that the material is partially hygroscopic, but Form I solids are isolated upon desorption. Form I of CEM-101 melts at about 200 °C by DSC analysis.

As one embodiment there is described Form I of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 8.8, 10.5, 13.2$  and  $18.6$ . As another embodiment there is described a solid form of CEM-101 comprising Form I of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 8.8, 10.5, 13.2$  and  $18.6$ . As another embodiment there is described a composition comprising CEM-101, where the majority of CEM-101 is Form I of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 8.8, 10.5, 13.2$  and  $18.6$ . As another embodiment there is described CEM-101 in each of the foregoing embodiments having an X-ray powder diffraction pattern substantially the same as that of FIG 1.

The new physical form, Form I, is physically stable and can be prepared substantially free of other physical forms, as described below. In one embodiment, there is described Form I of CEM-101 that is substantially free of Form II. The relative amounts of forms may be determined by a variety of analytical techniques, for example but not limited to, by the presence or absence of representative peaks, and/or by the relative peak heights and/or peak areas of appropriate discernable peaks in the XRPD spectrum. Form I of CEM-101, substantially free of other physical forms, may be characterized by an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 8.8, 10.5, 13.2$  and  $18.6$ . Peaks at about  $2\theta = 6.2, 19.7$  and/or  $21.9$  are also observed for this crystalline form. In another embodiment, there is described Form I of CEM-101 in each of the foregoing embodiments that is characterized by an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 8.8, 10.5, 13.2$  and  $18.6$ , and one or more additional peaks at about  $2\theta = 6.2, 19.7$  and/or  $21.9$ . In another embodiment, there is described Form I of CEM-101 in each of the

foregoing embodiments that is substantially free of Form II as determined by the X-ray powder diffraction pattern, wherein one or more peaks at  $2\theta = 5.6, 9.8$ , and/or  $11.7$  are absent or nearly absent.

In another embodiment, pharmaceutical compositions that include CEM-101 are described, where the composition comprises or consists essentially of Form I of CEM-101, as described in each of the foregoing embodiments. In another embodiment, pharmaceutical compositions that include CEM-101 are described, where the composition comprises CEM-101, where the CEM-101 is at least about 60%, at least about 80%, at least about 90%, at least about 95%, at least about 98%, or at least about 99% Form I. In another embodiment, pharmaceutical compositions that include CEM-101 are described, where the composition comprises CEM-101, where the CEM-101 is substantially free of Form II. In another embodiment, pharmaceutical compositions that include Form I of CEM-101 are described, where the relative amount of Form II is less than about 40%, 20%, 10%, 5%, 2% or 1%. In another embodiment, pharmaceutical compositions that include CEM-101 are described, where the relative amount of Form I and Form II is determined by the relative peak heights of specific peaks. Illustrative relative peak height ratios for the peaks at  $2\theta = 6.2$  and  $2\theta = 5.6$  are a ratio of about 5:1 or more, about 10:1 or more, or about 20:1 or more. As another embodiment there is described Form I of CEM-101, substantially free of other physical forms. As another embodiment there is described a pharmaceutical composition comprising CEM-101 having an X-ray powder diffraction pattern substantially the same as that of FIG 1.

The new physical form, Form II of CEM-101 is a crystalline form which may be described by its X-ray powder diffraction pattern. Peaks at approximate positions of about  $2\theta = 5.6, 7.9, 9.3, 11.7, 12.9$  and  $16.7$  are representative of this crystalline form. An example of an X-ray powder diffraction spectrum for Form II is shown in FIG. 2. A more detailed analysis of the peaks is described in Tables 3-4 below. Based on a single crystal X-ray determination and dynamic vapor sorption analysis, Form II appears to be a non-hygroscopic anhydrous crystalline form that melts at about  $225^\circ\text{C}$  as a single endothermic event by DSC analysis. It is appreciated herein that non-hygroscopic solids, such as Form II described herein, may be advantageous in the preparation of pharmaceutical compositions. Such advantages include improved handling and stability properties in manufacturing, improved lot to lot quality control.

As one embodiment there is described Form II of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 5.6, 7.9, 9.3$ ,

11.7, 12.9 and 16.7. As another embodiment there is described a solid form of CEM-101, comprising Form II of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 5.6, 7.9, 9.3, 11.7, 12.9$  and  $16.7$ . As another embodiment there is described a composition comprising CEM-101, where the majority of CEM-101 is Form II of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 5.6, 7.9, 9.3, 11.7, 12.9$  and  $16.7$ . As another embodiment there is described CEM-101 in each of the foregoing embodiments having an X-ray powder diffraction pattern substantially the same as that of FIG 2.

The new physical form, Form II, is physically stable and can be prepared substantially free of other physical forms, as described below. In one embodiment, there is described Form II of CEM-101 that is substantially free of Form I. The relative amounts of forms may be determined by a variety of analytical techniques, for example but not limited to, by the presence or absence of representative peaks, and/or by the relative peak heights and/or peak areas of appropriate discernable peaks in the XRPD spectrum. Form II of CEM-101, substantially free of other physical forms, may be characterized by an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 5.6, 7.9, 9.3, 11.7, 12.9$  and  $16.7$ . In another embodiment, there is described Form II of CEM-101 in each of the foregoing embodiments that is substantially free of Form I as determined by the X-ray powder diffraction pattern, wherein one or more peaks at  $2\theta = 6.2$  and/or  $8.8$  are absent or nearly absent.

In another embodiment, pharmaceutical compositions that include CEM-101 are described, where the composition comprises or consists essentially of Form II of CEM-101, as described in each of the foregoing embodiments. In another embodiment, pharmaceutical compositions that include CEM-101 are described, where the composition comprises CEM-101, where the CEM-101 is at least about 60%, at least about 80%, at least about 90%, at least about 95%, at least about 98%, or at least about 99% Form II. In another embodiment, pharmaceutical compositions that include Form II of CEM-101 are described, where the relative amount of Form I is less than about 40%, 20%, 10%, 5%, 2% or 1%. In another embodiment, pharmaceutical compositions that include CEM-101 are described, where the composition comprises CEM-101, where the CEM-101 is substantially free of Form I. In another embodiment, pharmaceutical compositions that include CEM-101 are described, where the relative amount of Form II and Form I is determined by the relative peak heights of specific peaks. Illustrative relative peak height ratios for the peaks at  $2\theta = 5.6$  and  $2\theta = 6.2$  are a ratio of about 5:1 or more, about 10:1 or more, or about 20:1 or more. As another embodiment there

is described Form II of CEM-101, substantially free of other physical forms. Form II of CEM-101, substantially free of other physical forms, may be characterized by an X-ray powder diffraction pattern with peaks at approximate positions of about  $2\theta = 5.6, 7.9, 9.3, 11.7, 12.9$  and  $16.7$ . As another embodiment there is described a pharmaceutical composition comprising CEM-101 having an X-ray powder diffraction pattern substantially the same as that of FIG 2.

As a further embodiment there is described a pharmaceutical composition comprising CEM-101 in any ratio of Form I and Form II. As a further embodiment there is described a pharmaceutical composition comprising CEM-101 in any ratio of Form I and amorphous CEM-101. As a further embodiment there is described a pharmaceutical composition comprising CEM-101 in any ratio of Form II and amorphous CEM-101. As a further embodiment there is described a pharmaceutical composition comprising CEM-101 in any ratio of Form I and Form II and amorphous CEM-101.

Form I of CEM-101, including Form I substantially free of other physical forms, may be prepared by recrystallization as described below in the Examples, for example by a recrystallization procedure as described in Table A., Experiments 18, 21-23 and 26. In the table, the ratios of solvent to CEM-101 are given in a volume:weight ratio (mL/mg or L/g) where "T" indicates "times" of volume. In general, Form I may be obtained by adding a solution of CEM-101 in a water miscible, polar organic solvent, such as for example acetone, methanol or ethanol, to water to afford Form I of CEM-101.

According to one embodiment, described herein is a process for the preparation of Form I of CEM-101. The process includes the step of adding a solution of CEM-101 in a water miscible, polar organic solvent to water, such as at a temperature below  $50^{\circ}\text{C}$ . In addition, the process may include one or more of the following additional steps: heating the solution of CEM-101, filtering the solution of CEM-101, reducing the volume of the solution of CEM-101 by evaporation, stirring the water during the addition of the solution of CEM-101. In another embodiment, the prepared Form I of CEM-101 is substantially free of other physical forms. In another embodiment, the prepared Form I of CEM-101 is substantially free of Form II.

According to another embodiment, described herein is a process for the preparation of Form I of CEM-101, which comprises one or more of the steps of dissolving a source of CEM-101 in acetone, methanol or ethanol, or a combination thereof, optionally above ambient temperature, optionally filtering the solution, reducing the volume of the resultant solution by evaporation, adding the solution to water at a temperature below  $50^{\circ}\text{C}$ , optionally



with stirring, and collecting the resulting crystalline solid. A further embodiment is one wherein the above solvent is acetone. A further embodiment is one wherein the above solvent is ethanol.

For any of the above processes a further embodiment is one wherein the solution  
5 is added to water at a temperature of about 10 °C to about 30 °C. Another embodiment is one wherein the solution is added to water dropwise. In another embodiment the prepared Form I of CEM-101 is substantially free of other physical forms. In another embodiment the prepared Form I of CEM-101 is substantially free of Form II.

For any of the above processes for the preparation of Form I of CEM-101, any of  
10 the solvents acetone, methanol or ethanol, or a combination thereof may be used. In another embodiment, the organic solution is slowly added to water at about 20-30 °C. In another embodiment, the volume:volume ratio of the organic solution to water is about 6 to about 15. In another embodiment, the volume:volume ratio of the organic solution to water is about 10 to about 13.

15 The above processes may be carried out with or without using seeds of Form I of CEM-101.

Form II of CEM-101, including Form II substantially free of other physical forms, may be prepared as described below in the Examples, for example by recrystallization as described in Table A., Experiments 1, 5, 6, 8, 9, 11, 12, 14, 16, 19 and 24, or by a slurry  
20 procedure as illustrated in Table B. In general, Form II may be obtained by adding water to a solution of CEM-101 in a water miscible, polar organic solvent. In addition, Form II of CEM-101 may be obtained by recrystallization from a number of organic solvents, with and without use of an antisolvent, and with or without use of seeding, as shown in Table A. Alternatively, a mixture of Form I and Form II may be converted into Form II of CEM-101 by  
25 slurring the mixture in, for example, 2-propanol (isopropyl alcohol, IPA) at 60 °C, or by slurring the mixture in 2-butanone (methyl ethyl ketone, MEK) under a variety of conditions.

According to one embodiment, described herein is a process for the preparation of Form II of CEM-101. The process includes the step of adding water to a solution of CEM-101 in a water miscible, polar organic solvent. In addition, the process may include one  
30 or more of the following additional steps: filtering the solution of CEM-101, reducing the volume of the solution of CEM-101 by evaporation, stirring the solution of CEM-101 during addition of the water, and collecting the resulting crystalline solid. In another embodiment, the water miscible, polar organic solvent is protic. In another embodiment, the water miscible,

polar organic solvent is aprotic. A further embodiment is one wherein the water miscible, polar organic solvent is acetone, acetonitrile, 1,4-dioxane, methanol or ethanol, or a combination thereof. A further embodiment is one wherein the solution of CEM-101 is above ambient temperature, for example about 65 to about 80 °C or about 65 °C. A further embodiment is one wherein water at about ambient temperature is added to the solution. Another embodiment is one wherein water is added to the solution dropwise. In one embodiment of any of the above processes for the preparation of Form II of CEM-101 the volume:volume ratio of organic solvent to water is from about 1 to about 10. In another embodiment the prepared Form II of CEM-101 is substantially free of other physical forms.

The above processes may be carried out with or without using seeds of Form II of CEM-101.

For the above procedures, when a source of CEM-101 is a solid, it may be CEM-101 in amorphous form, as Form I or Form II, as a further crystalline form, as a glass, or as a mixture of any of those forms. It is to be understood that a solution of CEM-101 may also provide a source of CEM-101. As another embodiment, there is described a process of purifying CEM-101 comprising converting one or more forms or mixtures of forms of the CEM-101 into Form I or Form II substantially free of other physical forms. After such purification, it may be desired to convert CEM-101 into a different physical form for further use.

In another embodiment, described herein is a solid form of CEM-101 prepared by a process that includes the step of adding a solution of CEM-101 in a water miscible, polar organic solvent to water, such as at a temperature below 50 °C. In addition, the process may include one or more of the following additional steps: optionally with heating, optionally filtering the solution, optionally reducing the volume of the resultant solution by evaporation, optionally with stirring, and collecting the resulting crystalline solid. In another embodiment, the water is at a temperature of about 10 °C to about 30 °C. In another embodiment, the solvent is acetone, methanol or ethanol, or a combination thereof. In another embodiment, the organic solution is slowly added to water at about 20-30 °C. In another embodiment, the volume:volume ratio of the organic solution to water is about 6 to about 15. In another embodiment, the volume:volume ratio of the organic solution to water is about 10 to about 13. In variations of the above, the process may include using seeds of Form I of CEM-101.

In another embodiment, described herein is a solid form of CEM-101 prepared by a process that includes the step of adding water to a solution of CEM-101 in a water

miscible, polar organic solvent. In addition, the process may include one or more of the following additional steps: optionally filtering the solution, optionally reducing the volume of the resultant solution by evaporation, optionally with stirring, and collecting the resulting crystalline solid. In another embodiment, the water miscible, polar organic solvent is protic. In another embodiment, the water miscible, polar organic solvent is aprotic. A further embodiment is one wherein the water miscible, polar organic solvent is acetone, acetonitrile, 1,4-dioxane, methanol or ethanol, or a combination thereof. A further embodiment is one wherein the solution of the water miscible, polar organic solvent is above ambient temperature, for example about 65 to about 80 °C or about 65 °C. A further embodiment is one wherein water at about ambient temperature is added to the solution. Another embodiment is one wherein water is added to the solution dropwise. In another embodiment, the volume:volume ratio of organic solvent to water is from about 1 to about 10. In variations of the above, the process may include using seeds of Form II of CEM-101.

As another embodiment, there is described a pharmaceutical composition comprising CEM-101 in crystalline form as described in any of the descriptions herein and further comprising at least one pharmaceutically acceptable carrier or excipient.

Illustratively, compositions may include one or more carriers, diluents, and/or excipients. The compounds described herein, or compositions containing them, may be formulated in a therapeutically effective amount in any conventional dosage forms appropriate for the methods described herein, and include one or more carriers, diluents, and/or excipients therefor. Such formulation compositions may be administered by a wide variety of conventional routes for the methods described herein, and in a wide variety of dosage formats, utilizing known procedures. Capsules and tablets are embodiments commonly used for oral administration of antibiotics. See generally, Remington: The Science and Practice of Pharmacy, (21<sup>st</sup> ed., 2005), as well as an illustrative formulation composition in the Examples.

As another embodiment, there is described a method of treatment of a bacterial infection, a protozoal infection, or a disorder related to a bacterial infection or protozoal infection comprising the step of administering to a subject in need thereof a therapeutically effective amount of CEM-101 in crystalline form as described herein, or a pharmaceutical composition thereof further comprising at least one pharmaceutically acceptable carrier or excipient. Illustrative dosing schedules include the daily administration of a composition, in a single or divided format, comprising about 1,200 mg, about 1,000 mg, about 800 mg, about 400 mg, about 200 mg, or about 100 mg.

As another embodiment, there is described a use of CEM-101 in crystalline form as described herein for the treatment of a bacterial infection, a protozoal infection, or a disorder related to a bacterial infection or protozoal infection.

As another embodiment, there is described a use of CEM-101 in crystalline form  
5 as described herein for the manufacture of a medicament for the treatment of a bacterial infection, a protozoal infection, or a disorder related to a bacterial infection or protozoal infection.

As a further embodiment, method or use described above is one wherein the subject is a mammal, a fish, a bird or a reptile. As another embodiment, there is described a  
10 method or use wherein the subject is a mammal. As another embodiment, there is described a method or use wherein the subject is a human.

The term “therapeutically effective amount” as used herein, refers to that amount of active compound or pharmaceutical agent that elicits the biological or medicinal response in a tissue system, animal or human that is being sought by a researcher, veterinarian, medical  
15 doctor or other clinician, which includes alleviation of the symptoms of the disease or disorder being treated. In one aspect, the therapeutically effective amount is that which may treat or alleviate the disease or symptoms of the disease at a reasonable benefit/risk ratio applicable to any medical treatment. However, it is to be understood that the total daily usage of the compounds and compositions described herein may be decided by the attending physician  
20 within the scope of sound medical judgment. The specific therapeutically-effective dose level for any particular patient will depend upon a variety of factors, including the disorder being treated and the severity of the disorder; activity of the specific compound employed; the specific composition employed; the age, body weight, general health, gender and diet of the patient; the time of administration, route of administration, and rate of excretion of the specific  
25 compound employed; the duration of the treatment; drugs used in combination or coincidentally with the specific compound employed; and like factors well known to the researcher, veterinarian, medical doctor or other clinician of ordinary skill.

As shown in the interconversion of slurries experiment summarized below in the Examples in Table B, slurries of Forms I and II are prepared in 2-propanol (IPA) and  
30 4-butanone (MEK) at ambient, sub-ambient, and elevated temperatures. In 2-propanol, conversion of Form I to Form II appears to be solubility driven at ambient and sub-ambient temperatures, with little apparent change observed in the ratio of Forms I and II by XRPD analysis over 3 days. Extending the interconversion period to 8 days at room temperature left

only a trace of Form I remaining. In 2-propanol, at elevated temperature, only Form II is obtained. Experiments based on 2-butanone did not have the apparent solubility limitation and gave Form II as the only observed form at sub-ambient, ambient and elevated temperatures. Based on these experiments and the DSC results, but without being bound by theory, it appears that Form II may be more stable than Form I throughout the temperature range. In addition, but without being bound by theory, the DSC results suggest that Form I and II are monotropically related.

As shown below in the Examples in Table C-1, Form I exhibited greater aqueous solubility than Form II over a pH range from 9.2 to 1.2.

When the forms of CEM-101 are dosed in a vehicle in which the compound is well solubilized, there is no observed difference in measured pharmacokinetic parameters, including C<sub>max</sub>, T<sub>max</sub>, and AUC, among Form I and Form II. When the forms of CEM-101 are dosed in a vehicle in which the compound is present as a solid, there is no statistical difference in measured pharmacokinetic parameters, including C<sub>max</sub>, T<sub>max</sub>, and AUC, among Form I and Form II.

In another embodiment, crystalline forms of CEM-101, and mixtures thereof, are described herein that show improved solubility compared to amorphous forms of CEM-101

## EXAMPLES

### X-Ray Powder Diffraction (XRPD) Peak Positions.

XRPD patterns were collected using an Inel XRG-3000 diffractometer equipped with a curved position sensitive detector with a  $2\theta$  range of  $120^\circ$ . An incident beam of Cu K $\alpha$  radiation (40 kV, 30 mA) was used to collect data in real time at a resolution of  $0.03^\circ 2\theta$ . Prior to the analysis, a silicon standard (NIST SRM 640c) was analyzed to verify the Si 111 peak position. Samples were prepared for analysis by packing them into thin-walled glass capillaries. Each capillary was mounted onto a goniometer head and rotated during data acquisition. The monochromator slit was set at 5 mm by 160  $\mu$ m.

Alternatively, XRPD patterns were collected using a PANalytical X'Pert Pro diffractometer. An incident beam of Cu K $\alpha$  radiation was produced using an Optix long, fine-focus source. An elliptically graded multilayer mirror was used to focus the Cu K $\alpha$  X-rays of the source through the specimen and onto the detector. Data were collected and analyzed using X'Pert Pro Data Collector software (v. 2.2b). Prior to the analysis, a silicon specimen (NIST SRM 640c) was analyzed to verify the Si 111 peak position. The specimen was

sandwiched between 3  $\mu\text{m}$  thick films, analyzed in transmission geometry, and rotated to optimize orientation statistics. A beam-stop and a helium atmosphere were used to minimize the background generated by air scattering. Soller slits were used for the incident and diffracted beams to minimize axial divergence. Diffraction patterns were collected using a scanning  
5 position-sensitive detector (X'Celerator) located 240 mm from the specimen.

The data presented herein contain X-ray diffraction patterns and tables with peak lists. It is to be understood that the range of data collected may be instrument dependent. Under typical circumstances, peaks within the range of up to about  $30^\circ 2\theta$  are selected. Although peaks may be labeled on diffraction patterns and listed in tables, it is to be understood  
10 that different rounding algorithms may be used to round each peak to the nearest 0.1 or 0.01  $^\circ 2\theta$ , depending upon the instrument used to collect the data and/or the inherent peak resolution. Should there be a difference, the peak positions listed in the tables should be used. The location of the peaks along the x-axis ( $^\circ 2\theta$ ) in both the figures and the tables may be automatically determined using appropriate software, which is typically resident on the  
15 instrument used and rounded to one or two significant figures after the decimal point based upon the above criteria. Peak position variabilities are given herein to within  $\pm 0.1^\circ 2\theta$  based upon recommendations outlined in the USP discussion of variability in x-ray powder diffraction (United States Pharmacopeia, USP 32, NF 27, Vol. 1, pg. 392, 2009). The accuracy and precision associated with any particular measurement reported herein has not been determined.  
20 Measurements on independently prepared samples on different instruments may lead to variability which is greater than  $\pm 0.1^\circ 2\theta$ . For d-space listings, the wavelength used to calculate d-spacings was 1.541874  $\text{\AA}$ , a weighted average of the  $\text{Cu-K}\alpha_1$  and  $\text{Cu-K}\alpha_2$  wavelengths (*Phys. Rev.* **A56**(6) 4554-4568 (1997)). Variability associated with d-spacing estimates was calculated from the USP recommendation, at each d-spacing, and provided in the  
25 respective data tables.

When multiple diffraction patterns are available, then assessments of particle statistics (PS) and/or preferred orientation (PO) are possible. Reproducibility among XRPD patterns from multiple samples analyzed on a single diffractometer indicates that the particle statistics are adequate. Consistency of relative intensity among XRPD patterns from multiple  
30 diffractometers indicates good orientation statistics. Alternatively, the observed XRPD pattern may be compared with a calculated XRPD pattern based upon a single crystal structure, if available. Two-dimensional scattering patterns using area detectors can also be used to evaluate PS/PO. If the effects of both PS and PO are determined to be negligible, then the

XRPD pattern is representative of the powder average intensity for the sample and prominent peaks may be identified as “Representative Peaks”. In general, it is appreciated that the more data collected to determine Representative Peaks, the more statistically significant is the classification of those peaks.

5

CEM-101 Form I.

One PANalytical pattern and one Inel pattern were analyzed for this material, and therefore at least partially optimized orientation and particle statistic effects could be assessed through comparison with multiple patterns. The peak positions and intensities are  
 10 consistent between patterns, indicating adequate particle and orientation statistics. Observed Peaks are shown in Figure 1 and Table 1, and Representative Peaks are listed in Table 2.

Table 1. Observed peaks for CEM-101 Form I.

	$^{\circ}2\theta$	d-space (Å)	Intensity (%)
15	$6.19 \pm 0.10$	$14.268 \pm 0.234$	13
	$8.47 \pm 0.10$	$10.443 \pm 0.125$	30
	$8.80 \pm 0.10$	$10.047 \pm 0.115$	68
	$9.34 \pm 0.10$	$9.473 \pm 0.102$	10
20	$10.52 \pm 0.10$	$8.407 \pm 0.080$	100
	$10.97 \pm 0.10$	$8.062 \pm 0.074$	46
	$12.04 \pm 0.10$	$7.349 \pm 0.061$	25
	$12.41 \pm 0.10$	$7.132 \pm 0.058$	43
	$13.20 \pm 0.10$	$6.709 \pm 0.051$	88
25	$13.68 \pm 0.10$	$6.472 \pm 0.047$	41
	$14.52 \pm 0.10$	$6.102 \pm 0.042$	22
	$14.85 \pm 0.10$	$5.965 \pm 0.040$	22
	$17.02 \pm 0.10$	$5.209 \pm 0.031$	45
	$18.03 \pm 0.10$	$4.921 \pm 0.027$	46
30	$18.61 \pm 0.10$	$4.768 \pm 0.026$	71
	$19.48 \pm 0.10$	$4.557 \pm 0.023$	48
	$19.73 \pm 0.10$	$4.500 \pm 0.023$	56
	$20.68 \pm 0.10$	$4.294 \pm 0.021$	38

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	21.17 ± 0.10	4.197 ± 0.020	39
	21.89 ± 0.10	4.061 ± 0.018	53
	23.41 ± 0.10	3.801 ± 0.016	25
	24.44 ± 0.10	3.642 ± 0.015	11
5	24.91 ± 0.10	3.574 ± 0.014	37
	25.61 ± 0.10	3.478 ± 0.013	18
	26.35 ± 0.10	3.383 ± 0.013	11
	26.80 ± 0.10	3.327 ± 0.012	24
	29.04 ± 0.10	3.075 ± 0.010	18
10	29.96 ± 0.10	2.983 ± 0.010	10

Table 2. Representative peaks for CEM-101 Form I.

	$^{\circ}2\theta$	d-space (Å)	Intensity (%)
15	8.80 ± 0.10	10.047 ± 0.115	68
	10.52 ± 0.10	8.407 ± 0.080	100
	13.20 ± 0.10	6.709 ± 0.051	88
	18.61 ± 0.10	4.768 ± 0.026	71

## 20 CEM-101 Form II.

One Inel pattern was analyzed for this material, and preferred orientation and particle statistic effects could be assessed through comparison with the simulated pattern from single crystal data (not shown). The peak positions and intensities are consistent between patterns, indicating adequate particle and orientation statistics. Observed peaks are shown in

25 Figure 2 and Table 3, and representative peaks are listed in Table 4.

Table 3. Observed peaks for CEM-101 Form II.

	$^{\circ}2\theta$	d-space (Å)	Intensity (%)
30	5.60 ± 0.10	15.772 ± 0.286	53
	7.85 ± 0.10	11.260 ± 0.145	54
	9.30 ± 0.10	9.505 ± 0.103	69
	9.82 ± 0.10	9.004 ± 0.092	36



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	10.65 ± 0.10	8.304 ± 0.078	36
	11.24 ± 0.10	7.871 ± 0.070	45
	11.66 ± 0.10	7.592 ± 0.065	75
	11.97 ± 0.10	7.395 ± 0.062	38
5	12.87 ± 0.10	6.880 ± 0.054	100
	13.28 ± 0.10	6.666 ± 0.050	33
	13.77 ± 0.10	6.432 ± 0.047	32
	14.15 ± 0.10	6.260 ± 0.044	36
	14.63 ± 0.10	6.054 ± 0.041	35
10	15.12 ± 0.10	5.861 ± 0.039	48
	16.71 ± 0.10	5.306 ± 0.032	78
	17.23 ± 0.10	5.147 ± 0.030	33
	17.50 ± 0.10	5.067 ± 0.029	36
	18.37 ± 0.10	4.830 ± 0.026	38
15	18.58 ± 0.10	4.776 ± 0.026	43
	18.78 ± 0.10	4.724 ± 0.025	40
	19.34 ± 0.10	4.590 ± 0.024	37
	19.68 ± 0.10	4.510 ± 0.023	46
	20.62 ± 0.10	4.308 ± 0.021	38
20	20.97 ± 0.10	4.237 ± 0.020	43
	21.17 ± 0.10	4.196 ± 0.020	47
	21.38 ± 0.10	4.156 ± 0.019	35
	21.83 ± 0.10	4.071 ± 0.019	34
	22.11 ± 0.10	4.021 ± 0.018	34
25	22.59 ± 0.10	3.936 ± 0.017	27
	23.32 ± 0.10	3.815 ± 0.016	32
	23.49 ± 0.10	3.787 ± 0.016	32
	24.15 ± 0.10	3.685 ± 0.015	28
	24.43 ± 0.10	3.644 ± 0.015	32
30	24.77 ± 0.10	3.594 ± 0.014	30
	25.61 ± 0.10	3.479 ± 0.013	30
	25.78 ± 0.10	3.456 ± 0.013	29
	26.23 ± 0.10	3.398 ± 0.013	27

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5	26.58 ± 0.10	3.354 ± 0.012	25
	27.23 ± 0.10	3.275 ± 0.012	26
	27.55 ± 0.10	3.238 ± 0.012	26
	27.86 ± 0.10	3.203 ± 0.011	31
	28.52 ± 0.10	3.130 ± 0.011	24
	29.49 ± 0.10	3.029 ± 0.010	26

Table 4. Representative peaks for CEM-101 Form II.

10	°2θ	d-space (Å)	Intensity (%)
	5.60 ± 0.10	15.772 ± 0.286	53
	7.85 ± 0.10	11.260 ± 0.145	54
	9.30 ± 0.10	9.505 ± 0.103	69
	11.66 ± 0.10	7.592 ± 0.065	75
15	12.87 ± 0.10	6.880 ± 0.054	100
	16.71 ± 0.10	5.306 ± 0.032	78

### Recrystallization Studies

Recrystallization conditions that yield Form I and Form II, as well as conditions which afford amorphous material or mixtures of Form I and Form II, as well as the outputs (recoveries) from the conditions are shown in the following Table A. Recrystallization Studies. The polymorph form was determined by analysis of the X-ray powder diffraction pattern for each isolated product. In the table, “T” represents the ratio of solvent to the mass of solid in mL/mg (or L/g); DCM means dichloromethane; DMF means dimethylformamide; and IPE means isopropylether.

Table A. Recrystallization Study Results

Experiment	CEM-101 Input	Solvent		Procedure	CEM-101 Output	Polymorph Form
1	5 g	Acetone (5T)	Water (10T)	Dissolved solid in acetone and added water dropwise at 30 °C	4.5 g	Form II
2	5 g	DCM (5T)		Dissolved in DCM and freeze dried	4.4 g	Amorphous

3	5 g	Acetone (5T)	Water (50T)	Dissolved solid in acetone and added to water dropwise at 30 °C	4.4 g	Form I + Form II
4	2 g	DMF(2T)	Water (50T)	Dissolved solid in DMF and added to water dropwise at 28 °C	1.8 g	Form I
5	3 g	Methanol (18T)	Water (18T)	Dissolved solid in methanol and added water dropwise at 28 °C	2.5 g	Form II
6	3 g	Ethanol (10T)	Water (10T)	Dissolved solid in ethanol and added water dropwise at 28 °C	2.2 g	Form II
7	3 g	Methanol (18T)		Dissolved in methanol and freeze dried	2.7 g	Form II + Form I
8	3 g	DCM (3T)	Cyclohexane (20T)	Dissolved solid in DCM and added to cyclohexane in one portion at 28 °C	2.3 g	Form II
9	3 g	Ethanol (10T)	IPE (33T)	Dissolved solid in ethanol and added to IPE in one portion at 28 °C	1.2 g	Form II
10	2 g	Acetonitrile (4T)		Dissolved solid in acetonitrile and cooled to 30 °C	0.6 g	Form I + Form II
11	2 g	1,4-Dioxane (5T)	Water (5T)	Dissolved solid in 1,4-Dioxane at 70 °C and added water at 0 °C to 5 °C	2.1	Form II
12	2 g	Acetonitrile (4T)	Water (4T)	Dissolved solid in acetonitrile at 80 °C and added water at 55 °C	1.6 g	Form II
13	1 g	Acetonitrile (4T)		Dissolved solid in acetonitrile at 80 °C and seeded with 10 mg of Form I	0.5 g	Form II + Form I
14	1g	Acetonitrile (4T)		Dissolved solid in acetonitrile at 80 °C and seeded with 100 mg of Form I	0.4 g	Form II
15	12 g	DCM (3T)		Dissolved in DCM and freeze dried	9.3 g	Amorphous

16	1 g	Ethanol (15T)	Water (5T)	Dissolved solid (Form I) in ethanol (15 mL) in 65 °C, reduced volume to 5 mL and added water (5 mL) dropwise at 28 °C	0.8 g	Form II
17	2 g	DMF(2T)	Water (50T)	Dissolved solid (Form II) in DMF (4 mL) and added to water (100mL) dropwise at 28 °C	1.9 g	Form I + Form II
18	5 g	Acetone (7T)	Water (50T)	Dissolved solid (Form II) in acetone (35 mL) in 65 °C, reduced volume to 20 mL and added to water (100 mL) dropwise at 28 °C. The wet solid was suspended in water and stirred under heating at 65 °C, cooled and filtered.	4.9 g	Form I
19	2 g	Water		Dissolved solid (Form II) in water (100 mL) and stirred under heating at 60 °C, cooled and filtered.	1.8 g	Form II
20	5 g	Ethanol (15T)	Water (5T)	Dissolved solid (Form II) in ethanol (75 mL) at 65 °C, reduced volume to 35 mL and added water dropwise at 60 °C. Ethanol was removed by distillation after formation of the solid, stirring under heating, cooled and filtered.	4.8 g	Unknown
21	5 g	Acetone (6T)	Water (60T)	Dissolved solid (Form I + II) in acetone (30 mL) at 65 °C, filtered, reduced volume to 20 mL and added to water (300 mL) dropwise at 27 °C, stirred and filtered.	4.5g	Form I
22	5 g	Acetone (8T)	Water (60T)	Dissolved solid (Form I + II) in acetone (40 mL) at 65 °C, filtered, reduced volume to 30 mL and added to water (450 mL) dropwise at 27 °C, stirred and filtered.	4.5g	Form I

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23	2 g	Ethanol (15T)	Water (60T)	Dissolved solid (Form I + II) in ethanol (30 mL) at 65 °C, filtered, reduced volume to 16 mL and added to water (120 mL) dropwise at 27 °C, stirred and filtered.	1.7 g	Form I
24	5 g	Acetone (6T)	Water (60T)	Dissolved solid (Form I + II) in acetone (30 mL) at 65 °C, filtered, reduced volume to 20 mL and water (300 mL) was added dropwise at 27 °C, stirred and filtered.	4.4 g	Form II
25	5 g	Acetone (7T)	Water (50T)	Dissolved solid (Form I + II) in acetone (35 mL) at 65 °C, filtered, reduced volume to 25 mL and added to water (250 mL) dropwise at 27 °C, stirred and filtered.	4.5 g	Form I + little of Form II
26	5 g	Ethanol (15T)	Water (50T)	Dissolved solid (Form I + II) in ethanol (75 mL) at 65 °C, filtered, reduced volume to 40 mL and added to water (250 mL) dropwise at 27 °C, stirred and filtered.	4.4 g	Form I

### Hot Stage Microscopy and DSC

Form I of CEM-101 exhibits a melt onset at about 180 °C and final melt at about 200 °C by hot stage microscopy and exhibits endothermic events at 170 and 197-198 °C by differential scanning calorimetry (DSC). Form II of CEM-101 exhibits a melt onset at about 215 °C by hot stage microscopy and a DSC peak at about 225 °C, as a single endothermic event. Mixtures of varying amounts of Form I and Form II have exhibited endothermic events at 194-199 and at 219-225 °C by DSC, depending upon the ratio of the forms. It is to be understood that hot stage microscopy and/or DSC may be used to determine the presence or absence of certain forms in the compounds and compositions described herein.

### Interconversion Studies.

Interconversion studies by slurring of Form I and Form II are shown in the following Table B in which the starting solid was a mixture of Form I and Form II; IPA is isopropyl alcohol (isopropanol) and MEK is methyl ethyl ketone (2-butanone).

Table B. Interconversion Slurries for CEM-101 Form A and B Solids

Solvent	Conditions <sup>a</sup>	XRPD Result <sup>b</sup>
IPA	60 °C 3 days	Form II
	RT 3 days	Form I + II
	RT 5 days <sup>c</sup> (8 days total)	Form II + trace Form I
	2 - 8 °C 3 days	Form I + II
	2 - 8 °C 5 days <sup>d</sup> (8 days total)	Form I + II
MEK	60 °C 3 days	IS <sup>b</sup>
	60 °C 3 days <sup>c</sup> (6 days total)	Form II
	RT 3 days	Form II
	2 - 8 °C 3 days	Form II

a. Reported times and temperatures are approximate. RT = ambient temperature.

5 b. XRPD = X-ray powder diffraction, IS = insufficient solids for analysis.

c. Continuation of previous slurry with additional solids.

d. Continuation of previous slurry.

#### Aqueous Solubility.

10 Using a linear calibration curve obtained by plotting the concentration of CEM-101 vs. LC/MS-MS peak areas, the aqueous solubility of forms of CEM-101 are obtained as follows: Test compounds (dry powder) are added to 0.9% saline (initial pH 6.03) until precipitation, and the mixture is incubated for 6 h with shaking. After the incubation period, the samples are centrifuged twice and solubility is estimated using the linearity standard curve for  
15 the compound: Form I showed a solubility of 1411 µg/mL.

Using a linear calibration curve obtained by plotting the concentration of CEM-101 vs. LC/MS-MS peak areas, the aqueous solubility of forms of CEM-101 was obtained as follows: Test compounds (dry powder) were added to water with the indicated pH until precipitation, and the mixture was incubated for 6 h with shaking. After the incubation  
20 period, the samples were centrifuged twice and solubility was estimated using the linearity standard curve for the compound: Media: Water at pH: pH 9.2, 7.4, 4 and 1.2 (adjusted using 0.1N NaOH and 0.1 N HCl); Incubation: 6 h at 26 °C with shaking; Test concentrations: Dry powder added till saturation; Detection: LC/MS-MS. The results are shown in Table C-1.

Table C-1. Aqueous Solubility Study

pH	Form II ( $\mu\text{g/mL}$ )	Form I ( $\mu\text{g/mL}$ )
9.2	331	1751
7.4	305	2224
4	361	4656
1.2	3638	4808

## Intrinsic Dissolution Comparison.

Mean intrinsic dissolution rates for exemplary batches of the two forms are shown in Table cC-2 for 3 batches of Form I (SD and %CV for one batch shown) and for Form II.

Table C-2. Mean Intrinsic Dissolution Studies.

Dissolution Medium	Mean intrinsic dissolution rate ( $\text{mg/min/cm}^2$ )							
	Form I					Form II		
	Batch A	Batch B	Batch C	SD*	% CV*		SD	% CV
0.1 N Hydrochloric Acid	9.4	10.6	7.9	35.8	9.8	8.8	38.0	9.4
Acetate buffer, pH 4.5	2.1	2.8	2.7	6.43	5.2	2.7	6.4	10.3
Phosphate buffer, pH 6.8	0.004	0.03	0.02	0.53	53.0	0.01	0.5	51.1
Phosphate buffer, pH 7.6	0.02	0.001	ND	NA	NA	ND	NA	NA
Water	2.0	0.7	1.6	4.91	9.6	ND	NA	NA

\* SD and CV% for Batch C only. ND, not determined. NA, not applicable.

## 10 Pharmacokinetic Evaluation of CEM-101 in Balb/c Mice.

The pharmacokinetics of lots of CEM-101 characterized as Form I and Form II were evaluated in Balb/c mice receiving a single dose of 20 or 100 mg/kg body weight (b.w.) via oral gavage. The doses were prepared as 2.0 mg/mL or 10.0 mg/mL in a vehicle of 0.5% (w/v) carboxymethyl cellulose in water and a dose volume of 10 mL/kg b.w. Blood samples were collected at various time points during the next 6 h post dose. The results are shown as follows:

Table D: Plasma concentrations of CEM-101 in  $\mu\text{g/mL}$  vs. time in female Balb/c mouse at 20 mg/kg b.w.

Table D. CEM-101 Form I and Form II Polymorphs Oral pharmacokinetics studies in female Balb/c mouse (20 mg/kg b.w.) Plasma concentrations ( $\mu\text{g/mL}$ ); Female Balb/c mouse (20 mg/kg b.w.)						
Time (h)	CEM-101 Form II			CEM-101 Form I		
	Mean		Stdv	Mean		Stdv
0.00	0.0	$\pm$	0.0	0.0	$\pm$	0.0
0.25	6.2	$\pm$	1.6	8.2	$\pm$	2.4
0.50	8.8	$\pm$	0.8	13.6	$\pm$	2.0
1.00	7.3	$\pm$	0.9	12.0	$\pm$	1.7
2.00	6.1	$\pm$	1.0	11.3	$\pm$	1.4
4.00	5.5	$\pm$	1.7	7.7	$\pm$	0.7
6.00	1.3	$\pm$	0.5	4.2	$\pm$	0.4

5 Table E: Plasma concentrations of CEM-101 in  $\mu\text{g/mL}$  vs. time in male Balb/c mouse at 20 mg/kg b.w.

Table E. CEM-101 Form I and Form II Polymorphs Oral pharmacokinetics studies in male Balb/c mouse (20 mg/kg b.w.) Plasma concentrations ( $\mu\text{g/mL}$ ); Male Balb/c mouse (20 mg/kg b.w.)						
Time (h)	CEM-101 Form II			CEM-101 Form I		
	Mean		Stdv	Mean		Stdv
0.00	0.0	$\pm$	0.0	0.0	$\pm$	0.0
0.25	4.1	$\pm$	0.8	5.3	$\pm$	1.8
0.50	6.7	$\pm$	0.6	7.7	$\pm$	1.6
1.00	5.9	$\pm$	0.8	9.5	$\pm$	0.9
2.00	5.6	$\pm$	0.4	6.4	$\pm$	0.8
4.00	4.9	$\pm$	1.1	5.9	$\pm$	0.6
6.00	2.9	$\pm$	0.6	2.6	$\pm$	0.8

Table F: Plasma concentrations of CEM-101 in  $\mu\text{g/mL}$  vs. time in female Balb/c mouse at 100 mg/kg b.w.

Table F. CEM-101 Form I and Form II Polymorphs Oral pharmacokinetics studies in female Balb/c mouse (100 mg/kg b.w.) Plasma concentrations ( $\mu\text{g/mL}$ ); Female Balb/c mouse (100 mg/kg b.w.)						
Time (h)	CEM-101 Form II			CEM-101 Form I		
	Mean		Stdv	Mean		Stdv
0.00	0.0	$\pm$	0.0	0.0	$\pm$	0.0
0.25	7.3	$\pm$	0.9	11.9	$\pm$	1.7
0.50	10.5	$\pm$	1.4	11.6	$\pm$	1.6
1.00	9.6	$\pm$	2.2	14.7	$\pm$	2.3
2.00	9.5	$\pm$	2.2	14.1	$\pm$	2.9
4.00	10.2	$\pm$	1.0	16.0	$\pm$	2.3
6.00	7.8	$\pm$	1.1	19.5	$\pm$	2.3



Table G: Plasma concentrations of CEM-101 in  $\mu\text{g/mL}$  vs. time in male Balb/c mouse at 100 mg/kg b.w.

Table G. CEM-101 Form I and Form II Polymorphs Oral pharmacokinetics studies in female Balb/c mouse (100 mg/kg b.w.) Plasma concentrations ( $\mu\text{g/mL}$ ); Male Balb/c mouse (100 mg/kg b.w.)						
Time (h)	CEM-101 Form II			CEM-101 Form I		
	Mean		Stdv	Mean		Stdv
0.00	0.0	$\pm$	0.0	0.0	$\pm$	0.0
0.25	6.8	$\pm$	0.7	11.3	$\pm$	2.5
0.50	6.9	$\pm$	1.1	10.7	$\pm$	3.0
1.00	8.7	$\pm$	2.7	13.1	$\pm$	3.2
2.00	9.3	$\pm$	1.2	13.4	$\pm$	3.1
4.00	10.6	$\pm$	1.4	17.4	$\pm$	2.9
6.00	7.2	$\pm$	0.8	12.0	$\pm$	2.0

5

Table H: Mean Plasma PK Parameters at 20 mg/kg.

Table H. CEM-101 Form I and Form II Polymorphs Oral pharmacokinetics studies in Balb/c mouse Mean Plasma PK Parameters				
	Male – 20 mg/kg		Female - 20 mg/kg	
Parameters	CEM-101 Form II	CEM-101 Form I	CEM-101 Form II	CEM-101 Form I
Route of administration	Oral	Oral	Oral	Oral
Dose (mg/kg)	20	20	20	20
Cmax ( $\mu\text{g/mL}$ )	6.73	9.5	8.8	13.6
Tmax (h)	0.5	1	0.5	0.5
AUClast (h* $\mu\text{g/mL}$ ) (0 to 6 h)	29	35	31.6	53
AUCinf (h* $\mu\text{g/mL}$ )	49	46	36	70
AUCextrap (%)	42	24	12	24

Table I: Mean Plasma PK Parameters at 100 mg/kg.

Table I. CEM-101 Form I and Form II Polymorphs Oral pharmacokinetics studies in Balb/c mouse				
Mean Plasma PK Parameters				
	Male – 100 mg/kg		Female - 100 mg/kg	
Parameters	CEM-101 Form II	CEM-101 Form I	CEM-101 Form II	CEM-101 Form I
Route of administration	Oral	Oral	Oral	Oral
Dose (mg/kg)	100	100	100	100
C <sub>max</sub> (µg/mL)	10.6	17.4	10.5	19.5
T <sub>max</sub> (h)	4	4	4	6
AUC <sub>last</sub> (h*µg/mL) (0 to 6 h)	66	83.5	55	91
AUC <sub>inf</sub> (h*µg/mL)	99	NC	NC	NC
AUC <sub>extrap</sub> (%)	33	NC	NC	NC

## Pharmacokinetic (PK) Comparison.

Results of a further oral pharmacokinetic study of Form I and Form II in groups  
5 of 5 female Balb/c mice receiving a single dose at 5, 10 and 20 mg/kg is shown in Table J.

Table J. Mean Plasma PK Parameters

		Dosing											
		5 mg/kg				10 mg/kg				20 mg/kg			
Form	c	t1/2	Tmax	Cmax	AUC 0-24	t1/2	Tmax	Cmax	AUC 0-24	t1/2	Tmax	Cmax	AUC 0-24
I	N	1	5	5	5	4	5	5	5	4	5	5	5
	Mean	1.32	0.600	1.43	3.30	3.60	2.40	4.68	17.7	2.10	1.60	6.64	26.2
	SD	NC	0.224	0.249	0.551	1.65	0.894	1.31	3.25	0.509	0.548	1.84	4.84
	Min	1.32	0.500	1.02	2.78	2.44	2.00	3.21	14.4	1.73	1.00	4.66	19.5
	Median	1.32	0.500	1.54	3.16	2.95	2.00	4.09	17.2	1.91	2.00	5.91	26.7
	Max	1.32	1.00	1.65	4.24	6.05	4.00	6.11	21.1	2.85	2.00	9.34	33.0
	CV%	NC	37.3	17.4	16.7	46.0	37.3	27.9	18.3	24.2	34.2	27.7	18.5
II	N	5	5	5	5	3	5	5	5	2	5	5	5
	Mean	1.17	1.20	1.85	4.69	1.42	1.25	2.63	7.58	2.46	1.10	5.36	20.1
	SD	0.297	0.447	0.249	0.819	0.263	0.750	1.22	2.27	0.0517	0.548	0.837	3.33
	Min	0.935	1.00	1.55	4.21	1.12	0.250	1.50	4.62	2.43	0.500	3.88	16.3
	Median	1.12	1.00	1.80	4.31	1.53	1.00	2.42	7.59	2.46	1.00	5.66	21.7
	Max	1.67	2.00	2.12	6.14	1.61	2.00	4.69	10.0	2.50	2.00	5.96	23.4
	CV%	25.3	37.3	13.5	17.5	18.5	60.0	46.3	30.0	2.10	49.8	15.6	16.6

## Examples of Pharmaceutical Compositions using CEM-101 Form I.

The following formulation is used to provide Size 0 hard gelatin capsules

5 containing 200 mg of CEM-101 per capsule.

	Material	% w/w	Qty/Cap (mg)
	CEM-101	61.54	200.00
	Avicel PH101	30.96	100.63
	Plasdone K29/32	2.00	6.50
10	Ac-Di-Sol	4.00	13.00
	Sodium Lauryl Sulfate, NF	1.00	3.25
	Magnesium Stearate, NF (Vegetable Grade)	0.50	1.63
	Purified Water,* USP	64.3	-
15	Total	100.00	325.00

\* Estimated amount of purified water. Removed during processing; not in final formula.

The following formulation is used to provide tablets containing 200 mg per tablet, containing 54% drug load and a target weight of 370 mg/tablet. The drug product is manufactured by wet granulation and the tablets are compressed at 6 kp.

Material	% w/w	Qty/Tablet (mg)
CEM-101* (Intra-granular)	54.04	200.00
Avicel PH101 (Intra-granular)	18.00	66.60
10 Sodium Lauryl Sulfate (Intra-granular)	1.00	3.70
Plasdone K29/32 (Intra-solution)	3.00	11.10
Pearlitol 200SD (Extra-granular)	17.95	66.40
Ac-Di-Sol (Extra-granular)	5.00	18.50
15 Cab-O-Sil (Extra-granular)	0.50	1.85
Magnesium Stearate (Vegetable Grade) (Extra-granular)	0.50	1.85
Purified Water**		
Total:	100.00	370.00

20 \* Adjusted for potency

\*\* Removed during processing, not in final formulation.

EXAMPLE. The stability of Form I and Form II of CEM-101 was evaluated under various conditions, as shown in the following Tables. In each case, there was no observed change in color of the test material during the entire study. In each case, the test material was first placed in Primary Packaging Material (LLDPE bag within a HMHDPE /LDPE/ LDPE blend bag, and then heat sealed). The Primary Packaging Material was placed in Secondary Packaging Material (HDPE drum). All other impurities were less than 1% at each time point.

30 Form II, 2-8°C

	Initial	3 Month	6 Month	9 Month	12 Month
Water	1.01%	1.24%	1.39%	1.38%	1.37%
Chromatographic Purity	97.0	96.0	96.8	96.4	96.8
3-Ethynylaniline	Not Detected	Not Detected	Not Detected	0.01%	0.12%
Assay (on hydrous basis)	93.9	93.4	93.6	93.3	93.0

## Form II, 25°C/60% RH

	Initial	3 Month	6 Month	9 Month	12 Month
Water	1.01%	1.16%	1.42%	1.45%	1.48%
Chromatographic Purity	97.0%	96.0%	96.7%	96.2%	96.1%
3-Ethynylaniline	Not Detected	Not Detected	Not Detected	0.04%	0.11%
Assay (on hydrous basis)	93.9%	93.6%	93.7%	93.2%	93.0%

## Form II, 40°C/75% RH

	Initial	3 Month	6 Month	9 Month	12 Month
Water	1.01%	1.24%	1.62%	1.51%	1.56%
Chromatographic Purity	97.0%	95.9%	96.5%	96.2%	97.1%
3-Ethynylaniline	Not Detected	Not Detected	Not Detected	0.02%	0.05%
Assay (on hydrous basis)	93.9%	93.0%	93.1%	92.5%	92.3%

5

## Form I (Lot 3), 2-8°C

	Initial	3 Month	6 Month	12 Month
Water	1.11%	1.63%	1.61%	1.69%
Chromatographic Purity	98.3%	98.1%	98.4%	98.5%
3-Ethynylaniline	0.01%	0.01%	Not Detected	Not Detected
Assay (on hydrous basis)	99.5%	98.9%	98.8%	98.7%

## Form I (Lot 3), 25°C/60% RH

	Initial	3 Month	6 Month	12 Month
Water	1.11%	1.65%	1.71%	1.75%
Chromatographic Purity	98.3%	98.1%	98.3%	98.4%
3-Ethynylaniline	0.01%	0.01%	Not Detected	Not Detected
Assay (on hydrous basis)	99.5%	98.7%	98.6%	98.5%

## 10 Form I (Lot 3), 40°C/75% RH

	Initial	3 Month	12 Month
Water	1.11%	1.68%	1.84%
Chromatographic Purity	98.3%	98.0%	98.3%
3-Ethynylaniline	0.01%	0.01%	0.01%
Assay (on hydrous basis)	99.5%	98.5%	98.3%

## Form I (Lot 4), 2-8°C

	Initial	3 Month	6 Month	12 Month
Water	0.92%	1.56%	1.47%	1.51%
Chromatographic Purity	98.2%	98.1%	98.3%	98.4%
3-Ethynylaniline	0.01%	0.01%	0.01%	Not Detected
Assay (on hydrous basis)	99.0%	98.4%	98.3%	98.2%

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Form I (Lot 4), 25°C/60% RH

	Initial	3 Month	6 Month	12 Month
Water	0.92%	1.59%	1.75%	1.78%
Chromatographic Purity	98.2%	98.1%	98.4%	98.4%
3-Ethynylaniline	0.01%	0.01%	Not Detected	Not Detected
Assay (on hydrous basis)	99.0%	98.3%	98.2%	98.1%

Form I (Lot 4), 40°C/75% RH

	Initial	3 Month	12 Month
Water	0.92%	1.65%	1.82%
Chromatographic Purity	98.2%	98.4%	98.3%
3-Ethynylaniline	0.01%	0.01%	0.01%
Assay (on hydrous basis)	99.0%	98.2%	98.1%

## WHAT IS CLAIMED IS:

1. The compound CEM-101 in crystalline form.
2. The form of claim 1 which is Form I of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $^{\circ}2\theta = 8.8, 10.5, 13.2$  and 18.6.
3. CEM-101, comprising Form I of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $^{\circ}2\theta = 8.8, 10.5, 13.2$  and 18.6.
4. Form I of CEM-101 as claimed in claim 2 or 3 that is substantially free of Form II.
5. The form of claim 4 as determined by the X-ray powder diffraction pattern, wherein one or more peaks at  $^{\circ}2\theta = 5.6, 9.8,$  and/or 11.7 are absent or nearly absent.
6. The form of claim 1 which is Form II of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $^{\circ}2\theta = 5.6, 7.9, 9.3, 11.7, 12.9$  and 16.7.
7. CEM-101, comprising Form II of CEM-101 having an X-ray powder diffraction pattern with peaks at approximate positions of about  $^{\circ}2\theta = 5.6, 7.9, 9.3, 11.7, 12.9$  and 16.7.
8. Form II of CEM-101 as claimed in claim 6 or 7 that is substantially free of Form I.
9. The form of claim 8 as determined by the X-ray powder diffraction pattern, wherein one or more peaks at about  $^{\circ}2\theta = 6.2$  and/or 8.8 are absent or nearly absent.
10. The form of claim 1 which is Form I of CEM-101 having an X-ray powder diffraction pattern substantially the same as that of FIG. 1.
11. The form of claim 1 which is Form I of CEM-101 having an X-ray powder diffraction pattern substantially the same as that of FIG. 2.
12. A pharmaceutical composition comprising CEM-101 in crystalline form as described in any of the preceding claims 1-11 and further comprising at least one pharmaceutically acceptable carrier or excipient.
13. A method of treatment of a bacterial infection, a protozoal infection, or a disorder related to a bacterial infection or protozoal infection comprising the step of administering to a subject in need thereof a therapeutically effective amount of CEM-101 in crystalline form as described in any of Claims 1-11, or a pharmaceutical composition thereof further comprising at least one pharmaceutically acceptable carrier or excipient.

14. Use of CEM-101 in crystalline form as described in any of claims 1-11 for the treatment of a bacterial infection, a protozoal infection, or a disorder related to a bacterial infection or protozoal infection.

15. Use of CEM-101 in crystalline form as described in any of claims 1-11 for the manufacture of a medicament for the treatment of a bacterial infection, a protozoal infection, or a disorder related to a bacterial infection or protozoal infection.

16. The method or use of any of claims 13-15 wherein the subject is a mammal, a fish, a bird or a reptile.

17. The method or use of claim 16 wherein the subject is a mammal.

18. The method or use of claim 17 wherein the subject is a human.

19. A process for the preparation of Form I of CEM-101, the process comprising the step of adding a solution of CEM-101 in a water miscible, polar organic solvent to water at a temperature below 50 °C.

20. The process of claim 19 wherein the Form I of CEM-101 is substantially free of other physical forms.

21. The process of claim 19 or 20 further comprising one or more of the following steps:

heating the solution of CEM-101;

filtering the solution of CEM-101;

reducing the volume of the solution of CEM-101 by evaporation; and

stirring the water during addition of the solution of CEM-101.

22. The process of claim 21 wherein the solvent is acetone, methanol or ethanol, or a combination thereof.

23. The process of claim 22 wherein the solvent is acetone.

24. The process of claim 22 wherein the solution is added to water at a temperature of about 10 °C to about 30 °C.

25. A process for the preparation of Form II of CEM-101, the process comprising the step of adding water to a solution of CEM-101 in a water miscible, polar organic solvent.

26. The process of claim 21 wherein the Form II of CEM-101 is substantially free of other physical forms.

27. The process of claim 25 or 26 further comprising one or more of the following steps:



filtering the solution of CEM-101;  
reducing the volume of the solution of CEM-101 by evaporation; and  
stirring the solution of CEM-101 during addition of the water.

28. The process of claim 27 wherein the solvent is acetone, acetonitrile,  
5 1,4-dioxane, methanol or ethanol, or a combination thereof.

29. The process of claim 28 wherein the solution of CEM-101 is above  
ambient temperature.

30. A process of purifying CEM-101 comprising converting one or more  
forms or mixtures of forms of the CEM-101 into Form I or Form II substantially free of other  
10 physical forms.

31. The process of claim 30 further comprising the step of adding a solution  
of the CEM-101 in a water miscible, polar organic solvent to water at a temperature below  
50 °C.

32. The process of claim 30 further comprising the step of adding water to a  
15 solution of the CEM-101 in a water miscible, polar organic solvent.

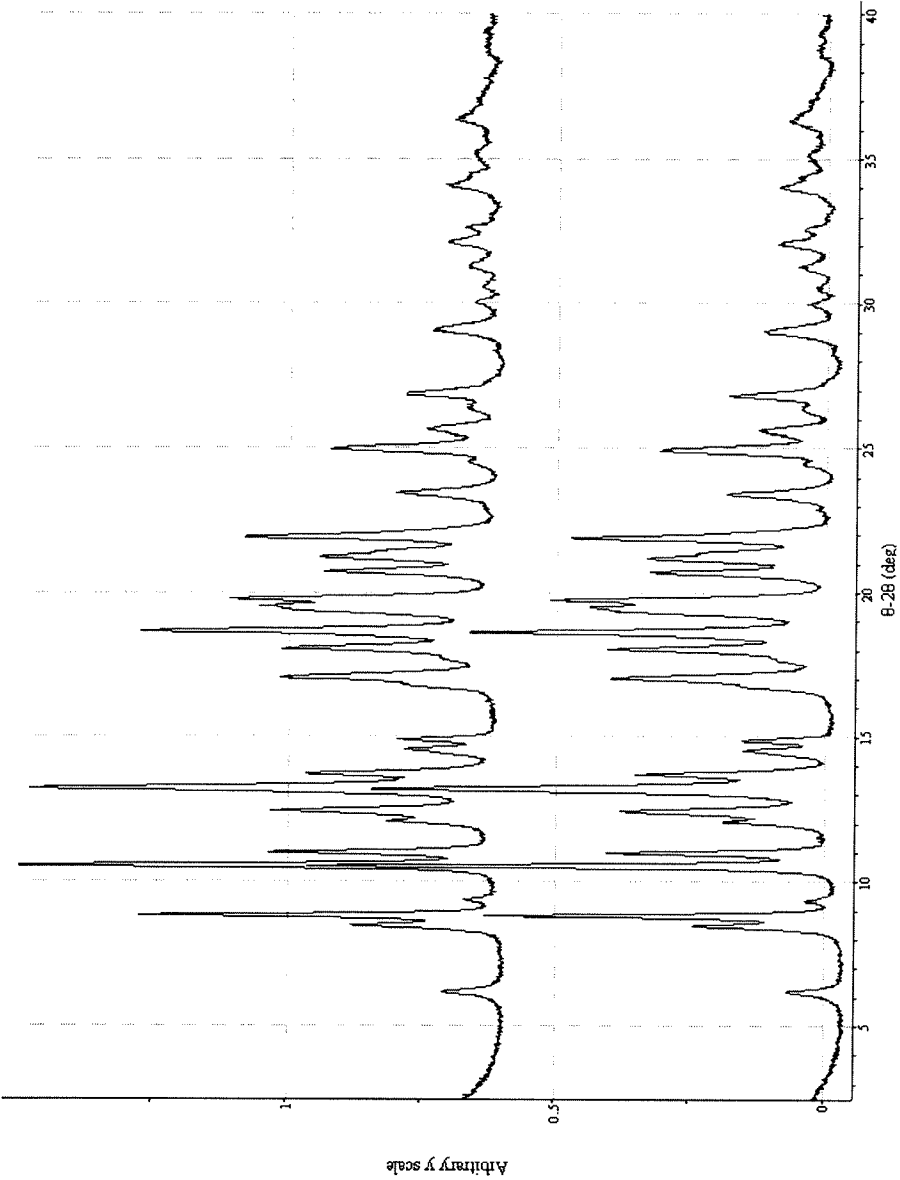


FIG. 1

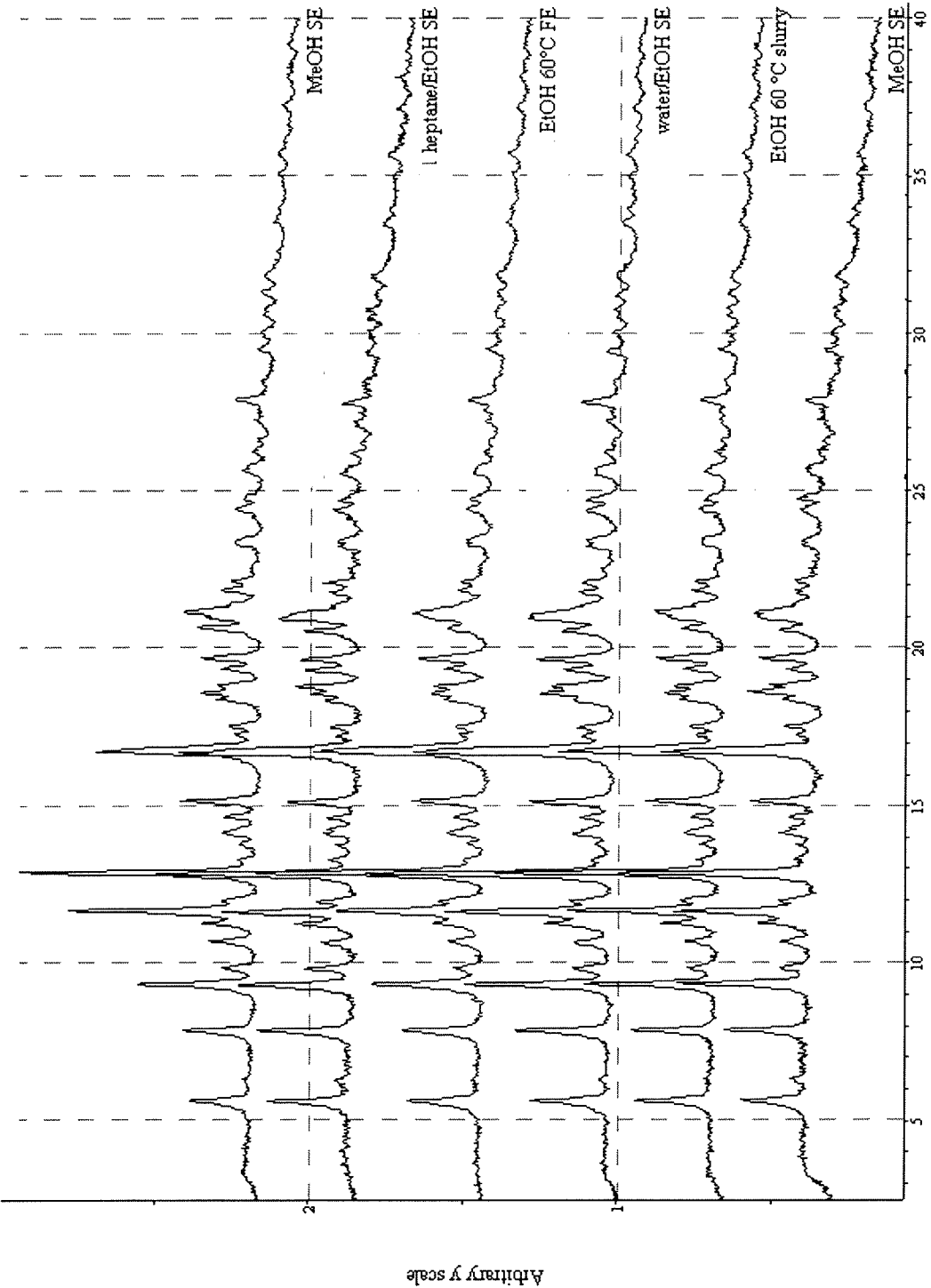


FIG. 2

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - C07H 17/08 (2011.01)

USPC - 536/7.4

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

USPC - 536/7.4

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
USPC - 514/28, 514/29, 514/338, 514/375; 536/7.4, 536/7.2, 536/124 (words only)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

\*\*\* Databases: WEST (PGPB, USPT, USOC, EPAB, JPAB); Google

\*\*\* Search Terms Used: Cempira, Pereira, CEM-101, OP-1068, solithromycin, ketolide, fluoroketolide, macrolide, crystal, crystallized, crystalline, x-ray, diffraction, form a, form b

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2006/0100164 A1 (Liang et al.) 11 May 2006 (11.05.2006), especially para [0421]-[0422]	1-11 and 19-32
Y	US 2007/0167382 A1 (Finkelstein et al.) 19 July 2007 (19.05.2007), especially Fig. 8, para [0003], [0014]-[0016], [0025], [0029], [0044], [0047]-[0048], [0058], [0060]-[0061], [0063], [0070], [0076], [0078]-[0079], [0082],	1-11 and 19-32
Y	Jones et al., "MIC Quality Control Guidelines and Disk Diffusion Test Optimization for CEM-101, a Novel Fluoroketolide," 30 December 2009 (30.12.2009). Journal of Clinical Microbiology, Vol. 48, No. 4, Pg. 1470?1473; especially pg 1470, col 1, para 1	1-11 and 19-32

☐ Further documents are listed in the continuation of Box C.

## \* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

07 May 2011 (07.05.2011)

Date of mailing of the international search report

25 MAY 2011

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents  
P.O. Box 1450, Alexandria, Virginia 22313-1450  
Facsimile No. 571-273-3201

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300  
PCT OSP: 571-272-7774

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 12-18  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.