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UNITED STATES DISTRICT COURT
DISTRICT OF NEW JERSEY

CELGENE CORPORATION, **Plaintiff,** **v.** **ACCORD HEALTHCARE, INC.,** **Defendant.**	**Civil Action No. _____** **COMPLAINT FOR PATENT INFRINGEMENT** **(Filed Electronically)**

Plaintiff Celgene Corporation ("Celgene"), by its undersigned attorneys, for its Complaint against Defendant Accord Healthcare, Inc. ("Accord"), alleges as follows:

Nature of the Action

1. This is an action for patent infringement under the patent laws of the United States, 35 U.S.C. § 100, *et seq*., arising from Accord's submission of Abbreviated New Drug Application ("ANDA") No. 218872 ("Accord's ANDA") to the United States Food and Drug Administration ("FDA") seeking approval to manufacture, use, import, distribute, offer to sell, and/or sell generic versions of Revlimid® (lenalidomide) drug products prior to the expiration of United States Patent Nos. 7,465,800 (the "'800 patent"), 7,855,217 (the "'217 patent"), and 8,741,929 (the "'929 patent") (collectively, "the patents-in-suit"), all owned by Celgene.

The Parties

2. Plaintiff Celgene is a biopharmaceutical company committed to improving the lives of patients worldwide. Celgene focuses on, and invests heavily in, the discovery and development of products for the treatment of severe and life-threatening conditions. Celgene is a world leader in the treatment of many such diseases, including cancer. Celgene is a corporation organized and existing under the laws of the State of Delaware, having a principal place of business at 86 Morris Avenue, Summit, New Jersey 07901.

3. On information and belief, Defendant Accord Healthcare, Inc. is a corporation organized and existing under the laws of the State of North Carolina, having a principal place of business at 1009 Slater Road, Suite 210-B, Durham, North Carolina 27703.

The Patents-in-Suit

4. On December 16, 2008, the United States Patent and Trademark Office ("USPTO") duly and lawfully issued the '800 patent, entitled, "Polymorphic Forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione." A copy of the '800 patent is attached hereto as Exhibit A.

5. On December 21, 2010, the USPTO duly and lawfully issued the '217 patent, entitled, "Polymorphic Forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione." A copy of the '217 patent is attached hereto as Exhibit B.

6. On June 3, 2014, the USPTO duly and lawfully issued the '929 patent, entitled, "Methods using 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione for the treatment of mantle cell lymphomas." A copy of the '929 patent is attached hereto as Exhibit C.

The Revlimid® Drug Product

7. The claims of the patents-in-suit cover, *inter alia*, solid forms of lenalidomide, pharmaceutical compositions containing solid forms of lenalidomide, and methods of using and administering of lenalidomide or pharmaceutical compositions comprising lenalidomide.

8. Pursuant to 21 U.S.C. § 355(b)(1) and attendant FDA regulations, the patents-in-suit are listed in the FDA publication, "Approved Drug Products with Therapeutic Equivalence Evaluations" (the "Orange Book"), with respect to Revlimid®.

9. The FDA-approved prescribing information for Revlimid® instructs and encourages physicians, pharmacists, other healthcare workers, and patients to administer Revlimid® for the treatment of, *inter alia*, adult patients with mantle cell lymphoma whose disease has relapsed or progressed after two prior therapies, one of which included bortezomib.

10. The FDA-approved prescribing information for Revlimid® instructs and encourages physicians, pharmacists, other healthcare workers, and patients to administer Revlimid® according to one or more of the methods claimed in the patents-in-suit.

Jurisdiction and Venue

11. This Court has jurisdiction over the subject matter of this action pursuant to 28 U.S.C. §§ 1331, 1338(a), 2201, and 2202.

12. This Court has personal jurisdiction over Accord because, *inter alia*, it: (1) has purposefully availed itself of the privilege of doing business in New Jersey and purposefully has conducted and continues to conduct business in this Judicial District; and (2) maintains extensive and systematic contacts with the State of New Jersey, including through the marketing, distribution, and/or sale of generic pharmaceutical drugs in New Jersey, either directly or through its affiliates and/or agents, including by selling pharmaceutical products in New Jersey.

13. On information and belief, Accord Healthcare Inc. is registered with the State of New Jersey's Department of Health as a drug manufacturer and wholesaler under Registration No. 5005082, doing business as "Accord Biopharma Inc."

14. On information and belief, Intas Pharmaceuticals Ltd. is registered with the State of New Jersey's Department of Health as a drug manufacturer under Registration No. 5003815, doing business as "Accord Healthcare Inc."

15. On information and belief, Accord is in the business of, among other things, manufacturing, marketing, importing, offering for sale, and selling pharmaceutical products, including generic drug products, throughout the United States, including in this Judicial District.

16. On information and belief, Accord intends to, *inter alia*, manufacture, use, import, distribute, offer to sell, and/or sell Accord's Proposed Products throughout the United States, including in this Judicial District.

17. On information and belief, this Judicial District is a likely destination for the generic drug products described in Accord's ANDA.

18. On information and belief, Accord derives substantial revenue from directly or indirectly selling generic pharmaceutical products throughout the United States, including in this Judicial District.

19. On information and belief, Accord submitted ANDA No. 218872 seeking FDA approval to engage in the manufacturing, use, importation, distribution, offer to sell, and/or sale of the 2.5 mg, 5 mg, 10 mg, 15 mg, 20 mg, and 25 mg lenalidomide capsules that are the subject of Accord's ANDA ("Accord's Proposed Products"), throughout the United States, including in New Jersey and in this Judicial District, prior to the expiration of the patents-in-suit.

20. On information and belief, Accord intends to benefit directly if its ANDA is approved by participating in the manufacture, importation, distribution, and/or sale of Accord's Proposed Products.

21. Accord has previously litigated patent infringement matters in this Judicial District and has affirmatively availed itself of the jurisdiction of this Court by filing counterclaims in this Judicial District. *See, e.g.*, *Janssen Pharmaceuticals, Inc., et al. v. Accord Healthcare Inc., et al.*, No. 22-856 (D.N.J.); *Eagle Pharmaceuticals, Inc., et al. v. Accord Healthcare Inc.*, No. 19-9031 (D.N.J.), *Sumitomo Dainippon Pharma Co., Ltd., et al. v. Aurobindo Pharma Ltd., et al.*, No. 18-2620 (D.N.J.); *Sanofi-Aventis US LLC v. Accord Healthcare, Inc.*, No. 14-8079 (D.N.J.).

22. Venue is proper in this Judicial District for Accord pursuant to 28 U.S.C. §§ 1391 and/or 1400(b).

Acts Giving Rise To This Suit

23. Pursuant to Section 505 of the Federal Food Drug and Cosmetic Act ("FFDCA"), Accord submitted its ANDA seeking approval to engage in the commercial manufacture, use, sale, offer for sale, or importation into the United States of Accord's Proposed Products before the patents-in-suit expire.

24. On information and belief, following FDA approval of Accord's ANDA, Accord will make, use, sell, or offer to sell Accord's Proposed Products throughout the United States, or import such generic products into the United States.

25. On information and belief, in connection with the submission of its ANDA as described above, Accord provided a written certification to the FDA pursuant to Section 505 of the FFDCA, 21 U.S.C. § 355(j)(2)(A)(vii)(IV) ("Accord's Paragraph IV Certification"), alleging

that the claims of the patents-in-suit are invalid and/or will not be infringed by the activities described in Accord's ANDA.

26. No earlier than September 22, 2023, Accord sent to Celgene a written notice of its Paragraph IV Certification ("Accord's Notice Letter"). Accord's Notice Letter alleged that the claims of the patents-in-suit are invalid and/or will not be infringed by the activities described in Accord's ANDA. Accord's Notice Letter also informed Celgene that Accord seeks approval to market Accord's Proposed Products before the patents-in-suit expire. Accord specifically directed Accord's Notice Letter to Celgene's headquarters in Summit, New Jersey, in this Judicial District.

Count I: Infringement of the '800 Patent

27. Celgene repeats and realleges the allegations of the preceding paragraphs as if fully set forth herein.

28. Accord's submission of its ANDA, with the accompanying Paragraph IV Certification and notice to Celgene of same, to engage in the commercial manufacture, use, sale, offer for sale, or importation into the United States of Accord's Proposed Products, prior to the expiration of the '800 patent, constitutes infringement of one or more of the claims of that patent under 35 U.S.C. § 271(e)(2)(A).

29. There is a justiciable controversy between the parties hereto as to the infringement of the '800 patent.

30. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will infringe one or more claims of the '800 patent under 35 U.S.C. § 271(a) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States.

31. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will induce infringement of one or more claims of the '800 patent under 35 U.S.C. § 271(b) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States. On information and belief, upon FDA approval of Accord's ANDA, Accord will intentionally encourage acts of direct infringement with knowledge of the '800 patent and knowledge that its acts are encouraging infringement.

32. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will contributorily infringe one or more claims of the '800 patent under 35 U.S.C. § 271(c) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States. On information and belief, Accord has had and continues to have knowledge that Accord's Proposed Products are especially adapted for a use that infringes one or more claims of the '800 patent and that there is no substantial non-infringing use for Accord's Proposed Products.

33. Celgene will be substantially and irreparably damaged and harmed if Accord's infringement of the '800 patent is not enjoined.

34. Celgene does not have an adequate remedy at law.

35. This case is an exceptional one, and Celgene is entitled to an award of its reasonable attorneys' fees under 35 U.S.C. § 285.

Count II: Infringement of the '217 Patent

36. Celgene repeats and realleges the allegations of the preceding paragraphs as if fully set forth herein.

37. Accord's submission of its ANDA, with the accompanying Paragraph IV Certification and notice to Celgene of same, to engage in the commercial manufacture, use, sale,

offer for sale, or importation into the United States of Accord's Proposed Products, prior to the expiration of the '217 patent, constitutes infringement of one or more of the claims of that patent under 35 U.S.C. § 271(e)(2)(A).

38. There is a justiciable controversy between the parties hereto as to the infringement of the '217 patent.

39. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will infringe one or more claims of the '217 patent under 35 U.S.C. § 271(a) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States.

40. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will induce infringement of one or more claims of the '217 patent under 35 U.S.C. § 271(b) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States. On information and belief, upon FDA approval of Accord's ANDA, Accord will intentionally encourage acts of direct infringement with knowledge of the '217 patent and knowledge that its acts are encouraging infringement.

41. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will contributorily infringe one or more claims of the '217 patent under 35 U.S.C. § 271(c) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States. On information and belief, Accord has had and continues to have knowledge that Accord's Proposed Products are especially adapted for a use that infringes one or more claims of the '217 patent and that there is no substantial non-infringing use for Accord's Proposed Products.

42. Celgene will be substantially and irreparably damaged and harmed if Accord's infringement of the '217 patent is not enjoined.

43. Celgene does not have an adequate remedy at law.

44. This case is an exceptional one, and Celgene is entitled to an award of its reasonable attorneys' fees under 35 U.S.C. § 285.

Count III: Infringement of the '929 Patent

45. Celgene repeats and realleges the allegations of the preceding paragraphs as if fully set forth herein.

46. Accord's submission of its ANDA, with the accompanying Paragraph IV Certification and notice to Celgene of same, to engage in the commercial manufacture, use, sale, offer for sale, or importation into the United States of Accord's Proposed Products, prior to the expiration of the '929 patent, constitutes infringement of one or more of the claims of that patent under 35 U.S.C. § 271(e)(2)(A).

47. There is a justiciable controversy between the parties hereto as to the infringement of the '929 patent.

48. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will infringe one or more claims of the '929 patent under 35 U.S.C. § 271(a) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States.

49. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will induce infringement of one or more claims of the '929 patent under 35 U.S.C. § 271(b) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States. On information and belief, upon FDA approval of Accord's ANDA, Accord will intentionally encourage acts of direct infringement with knowledge of the '929 patent and knowledge that its acts are encouraging infringement.

50. Unless enjoined by this Court, upon FDA approval of Accord's ANDA, Accord will contributorily infringe one or more claims of the '929 patent under 35 U.S.C. § 271(c) by making, using, offering to sell, selling, and/or importing Accord's Proposed Products in the United States. On information and belief, Accord has had and continues to have knowledge that Accord's Proposed Products are especially adapted for a use that infringes one or more claims of the '929 patent and that there is no substantial non-infringing use for Accord's Proposed Products.

51. Celgene will be substantially and irreparably damaged and harmed if Accord's infringement of the '929 patent is not enjoined.

52. Celgene does not have an adequate remedy at law.

53. This case is an exceptional one, and Celgene is entitled to an award of its reasonable attorneys' fees under 35 U.S.C. § 285.

PRAYER FOR RELIEF

WHEREFORE, Plaintiff Celgene respectfully requests the following relief:

(A) A Judgment that Accord has infringed the patents-in-suit by submitting ANDA No. 218872 with the accompanying Paragraph IV Certification and notice to Celgene of same;

(B) A Judgment that Accord has infringed, and that Accord's making, using, selling, offering to sell, or importing Accord's Proposed Products will infringe one or more claims of the patents-in-suit;

(C) An Order that the effective date of FDA approval of ANDA No. 218872 be a date which is not earlier than the later of the expiration of the patents-in-suit, or any later expiration of exclusivity to which Celgene is or becomes entitled;

(D) Preliminary and permanent injunctions enjoining Accord and its officers, agents, attorneys and employees, and those acting in privity and/or concert with them, from making, using, offering to sell, selling, or importing Accord's Proposed Products until after the expiration of the patents-in-suit, or any later expiration of exclusivity to which Celgene is or becomes entitled;

(E) A permanent injunction, pursuant to 35 U.S.C. § 271(e)(4)(B), restraining and enjoining Accord, its officers, agents, attorneys and employees, and those acting in privity and/or concert with them, from practicing the subject matter claimed in the patents-in-suit, or from actively inducing or contributing to the infringement of any claim of the patents-in-suit, until after the expiration of the patents-in-suit, or any later expiration of exclusivity to which Celgene is or becomes entitled;

(F) A Judgment that the commercial manufacture, use, offer for sale, sale, and/or importation into the United States of Accord's Proposed Products will directly infringe, induce infringement of, and/or contribute to infringement of the patents-in-suit;

(G) To the extent that Accord, its officers, agents, attorneys and/or employees, or those acting in privity and/or concert with them, has committed any acts with respect to the subject matter claimed in the patents-in-suit, other than those acts expressly exempted by 35 U.S.C. § 271(e)(1), a Judgment awarding Celgene damages for such acts;

(H) If Accord, its officers, agents, attorneys, and/or employees, or those acting in privity and/or concert with them, engages in the commercial manufacture, use, offer for sale, sale, and/or importation into the United States of Accord's Proposed Products prior to the expiration of the patents-in-suit, a Judgment awarding damages to Celgene resulting from such infringement, together with interest;

(I) A Judgment declaring that the patents-in-suit remain valid and enforceable;

(J) A Judgment that this is an exceptional case pursuant to 35 U.S.C. § 285 and awarding Celgene its attorneys' fees incurred in this action;

(K) A Judgment awarding Celgene its costs and expenses incurred in this action; and

(L) Such further and other relief as this Court may deem just and proper.

Dated: October 16, 2023

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CERTIFICATION PURSUANT TO L. CIV. R. 11.2 & 40.1

Pursuant to Local Civil Rules 11.2 and 40.1, I hereby certify that the matter captioned *Celgene Corporation v. Deva Holding A.S.*, 23-2992 (SDW)(LDW) (D.N.J.) is related to the matter in controversy because the matter in controversy involves the same plaintiff and some of the same patents, and because Accord is seeking FDA approval to market generic versions of the same pharmaceutical product.

I further certify that more than twenty-five related matters have been before the Honorable Susan D. Wigenton and the Honorable Leda D. Wettre, which are related to the matter in controversy because they involved the same plaintiff and some of the same patents, and/or because Accord is seeking FDA approval to market generic versions of the same pharmaceutical product. *See Celgene Corporation v. Qilu Pharmaceutical Co. Ltd.*, Civil Action No. 22-3753 (SDW)(LDW) (D.N.J.) (complaint filed on June 13, 2022, civil case terminated on October 14, 2022); *Celgene Corporation v. Oncogen Pharma (Malaysia) Sdn Bhd*, Civil Action No. 22-2952, (SDW)(LDW) (D.N.J.) (complaint filed on May 20, 2022, civil case terminated on May 25, 2022); *Celgene Corporation v. Hikma Pharmaceuticals USA Inc.*, 21-20459 (SDW)(LDW) (D.N.J.) (complaint filed on December 10, 2021, civil case terminated on January 13, 2022); *Celgene Corporation v. Alembic Pharmaceuticals Ltd*, Civil Action No. 21-20099 (SDW)(LDW) (D.N.J.) (complaint filed on November 18, 2021, civil case terminated on July 5, 2022); *Celgene Corporation v. Torrent Pharmaceuticals Ltd*, Civil Action No. 21-12927 (SDW)(LDW) (D.N.J) (complaint filed on June 23, 2021, civil case terminated on August 12, 2021); *Celgene Corporation v. Biocon Pharma Limited*, Civil Action No. 21-11261 (SDW)(LDW) (D.N.J.) (complaint filed on May 14, 2021, civil case terminated on September 8, 2021); *Celgene Corporation v. Hikma Pharmaceuticals USA, Inc.*, Civil Action No. 21-10398

(SDW)(LDW) (D.N.J.) (complaint filed on April 28, 2021, civil case terminated on January 13, 2022); *Celgene Corporation v. Aurobindo Pharma Ltd.*, Civil Action No. 21-624 (SDW)(LDW) (D.N.J.) (complaint filed on January 12, 2021, civil case terminated on July 19, 2021); *Celgene Corporation v. Hetero Labs Limited*, Civil Action No. 20-14389 (SDW)(LDW) (D.N.J.) (complaint filed on October 13, 2020, civil case terminated on September 27, 2021); *Celgene Corporation v. Lupin Ltd.*, Civil Action No. 20-8570 (SDW)(LDW) (D.N.J.) (complaint filed on July 9, 2020, civil case terminated on December 14, 2021); *Celgene Corporation v. Cipla Limited*, Civil Action No. 20-7759 (SDW)(LDW) (D.N.J.) (complaint filed on June 24, 2020, civil case terminated on December 14, 2020); *Celgene Corporation v. Aurobindo Pharma Ltd.*, Civil Action No. 20-315 (SDW)(LDW) (D.N.J.) (complaint filed on January 8, 2020, civil case terminated on July 19, 2021); *Celgene Corporation v. Mylan Pharmaceuticals Inc.*, Civil Action No. 19-22231 (SDW)(LDW) (D.N.J.) (complaint filed on December 31, 2019, civil case terminated on July 22, 2021); *Celgene Corporation v. Cipla Limited*, Civil Action No. 19-14731 (SDW)(LDW) (D.N.J.) (complaint filed on July 3, 2019, civil case terminated on December 14, 2020); *Celgene Corporation v. Apotex Inc.*, Civil Action No. 19-13994 (SDW)(LDW) (D.N.J.) (complaint filed on June 19, 2019, civil case terminated on March 10, 2021); *Celgene Corporation v. Sun Pharmaceutical Industries, Inc.*, Civil Action No. 19-10099 (SDW)(LDW) (D.N.J.) (complaint filed on April 16, 2019, civil case terminated on June 22, 2021); *Celgene Corporation v. Hetero Labs Limited*, Civil Action No. 18-17463 (SDW)(LDW) (D.N.J.) (complaint filed on December 20, 2018, civil case terminated on January 11, 2021); *Celgene Corporation v. Sun Pharmaceutical Industries, Inc.*, Civil Action No. 18-11630 (SDW)(LDW) (D.N.J.) (complaint filed on July 13, 2018, civil case terminated on June 22, 2021); *Celgene Corporation v. Lotus Pharmaceutical Co., Ltd.*, Civil Action No. 18-11518 (SDW)(LDW)

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I further certify that, to the best of my knowledge, the matter in controversy is not the subject of any other action pending in any court, or of any pending arbitration or administrative proceeding.

Dated: October 16, 2023

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EXHIBIT A

US007465800B2

(12) **United States Patent**
Jaworsky et al.

(10) **Patent No.: US 7,465,800 B2**
(45) **Date of Patent: Dec. 16, 2008**

(54) **POLYMORPHIC FORMS OF 3-(4-AMINO-1-OXO-1,3 DIHYDRO-ISOINDOL-2-YL)-PIPERIDINE-2,6-DIONE**

(75) Inventors: **Markian S. Jaworsky**, Hopewell, NJ (US); **Roger Shen-Chu Chen**, Edison, NJ (US); **George W. Muller**, Bridgewater, NJ (US)

(73) Assignee: **Celgene Corporation**, Summit, NJ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 596 days.

(21) Appl. No.: **10/934,863**

(22) Filed: **Sep. 3, 2004**

(65) **Prior Publication Data**

US 2005/0096351 A1 May 5, 2005

Related U.S. Application Data

(60) Provisional application No. 60/499,723, filed on Sep. 4, 2003.

(51) **Int. Cl.**
C07D 401/04 (2006.01)

(52) **U.S. Cl.** **546/200**; 514/323

(58) **Field of Classification Search** 546/200; 514/323

See application file for complete search history.

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Primary Examiner—Celia Chang
(74) *Attorney, Agent, or Firm*—Jones Day

(57) **ABSTRACT**

Polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione are disclosed. Compositions comprising the polymorphic forms, methods of making the polymorphic forms and methods of their use are also disclosed.

14 Claims, 48 Drawing Sheets

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Fig. 1

IR SPECTRUM OF FORM A

Fig. 2

RAMAN SPECTRUM OF FORM A
Raman Intensity
8
7
6
5
4
3
2
1
3000
2000
1000
Raman shift (cm-1)

Fig. 3

(TOP) AND DSC (BOTTOM) OF FORM A
TGA
0.3864%
(0.01380mg)
Weight (%)
Deriv.Weight (%/°C)
Temperature (°C)
DSC
270.28°C
Heat Flow (W/g)
Temperature (°C)

Fig. 4

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Fig. 5

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Fig. 6

IR SPECTRUM OF FORM B

Fig. 7

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RAMAN SPECTRUM OF FORM B

Fig. 8

TGA (TOP) AND DSC (BOTTOM) OF FORM B
TGA
Weight (%)
Deriv.Weight (%/°C)
3.100%
(0.2519mg)
Temperature (°C)
DSC
Heat Flow (W/g)
146.16°C
268.32°C
Temperature (°C)

Fig. 9

TG-IR RESULTS FOR FORM B

Fig. 10

MOISTURE SORPTION/DESORPTION ISOTHERM FOR FORM B
Weight (% change)
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
80
90
100
%RH
Adsorption
Desorption

Fig. 11

XRPD PATTERN OF FORM C
6000
4000
2000
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 12

IR SPECTRUM OF FORM C

Fig. 13

RAMAN SPECTRUM OF FORM C

Fig. 14

TGA (TOP) AND DSC (BOTTOM) OF FORM C
TGA
105
100
95
90
85
Weight (%)
0.6
0.4
0.2
0.0
-0.2
Deriv.Weight (%/°C)
10.02%
(0.4908mg)
0
50
100
150
200
250
300
350
Temperature (°C)
DSC
2
0
-2
-4
-6
Heat Flow (W/g)
150.26°C
269.39°C
0
50
100
150
200
250
300
350
Temperature (°C)

Fig. 15

TG-IR RESULTS FOR FORM C

Fig. 16

MOISTURE SORPTION/DESORPTION ISOTHERM FOR FORM C
1.000
0.000
-1.000
-2.000
-3.000
-4.000
-5.000
-6.000
-7.000
-8.000
Weight (% change)
0
10
20
30
40
50
60
70
80
90
100
%RH
Adsorption
Desorption

Fig. 17

XRPD PATTERN OF FORM D
4000
3000
2000
1000
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 18

IR SPECTRUM OF FORM D

Fig. 19

RAMAN SPECTRUM OF FORM D

Fig. 20

TGA (TOP) AND DSC (BOTTOM) OF FORM D

Fig. 21

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Fig. 22

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Fig. 23

TGA (TOP) AND DSC (BOTTOM) OF FORM E
TGA
Weight (%)
Deriv.Weight (%/°C)
10.58%
(0.8443mg)
11.96%
(0.9553mg)
Temperature (°C)
DSC
Heat Flow (W/g)
168.79°C
161.47°C
98.99°C
268.84°C
Temperature (°C)

Fig. 24

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Fig. 25

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Fig. 26

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Fig. 27

XRPD PATTERN OF FORM G
400
300
200
100
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 28

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Fig. 29

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Fig. 30

TGA (TOP) AND DSC (BOTTOM) OF FORM H
TGA
1.657%
(0.1532mg)
Weight (%)
Deriv.Weight (%/°C)
Temperature (°C)
DSC
87.41°C
268.67°C
Heat Flow (W/g)
Temperature (°C)

Fig. 31

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Fig. 32

Fig. 33

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Fig. 34

Fig. 35

XRPD PATTERN OF POLYMORPH MIXTURE

Fig. 36

TGA CURVE OF POLYMORPH B
Sample: 5274-104-B
Size: 7.8320 mg
Method: Ramp
TGA
Run Date: 509-Jun-04 17:04
Instrument: TGA 0.500 V5.3 Build 171
3.712%
(0.2907 mg)
Weight (%)
101
100
99
98
97
96
95
0
50
100
150
200
250
300
Temperature (°C)

Fig. 37

TGA CURVE OF POLYMORPH B
Sample: 5274-100-C
Size: 10.9430 mg
Method: Ramp
Comment: Evotec Batch 1675C H2O
TGA
Run Date: 509-Jun-04 11:20
Instrument: TGA 0.500 V5.3 Build 171
3.952%
(0.4324 mg)
Weight (%)
100
99
98
97
96
95
0
50
100
150
200
250
300
Temperature (°C)

Fig. 38

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Fig. 39

Fig. 40

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Fig. 41

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Fig. 42

Fig. 43

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Fig. 44

Fig. 45

DSC OF POLYMORPH MIXTURE
Sample: 5222-161-A
Size: 0.0000 mg
Method: Cell constant calibration
Comment: OAI batch 15
DSC
Run Date: 11-jUN-04 12:44
Instrument: DSC Q 1000 V7.3 Build 249
91.17°C
(30.91 mJ)
151.30°C
(189.7 mJ)
267.93°C
(424.9 mJ)
107.01°C
153.91°C
269.86°C
Heat Flow (mW)
2
0
-2
-4
-6
-8
0
50
100
150
200
250
300
Temperature (°C)

Fig. 46

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Fig. 47

UV-VIS SCAN OF 0.04MG/ML SOLUTION
0.04mg/mL in Dissolution Medium
Absorbance
3.0000
2.5000
2.0000
1.5000
1.0000
0.5000
0.0000
200.0
225.0
250.0
275.0
300.0
Wavelength (nm)

Fig. 48

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Fig. 49

CALIBRATION CURVE FOR
3-(4-AMINO-1-OXO-1,3 DIHYDROISOINDOL-2-YL)-PIPERIDINE-2,6-DIONE

Fig. 50

SOLUBILITY OF FORM A
Concentration (mg/mL)
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
0
15
30
45
60
75
90
105
120
135
150
Time (min)

Fig. 51

SOLUBILITY OF FORM B
Concentration (mg/mL)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0
60
120
180
240
300
360
420
480
540
600
660
Time (min)

Fig. 52

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FIG.53

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FIG.54

POLYMORPHIC FORMS OF 3-(4-AMINO-1-OXO-1,3 DIHYDRO-ISOINDOL-2-YL)-PIPERIDINE-2,6-IONE

This application claims the benefit of U.S. provisional application 60/499,723, filed Sep. 4, 2003, the contents of which are incorporated by reference herein their entirety.

1. FIELD OF THE INVENTION

This invention relates to polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione, compositions comprising the polymorphic forms, methods of making the polymorphic forms and methods of their use for the treatment of diseases and conditions including, but not limited to, inflammatory diseases, autoimmune diseases, and cancer.

2. BACKGROUND OF THE INVENTION

Many compounds can exist in different crystal forms, or polymorphs, which exhibit different physical, chemical, and spectroscopic properties. For example, certain polymorphs of a compound may be more readily soluble in particular solvents, may flow more readily, or may compress more easily than others. See, e.g., P. DiMartino, et al., *J. Thermal Anal.,* 48:447-458 (1997). In the case of drugs, certain solid forms may be more bioavailable than others, while others may be more stable under certain manufacturing, storage, and biological conditions. This is particularly important from a regulatory standpoint, since drugs are approved by agencies such as the U.S. Food and Drug Administration only if they meet exacting purity and characterization standards. Indeed, the regulatory approval of one polymorph of a compound, which exhibits certain solubility and physico-chemical (including spectroscopic) properties, typically does not imply the ready approval of other polymorphs of that same compound.

Polymorphic forms of a compound are known in the pharmaceutical arts to affect, for example, the solubility, stability, flowability, fractability, and compressibility of the compound, as well as the safety and efficacy of drug products comprising it. See, e.g., Knapman, K. *Modern Drug Discoveries,* 2000, 53. Therefore, the discovery of new polymorphs of a drug can provide a variety of advantages.

U.S. Pat. Nos. 5,635,517 and 6,281,230, both to Muller et al., disclose 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione, which is useful in treating and preventing a wide range of diseases and conditions including, but not limited to, inflammatory diseases, autoimmune diseases, and cancer. New polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione can further the development of formulations for the treatment of these chronic illnesses, and may yield numerous formulation, manufacturing and therapeutic benefits.

3. SUMMARY OF THE INVENTION

This invention encompasses polymorphs of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. In certain aspects, the invention provides polymorphs of the compound identified herein as forms A, B, C, D, E, F, G, and H. The invention also encompasses mixtures of these forms. In further embodiments, this invention provides methods of making, isolating and characterizing the polymorphs.

This invention also provides pharmaceutical compositions and single unit dosage forms comprising a polymorph of

3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. The invention further provides methods for the treatment or prevention of a variety of diseases and disorders, which comprise administering to a patient in need of such treatment or prevention a therapeutically effective amount of a polymorph of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

4. BRIEF DESCRIPTION OF THE DRAWINGS

Specific aspects of the invention can be understood with reference to the attached figures:

FIG. **1** provides a representative X-ray powder diffraction (XRPD) pattern of Form A;

FIG. **2** provides a representative IR spectrum of Form A;

FIG. **3** provides a representative Raman spectrum of Form A;

FIG. **4** provides a representative thermogravimetric analysis (TGA) curve and a representative differential scanning calorimeter (DSC) thermogram of Form A;

FIG. **5** provides a representative moisture sorption/desorption isotherm of Form A;

FIG. **6** provides a representative XRPD pattern of Form B;

FIG. **7** provides a representative IR spectrum of Form B;

FIG. **8** provides a representative Raman spectrum of Form B;

FIG. **9** provides a representative TGA curve and a representative DSC thermogram of Form B;

FIG. **10** provides representative TG-IR results of Form B;

FIG. **11** provides a representative moisture sorption/desorption isotherm of Form B;

FIG. **12** provides a representative XRPD pattern of Form C;

FIG. **13** provides a representative IR spectrum of Form C;

FIG. **14** provides a representative Raman spectrum of Form C;

FIG. **15** provides a representative TGA curve and a representative DSC thermogram of Form C;

FIG. **16** provides representative TG-IR results of Form C;

FIG. **17** provides a representative moisture sorption/desorption isotherm of Form C;

FIG. **18** provides a representative XRPD pattern of Form D;

FIG. **19** provides a representative IR spectrum of Form D;

FIG. **20** provides a representative Raman spectrum of Form D;

FIG. **21** provides a representative TGA curve and a representative DSC thermogram of Form D;

FIG. **22** provides a representative moisture sorption/desorption isotherm of Form D;

FIG. **23** provides a representative XRPD pattern of Form E;

FIG. **24** provides a representative TGA curve and a representative DSC thermogram of Form E;

FIG. **25** provides a representative moisture sorption/desorption isotherm of Form E;

FIG. **26** provides a representative XRPD pattern for a sample of Form F;

FIG. **27** provides a representative thermogram of Form F;

FIG. **28** provides a representative XRPD pattern of Form G;

FIG. **29** provides a representative DSC thermogram for a sample of Form G;

FIG. **30** provides a representative XRPD pattern of Form H;

FIG. **31** provides a representative TGA curve and a representative DSC thermogram of Form H;

FIG. **32** provides a representative XRPD pattern of Form B;

FIG. **33** provides a representative XRPD pattern of Form B;

FIG. **34** provides a representative XRPD pattern of Form B;

FIG. **35** provides a representative XRPD pattern of Form E;

FIG. **36** provides a representative XRPD pattern of polymorph mixture;

FIG. **37** provides a representative TGA curve of Form B;

FIG. **38** provides a representative TGA curve of Form B;

FIG. **39** provides a representative TGA curve of Form B;

FIG. **40** provides a representative TGA curve of Form E;

FIG. **41** provides a representative TGA curve of polymorph mixture;

FIG. **42** provides a representative DSC thermogram of Form B;

FIG. **43** provides a representative DSC thermogram of Form B;

FIG. **44** provides a representative DSC thermogram of Form B;

FIG. **45** provides a representative DSC thermogram of Form E;

FIG. **46** provides a representative DSC thermogram of polymorph mixture;

FIG. **47** provides a UV-Vis scan of dissolution medium;

FIG. **48** provides a UV-Vis scan of 0.04 mg/ml of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in dissolution medium;

FIG. **49** provides a UV-Vis scan of 0.008 mg/ml of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in dissolution medium;

FIG. **50** provides a calibration curve for 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione;

FIG. **51** provides a solubility curve of Form A;

FIG. **52** provides a solubility curve of Form B;

FIG. **53** provides an intrinsic dissolution of Forms A, B and E; and

FIG. **54** provides an intrinsic dissolution of Forms A, B and E.

5. DETAILED DESCRIPTION OF THE INVENTION

5.1 Definitions

As used herein and unless otherwise indicated, the terms "treat," "treating" and "treatment" refer to the alleviation of a disease or disorder and/or at least one of its attendant symptoms.

As used herein and unless otherwise indicated, the terms "prevent," "preventing" and "prevention" refer to the inhibition of a symptom of a disease or disorder or the disease itself.

As used herein and unless otherwise indicated, the terms "polymorph" and "polymorphic form" refer to solid crystalline forms of a compound or complex. Different polymorphs of the same compound can exhibit different physical, chemical and/or spectroscopic properties. Different physical properties include, but are not limited to stability (e.g., to heat or light), compressibility and density (important in formulation and product manufacturing), and dissolution rates (which can affect bioavailability). Differences in stability can result from changes in chemical reactivity (e.g., differential oxidation, such that a dosage form discolors more rapidly when comprised of one polymorph than when comprised of another polymorph) or mechanical characteristics (e.g., tablets crumble on storage as a kinetically favored polymorph converts to thermodynamically more stable polymorph) or both (e.g., tablets of one polymorph are more susceptible to breakdown at high humidity). Different physical properties of polymorphs can affect their processing. For example, one polymorph might be more likely to form solvates or might be more difficult to filter or wash free of impurities than another due to, for example, the shape or size distribution of particles of it.

Polymorphs of a molecule can be obtained by a number of methods known in the art. Such methods include, but are not limited to, melt recrystallization, melt cooling, solvent recrystallization, desolvation, rapid evaporation, rapid cooling, slow cooling, vapor diffusion and sublimation. Polymorphs can be detected, identified, classified and characterized using well-known techniques such as, but not limited to, differential scanning calorimetry (DSC), thermogravimetry (TGA), X-ray powder diffractometry (XRPD), single crystal X-ray diffractometry, vibrational spectroscopy, solution calorimetry, solid state nuclear magnetic resonance (NMR), infrared (IR) spectroscopy, Raman spectroscopy, hot stage optical microscopy, scanning electron microscopy (SEM), electron crystallography and quantitative analysis, particle size analysis (PSA), surface area analysis, solubility, and rate of dissolution.

As used herein to refer to the spectra or data presented in graphical form (e.g., XRPD, IR, Raman and NMR spectra), and unless otherwise indicated, the term "peak" refers to a peak or other special feature that one skilled in the art would recognize as not attributable to background noise. The term "significant peaks" refers to peaks at least the median size (e.g., height) of other peaks in the spectrum or data, or at least 1.5, 2, or 2.5 times the median size of other peaks in the spectrum or data.

As used herein and unless otherwise indicated, the term "substantially pure" when used to describe a polymorph of a compound means a solid form of the compound that comprises that polymorph and is substantially free of other polymorphs of the compound. A representative substantially pure polymorph comprises greater than about 80% by weight of one polymorphic form of the compound and less than about 20% by weight of other polymorphic forms of the compound, more preferably greater than about 90% by weight of one polymorphic form of the compound and less than about 10% by weight of the other polymorphic forms of the compound, even more preferably greater than about 95% by weight of one polymorphic form of the compound and less than about 5% by weight of the other polymorphic forms of the compound, and most preferably greater than about 97% by weight of one polymorphic forms of the compound and less than about 3% by weight of the other polymorphic forms of the compound.

5.2 Polymorphic Forms

This invention is directed to polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione, which has the structure shown below:

This compound can be prepared according to the methods described in U.S. Pat. Nos. 6,281,230 and 5,635,517, the

entireties of which are incorporated herein by reference. For example, the compound can be prepared through catalytic hydrogenation of 3-(4-nitro-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. 3-(4-Nitro-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione can be obtained by allowing 2,6-dioxopiperidin-3-ammonium chloride to react with methyl 2-bromomethyl-4-nitrobenzoate in dimethylformamide in the presence of triethylamine. The methyl 2-bromomethyl-4-nitrobenzoate in turn is obtained from the corresponding methyl ester of nitro-ortho-toluic acid by conventional bromination with N-bromosuccinimide under the influence of light.

Polymorphs of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione can be obtained by techniques known in the art, including solvent recrystallization, desolvation, vapor diffusion, rapid evaporation, slow evaporation, rapid cooling and slow cooling. Polymorphs can be made by dissolving a weighed quantity of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in various solvents at elevated temperatures. The solutions of the compound can then be filtered and allowed to evaporate either in an open vial (for fast hot evaporation) or in a vial covered with aluminum foil containing pinholes (hot slow evaporation). Polymorphs can also be obtained from slurries. Polymorphs can be crystallized from solutions or slurries using several methods. For example, a solution created at an elevated temperature (e.g., 60° C.) can be filtered quickly then allowed to cool to room temperature. Once at room temperature, the sample that did not crystallize can be moved to a refrigerator then filtered. Alternatively, the solutions can be crash cooled by dissolving the solid in a solvent at an increased temperature (e.g., 45-65° C.) followed by cooling in a dry ice/solvent bath.

One embodiment of the invention encompasses Form A of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form A is an unsolvated, crystalline material that can be obtained from non-aqueous solvent systems. Another embodiment of the invention encompasses Form B of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form B is a hemihydrated, crystalline material that can be obtained from various solvent systems. Another embodiment of the invention encompasses Form C of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form C is a hemisolvated crystalline material that can be obtained from solvents such as, but not limited to, acetone. Another embodiment of the invention encompasses Form D of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form D is a crystalline, solvated polymorph prepared from a mixture of acetonitrile and water. Another embodiment of the invention encompasses Form E of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form E is a dihydrated, crystalline material. Another embodiment of the invention encompasses Form F of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form F is an unsolvated, crystalline material that can be obtained from the dehydration of Form E. Another embodiment of the invention encompasses Form G of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form G is an unsolvated, crystalline material that can be obtained from slurrying forms B and E in a solvent such as, but not limited to, tetrahydrofuran (THF). Another embodiment of the invention encompasses Form H of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form H is a partially hydrated crystalline material that can be obtained by exposing Form E to 0% relative humidity. Each of these forms is discussed in detail below.

Another embodiment of the invention encompasses a composition comprising amorphous 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione and crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione of form A, B, C, D, E, F, G or H. Specific compositions can comprise greater than about 50, 75, 90 or 95 weight percent crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

Another embodiment of the invention encompasses a composition comprising at least two crystalline forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione (e.g., a mixture of polymorph forms B and E).

5.2.1 Form A

The data described herein for Form A, as well as for Forms B-H, were obtained using the experimental methods described in Examples 6.3-6.7, provided below.

Form A can be obtained from various solvents, including, but not limited to 1-butanol, butyl acetate, ethanol, ethyl acetate, methanol, methyl ethyl ketone, and THF. FIG. **1** shows a representative XRPD pattern of Form A. The pattern is characterized by peaks, preferably significant peaks, at approximately 8, 14.5, 16, 17.5, 20.5, 24, and 26 degrees 2θ. Representative IR and Raman spectra data are provided in FIGS. **2** and **3**.

Representative thermal characteristics of Form A are shown in FIG. **4**. TGA data show a small weight increase up to about 150° C., indicating an unsolvated material. Weight loss above 150° C. is attributed to decomposition. The DSC curve of Form A exhibits an endotherm at about 270° C.

Representative moisture sorption and desorption data are plotted in FIG. **5**. Form A does not exhibit a significant weight gain from 5 to 95% relative humidity. Equilibrium can be obtained at each relative humidity step. As the form dries from 95% back down to 5% relative humidity, it tends to maintain its weight such that at 5% relative humidity it has typically lost only about 0.003% by weight from start to finish. Form A is capable of remaining a crystalline solid for about 11 days when stored at about 22, 45, 58, and 84% relative humidity.

Interconversion studies show that Form A can convert to Form B in aqueous solvent systems and can convert to Form C in acetone solvent systems. Form A tends to be stable in anhydrous solvent systems. In water systems and in the presence of Form E, Form A tends to convert to Form E.

When stored for a period of about 85 days under two different temperature/relative humidity stress conditions (room temperature/0% relative humidity (RH) and 40° C./93% RH), Form A typically does not convert to a different form.

In sum, Form A is a crystalline, unsolvated solid that melts at approximately 270° C. Form A is weakly or not hygroscopic and appears to be the most thermodynamically stable anhydrous polymorph of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione discovered thus far.

5.2.2 Form B

Form B can be obtained from many solvents, including, but not limited to, hexane, toluene, and water. FIG. **6** shows a representative XRPD pattern of Form B, characterized by peaks at approximately 16, 18, 22 and 27 degrees 2θ.

Solution proton NMR confirm that Form B is a form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Representative IR and Raman spectra are shown in FIGS. **7** and **8**, respectively. Compared to Form A, the IR spectrum for Form B has peaks at approximately 3513 and 1960 cm^{-1}.

Representative DSC and TGA data for Form B are shown in FIG. **9**. The DSC curve exhibits endotherms at about 146 and 268° C. These events are identified as dehydration and melting by hot stage microscopy experiments. Form B typi-

cally loses about 3.1% volatiles up to about 175° C. (per approximately 0.46 moles of water). Comparison of the IR spectrum of the volatiles with that of water indicates that they are water (See FIG. **10**). Calculations from TGA data indicate that Form B is a hemihydrate. Karl Fischer water analysis also supports this conclusion.

Representative moisture sorption and desorption data are shown in FIG. **11**. Form B typically does not exhibit a significant weight gain from 5% to 95% relative humidity, when equilibrium is obtained at each relative humidity step. As Form B dries from 95% back down to 5% relative humidity, it tends to maintain its weight such that at 5% relative humidity it typically has gained only about 0.022% by weight (about 0.003 mg) from start to finish. Form B does not convert to a different form upon exposure to about 84% relative humidity for about ten days.

Interconversion studies show that Form B typically converts to Form A in a THF solvent system, and typically converts to Form C in an acetone solvent system. In aqueous solvent systems such as pure water and 10% water solutions, Form B is the most stable of the polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. However, it can convert to Form E in the presence of water. Desolvation experiments show that upon heating at about 175° C. for about five minutes, Form B typically converts to Form A.

When stored for a period of about 85 days under two different temperature/relative humidity stress conditions (room temperature/0% RH and 40° C./93% RH), Form B does not convert to a different form.

In sum, Form B is a hemihydrated, crystalline solid which has a DSC thermogram exhibiting endotherms at about 146 and about 268° C. Interconversion studies show that Form B converts to Form E in aqueous solvent systems, and converts to other forms in acetone and other anhydrous systems.

5.2.3 Form C

Form C can be obtained from evaporations, slurries and slow cools in acetone solvent systems. A representative XRPD pattern of this form is shown in FIG. **12**. The data are characterized by peaks at approximately 15.5 and 25 degrees 2θ.

Solution proton NMR indicates that the 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione molecule is intact. Representative IR and Raman spectra are shown in FIGS. **13** and **14**, respectively. The IR spectrum of Form C is characterized by peaks at approximately 3466, 3373, and 3318 cm^{-1}. The Raman spectrum of Form C is characterized by peaks at about 3366, 3321, 1101, and 595 cm^{-1}.

Representative thermal characteristics for Form C are plotted in FIG. **15**. Form C loses about 10.02% volatiles up to about 175° C., indicating it is a solvated material. Weight loss above about 175° C. is attributed to decomposition. Identification of volatiles in Form C can be accomplished with TG-IR experiments. The representative IR spectrum captured after several minutes of heating, as depicted in FIG. **13**, when compared with a spectral library, shows acetone to be the best match. Calculations from TGA data show that Form C is a hemisolvate (approximately 0.497 moles of acetone). The DSC curve for Form C, shown in FIG. **15**, exhibits endotherms at about 150 and about 269° C. The endotherm at about 150° C. is attributed to solvent loss based on observations made during hot stage microscopy experiments. The endotherm at about 269° C. is attributed to the melt based on hot stage experiments.

Representative moisture sorption and desorption balance data are shown in FIG. **17**. Form C does not exhibit a significant weight gain from 5 to 85% relative humidity, when equilibrium is obtained at each relative humidity step up to 85% relative humidity. At 95% relative humidity, Form C experiences a significant weight loss of about 6.03%. As the sample dries from 95% back down to 5% relative humidity, the sample maintains the weight achieved at the end of the adsorption phase at each step down to 5% relative humidity. Form C is capable of converting to Form B when stored at about 84% relative humidity for approximately ten days.

Interconversion studies show that Form C typically converts to Form A in a THF solvent system and typically converts to Form E in an aqueous solvent system. In an acetone solvent system, Form C is the most stable form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Desolvation experiments performed on Form C show that upon heating at about 150° C. for about five minutes, Form C will typically convert to Form A.

In sum, Form C is a crystalline, hemisolvated solid, which has a DSC thermogram exhibiting endotherms at about 150 and about 269° C. Form C is not hygroscopic below about 85% RH, but can convert to Form B at higher relative humidities.

5.2.4 Form D

Form D can be obtained from evaporation in acetonitrile solvent systems. A representative XRPD pattern of the form is shown in FIG. **18**. The pattern is characterized by peaks at approximately 27 and 28 degrees 2θ.

Solution proton NMR indicates that the 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione molecule is intact. Representative IR and Raman spectra are shown in FIGS. **19** and **20**, respectively. The IR spectrum of Form D is characterized by peaks at approximately 3509, 2299, and 2256 cm^{-1}. The Raman spectrum of Form D is characterized by peaks at approximately 2943, 2889, 2297, 2260, 1646, and 1150 cm^{-1}.

Representative thermal characteristics for Form D are plotted in FIG. **21**. Form D loses about 6.75% volatiles up to about 175° C., indicating a solvated material. Weight loss above about 175° C. is attributed to decomposition. TG-IR experiments indicate that the volatiles are water and acetonitrile. Calculations from TG data show that about one mole of water is present in the sample. A representative DSC curve for Form D exhibits endotherms at about 122 and about 270° C. The endotherm at about 122° C. is attributed to loss of volatiles based on observations made during hot stage microscopy experiments. The endotherm at about 270° C. is attributed to the melt based on hot stage experiments.

Representative moisture sorption and desorption data are plotted in FIG. **22**. Form D does not exhibit a significant weight gain from 5 to 95% relative humidity when equilibrium is obtained at each relative humidity step. As the form dries from 95% back down to 5% relative humidity, it maintains its weight such that at 5% relative humidity the form has typically gained only about 0.39% by weight (about 0.012 mg) from start to finish. Form A is capable of converting to Form B when stored at about 84% relative humidity for approximately ten days.

Interconversion studies show that Form D is capable of converting to Form A in a THF solvent system, to Form E in an aqueous solvent system, and to Form C in an acetone solvent system. Desolvation experiments performed on Form D show that upon heating at about 150° C. for about five minutes Form D will typically convert to Form A.

In sum, Form D is a crystalline solid, solvated with both water and acetonitrile, which has a DSC thermogram exhibiting endotherms at about 122 and about 270° C. Form D is either weakly or not hygroscopic, but will typically convert to Form B when stressed at higher relative humidities.

5.2.5 Form E

Form E can be obtained by slurrying 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in water and by a slow evaporation of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in a solvent system with a ratio of about 9:1 acetone:water. A representative XRPD pattern is shown in FIG. **23**. The data are characterized by peaks at approximately 20, 24.5 and 29 degrees 2θ.

Representative thermal characteristics of Form E are plotted in FIG. **24**. Form E typically loses about 10.58% volatiles up to about 125° C., indicating that it is a solvated material. A second weight loss of an additional about 1.38% was observed between about 125° C. and about 175° C. Weight loss above about 175° C. is attributed to decomposition. Karl Fischer and TG-IR experiments support the conclusion that the volatile weight loss in Form E is due to water. The representative DSC curve for Form E exhibits endotherms at about 99, 161 and 269° C. Based on observations made during hot stage microscopy experiments, the endotherms at about 99 and about 161° C. are attributed to loss of volatiles. The endotherm at about 269° C. is attributed to the melt based on hot stage experiments.

Representative moisture sorption and desorption data are plotted in FIG. **25**. Form E typically does not exhibit a significant weight change from 5 to 95% relative humidity when equilibrium is obtained at each relative humidity step. As the sample dried from 95% back down to 5% relative humidity, the sample continues to maintain weight such that at 5% relative humidity the sample has lost only about 0.0528% by weight from start to finish.

Interconversion studies show that Form E can convert to Form C in an acetone solvent system and to Form G in a THF solvent system. In aqueous solvent systems, Form E appears to be the most stable form. Desolvation experiments performed on Form E show that upon heating at about 125° C. for about five minutes, Form E can convert to Form B. Upon heating at 175° C. for about five minutes, Form B can convert to Form F.

When stored for a period of 85 days under two different temperature/relative humidity stress conditions (room temperature/0% RH and 40° C./93% RH) Form E typically does not convert to a different form. When stored for seven days at room temperature/0% RH, Form E can convert to a new form, Form H.

5.2.6 Form F

Form F can be obtained by complete dehydration of Form E. A representative XRPD pattern of Form F, shown in FIG. **26**, is characterized by peaks at approximately 19, 19.5 and 25 degrees 2θ.

Representative thermal characteristics of Form F are shown in FIG. **27**. The representative DSC curve for Form F exhibits an endotherm at about 269° C. preceded directly by two smaller endotherms indicative of a crystallized form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. The DSC thermogram does not show any thermal events prior to the melt, suggesting that it is an unsolvated material.

5.2.7 Form G

Form G can be obtained by slurrying forms B and E in THF. A representative XRPD pattern of this form, shown in FIG. **28**, is characterized by a peak at approximately 23 degrees 2θ. Two other peaks unique to Form G appear at approximately 21 and 24.5 degrees 2θ.

Representative thermal characteristics of Form G are plotted in FIG. **29**. A representative DSC curve for Form G exhibits an endotherm at about 248° C. followed by a small, broad exotherm at about 267° C. No thermal events are seen in the DSC thermogram at lower temperatures, suggesting that it is an unsolvated material.

5.2.8 Form H

Form H can be obtained by storing Form E at room temperature and 0% RH for about 7 days. A representative XRPD pattern is shown in FIG. **30**. The pattern is characterized by a peak at 15 degrees 2θ, and two other peaks at 26 and 31 degrees 2θ.

Representative thermal characteristics are shown in FIG. **31**. Form H loses about 1.67% volatiles up to about 150° C. Weight loss above about 150° C. is attributed to decomposition. Karl Fischer data shows that Form H typically contains about 1.77% water (about 0.26 moles), suggesting that the weight loss seen in the TG is due to dehydration. The DSC thermogram shows a broad endotherm between about 50° C. and about 125° C., corresponding to the dehydration of Form H and a sharp endotherm at about 269° C., which is likely due to a melt.

When slurried in water with either Forms A or B, after about 14 days Form H can convert to Form E. When slurried in THF, Form H can convert to Form A. When slurried in acetone, Form H can convert to Form C.

In sum, Form H is a crystalline solid, hydrated with about 0.25 moles of water, which has a DSC thermogram exhibiting an endotherm between about 50 and 125° C. and an endotherm at about 269° C.

5.3 Methods of Use and Pharmaceutical Compositions

Polymorphs of the invention exhibit physical characteristics that are beneficial for drug manufacture, storage or use. All polymorphs of the invention have utility as pharmaceutically active ingredients or intermediates thereof.

This invention encompasses methods of treating and preventing a wide variety of diseases and conditions using polymorphs of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione. In each of the methods, a therapeutically or prophylactically effective amount of the compound is administered to a patient in need of such treatment or prevention. Examples of such disease and conditions include, but are not limited to, diseases associated with undesired angiogenesis, cancer (e.g., solid and blood borne tumors), inflammatory diseases, autoimmune diseases, and immune diseases. Examples of cancers and pre-cancerous conditions include those described in U.S. Pat. Nos. 6,281,230 and 5,635,517 to Muller et al. and in various U.S. patent applications to Zeldis, including application Ser. No. 10/411,649, filed Apr. 11, 2003 (Treatment of Myelodisplastic Syndrome); Ser. No. 10/438,213 filed May 15, 2003 (Treatment of Various Types of Cancer); Ser. No. 10/411,656, filed Apr. 11, 2003 (Treatment of Myeloproliferative Diseases). Examples of other diseases and disorders that can be treated or prevented using compositions of the invention are described in U.S. Pat. Nos. 6,235,756 and 6,114,335 to D'Amato and in other U.S. patent applications to Zeldis, including Ser. No. 10/693,794, filed Oct. 23, 2003 (Treatment of Pain Syndrome) and Ser. No. 10/699,154, filed Oct. 30, 2003 (Treatment of Macular Degeneration). The entirety of each of the patents and patent applications cited herein is incorporated herein by reference.

Depending on the disease to be treated and the subject's condition, polymorphs of the invention can be administered by oral, parenteral (e.g., intramuscular, intraperitoneal, intravenous, ICV, intracisternal injection or infusion, subcutaneous injection, or implantation), inhalation spray, nasal, vaginal, rectal, sublingual, or topical routes of administration and may be formulated, alone or together, in suitable dosage unit formulations containing conventional non-toxic pharmaceutically acceptable carriers, adjuvants and vehicles appropriate for each route of administration. Because individual poly-

morphs have different dissolution, stability, and other properties, the optimal polymorph used in methods of treatment may depend on the route of administration. For example, forms that are readily soluble in aqueous solutions are preferably used to provide liquid dosage forms, whereas forms that exhibit great thermal stability may be preferred in the manufacture of solid dosage forms (e.g., tablets and capsules).

Although the physical characteristics of polymorphs can, in some cases, affect their bioavailability, amounts of the polymorphs that are therapeutically or prophylactically effective in the treatment of various disease and conditions can be readily determined by those of ordinary skill in the pharmacy or medical arts. In certain embodiments of the invention, a polymorph is administered orally and in a single or divided daily doses in an amount of from about 0.10 to about 150 mg/day, or from about 5 to about 25 mg/day. In other embodiments, a polymorph is administered every other day in an amount of from about 0.10 to about 150 mg/day, or from about 5 to about 25 mg/day.

The invention encompasses pharmaceutical compositions and single unit dosage forms that can be used in methods of treatment and prevention, which comprise one or more polymorphs of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione and optionally one or more excipients or diluents. Specific compositions and dosage forms are disclosed in the various patents and patent applications incorporated herein by reference. In one embodiment, a single dosage form comprises a polymorph (e.g., Form B) in an amount of about 5, 10, 25 or 50 mg.

6. EXAMPLES

6.1 Polymorph Screen

A polymorph screen to generate the different solid forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione was carried out as follows.

A weighed sample of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione (usually about 10 mg) was treated with aliquots of the test solvent. Solvents were either reagent or HPLC grade. The aliquots were usually about 200 μL. Between additions, the mixture was usually shaken or sonicated. When the solids dissolved, as judged by visual inspection, estimated solubilities were calculated. Solubilities were estimated from these experiments based on the total solvent used to provide a solution. Actual solubilities may have been greater than those calculated due to the use of too-large solvent aliquots or to a slow rate of dissolution.

Samples were created by generating solutions (usually about 30 mg in 20 mL) at elevated temperatures, filtering, and allowing the solution to evaporate whether in an open vial (hot fast evaporation) or in a vial covered with aluminum foil containing pinholes (hot slow evaporation).

Slurry experiments were also performed. Usually about 25 mg of solid was placed in either 3 or 5 mL of solvent. The samples were then placed on orbital shakers at either ambient temperature or 40° C. for 4-10 days.

Crystallizations were performed using various cooling methods. Solid was dissolved in a solvent at an elevated temperature (e.g., about 60° C.), filtered quickly and allowed to cool to room temperature. Once at room temperature, samples that did not crystallize were moved to a refrigerator. Solids were removed by filtration or decantation and allowed to dry in the air. Crash cools were performed by dissolving solid in a solvent at an increased temperature (e.g., about 45-65° C.) followed by cooling in a dry ice/acetone bath.

Hygroscopicity studies were performed by placing portions of each polymorph in an 84% relative humidity chamber for approximately one week.

Desolvation studies were carried out by heating each polymorph in a 70° C. oven for approximately one week.

Interconversion experiments were carried out by making slurries containing two forms in a saturated solvent. The slurries were agitated for approximately 7-20 days at ambient temperature. The insoluble solids were recovered by filtration and analyzed using XRPD.

6.2 Preparation of Polymorphic Forms

Eight solid forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione were prepared as described below.

Form A was obtained by crystallization from various non-aqueous solvents including 1-butanol, butyl acetate, ethanol, ethyl acetate, methanol, methyl ethyl ketone, and tetrahydrofuran. Form B was also obtained by crystallization from the solvents hexane, toluene and water. Form C was obtained from evaporations, slurries, and slow cools in acetone solvent systems. Form D was obtained from evaporations in acetonitrile solvent systems. Form E was obtained most readily by slurrying 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in water. Form F was obtained by complete desolvation of Form E. It is found to be an unsolvated, crystalline material that melts at about 269° C. Form G was obtained by slurrying forms B and E in THF. Form H was obtained by stressing Form E at room temperature and 0% RH for 7 days.

6.2.1 Synthesis of Polymorphs B and E

Form B is the desired polymorph for the active pharmaceutical ingredient (API) of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. This form has been used in the formulation of API into drug product for clinical studies. Three batches were produced as apparent mixtures of polymorphs in the non-micronized API of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

Development work was carried out to define a process that would generate polymorph B from this mixture of polymorphs and could be implemented for strict polymorphic controls in the validation batches and future manufacturing of API of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Characterization of polymorphic forms produced during the work was performed by XRPD, DSC, TGA and KF.

A process was also developed for the large-scale preparation of Form E. Polymorph E material was prepared in order to carry out a comparison with polymorph B drug product in capsule dissolution testing of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. 150 g of a mixture of polymorphs in 3 L of water was stirred at room temperature for 48 hours. The product was collected by filtration and dried at 25° C. for 24 hours under vacuum. XRPD, DSC, TGA, KF and HPLC analyses confirmed that the material isolated was polymorph E.

In a preliminary work, it was demonstrated that stirring a suspension of a mixture of polymorphs of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione with water at high temperature (75° C.) for an extended period of time converted this mixture of polymorphs exclusively to form B. Several specific parameters were identified including temperature, solvent volume and drying parameters (temperature and vacuum). XRPD, DSC, TGA, KF and HPLC analyses were used to characterize all of the batches. After completing the optimization work, the optimized process was scaled-up to 100-200 g on three lots of API. Drying studies were carried

out at 20° C., 30° C. and 40° C., and 65° C. with a vacuum of 150 mm of Hg. The results are shown in Tables 1-5.

The cooling and holding periods of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione slurry were studied. The experimental laboratory data suggests that polymorph B seems to be forming first, and overtime equilibration to polymorph E at RT conditions occurs, therefore generating a mixture of polymorphs B and E. This result supports the fact that polymorph B seems to be a kinetic product, and that prolonged processing time converts the material to polymorph E resulting in a mixture of polymorphs B and E.

A laboratory procedure was developed to exclusively produce polymorph B of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. The procedure includes a stirred 10 volume water slurry at ~75° C. for 6-24 hours. The following preferred process parameters have been identified:

1. Hot slurry temperature of 70-75° C.
2. Product filtration of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione at 65-75° C.
3. Drying under vacuum at 60-70° C. is preferred for an efficient removal of unbound water in 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione wet cake.
4. The filtration step of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione may be a time sensitive operation. The use of efficient solid-liquid separation equipment is preferred.
5. Holding periods of water-wet cake of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione at KF higher than 5% may cause the kinetic equilibrations of polymorph B to mixed polymorphs of E and B.

Drying to KF <4.0% water was achieved in ~3 hours (30-70° C., 152 mm Hg). Polymorphs B and E were distinguished by the water levels as measured by KF and TGA. The reference sample of polymorph B is micronized API. In order to make accurate comparison by XRPD samples were gently grinded before submission for analysis. This increases the clarity of the identification of the polymorphic form. All samples were analyzed for XRPD, DSC, TGA, KF and HPLC.

TABLE 1

Preliminary Studies

Amount	Reaction conditions	Analysis	Results/ conclusion
2 g	Water, rt, 48 h	XRPD, DSC, TGA, KF	Polymorph E
25 g	Water, rt, 48 h	XRPD, DSC, TGA, KF	Polymorph E
5 g	Water, 70-75° C., 24 h then rt 24 h	XRPD, DSC, TGA, KF	Polymorph B
1 g	9:1 Acetone - water, Slow evpo.	XRPD, DSC, TGA, KF	Polymorph Mixture
1 g	175° C. 1 h in an oven	XRPD, DSC, TGA, KF	Polymorph A
0.5 g (polymorph A)	Water, rt, 24 h	XRPD, DSC, TGA, KF	Polymorph E
1 g polymorph B	Water, rt, 48 h	XRPD, DSC, TGA, KF	Polymorph E
1 g polymorph E	Water, 70-75° C., 24 h	XRPD, DSC, TGA, KF	Polymorph B
1 g	Slurry in heptane	XRPD, DSC, TGA, KF	No change

TABLE 2

Optimization of Temperature, Time and Solvent Volume

Amount	Amount Water (mL)	Temp (° C.)	Time (h)	Results/ conclusion
10 g	50	75	6	Mix
10 g	50	75	24	Polymorph B
10 g	100	70	6	Polymorph B
10 g	100	70	14	Polymorph B
10 g	100	70	21	Polymorph B
10 g	100	75	6	Polymorph B
10 g	100	75	24	Polymorph B
10 g	100	75	6	Polymorph B
10 g	100	75	19	Polymorph B
10 g	100	75	14	Polymorph B
10 g	100	75	24	Polymorph B
5 g	100	75	18	Polymorph B
10 g	100	80	6	Polymorph B
10 g	100	80	20	Polymorph B
10 g	200	45	6	Polymorph B + E
10 g	200	45	24	Polymorph E
10 g	200	60	48	Polymorph B
10 g	200	75	6	Mix
10 g	200	75	24	Polymorph B
10 g	200	75	13	Polymorph B
10 g	200	75	24	Polymorph B

Optimum conditions were determined to be 10 volumes of solvent (H_2O), 70-80° C. for 6-24 hours.

TABLE 3

Holding Time

Amount	Reaction Conditions	Holding Time (h)	Holding Temp (° C.)	Results/ Conclusion
5 g	Water, 70-75° C., 24 h	24	23-25	Polymorph B
1 g Polymorph B	Water, 70-75° C., 24 h	48	23-25	Polymorph E
2 g	Water, 40 mL	16	23-25	Polymorph E
150 g	Water, 3.0 L	24	23-25	Polymorph E
150 g	Water, 3.0 L	48	23-25	Polymorph E
10 g	Water, 100 mL, 24 h, 75° C.	18	23-25	Polymorph B
10 g	Water, 100 mL, 24 h, 75° C.	18	40	Polymorph B
10 g	Water, 200 mL, 24 h, 75° C.	14	−5	Mix
10 g	Water, 200 mL, 24 h, 75° C.	14	23-25	Polymorph E
10 g	Water, 200 mL, 24 h, 75° C.	14	40	Mix
10 g	Water, 100 mL, 24 h, 75° C.	21	23-25	Polymorph E
10 g	Water, 100 mL, 24 h, 75° C.	21	40	Mix
10 g	Water, 100 mL, 14 h, 75° C.	2	23-25	Mix

Holding time gave mixed results and it was determined that the material should be filtered at 60-65° C. and the material washed with 0.5 volume of warm (50-60° C.) water.

TABLE 4

Scale-up Experiments

Amount	Amount Water (L)	Temp (° C.)	Time (h)	Results/ Conclusion
100 g	1.0	75	6	Polymorph B
100 g	1.0	75	22	Polymorph B

TABLE 4-continued

Scale-up Experiments

Amount	Amount Water (L)	Temp (° C.)	Time (h)	Results/ Conclusion
100 g	1.0	75	6	Polymorph B
100 g	1.0	75	24	Polymorph B
100 g	1.0	75	6	Polymorph B
100 g	1.0	75	22	Polymorph B

TABLE 5

Drying Studies

Amount	Drying Time (h)	Drying Temp (° C.)	Vacuum (mm Hg)	KF§ (%)	Results/ Conclusion
100 g	0	—	—	3.690	Polymorph B
100 g	3	30	152	3.452	Polymorph B
100 g	8	30	152	3.599	Polymorph B
100 g	0	—	—	3.917	Polymorph B
100 g	5	40	152	3.482	Polymorph B
100 g	22	40	152	3.516	Polymorph B
100 g	3	40	152	3.67	Polymorph B
100 g	22	40	152	3.55	Polymorph B

* Reaction Conditions: Water 1 L, 75° C., 22-24 h;
§Average of 2 runs.

Drying studies determined that the material should be dried at 35-40° C., 125-152 mm Hg for 3 to 22 h or until the water content reaches ≦4% w/w.

For a large scale preparation of polymorph E (5222-152-B), a 5-L round bottom flask was charged with 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione (150 g, 0.579 mol) and water (3000 mL, 20 vol). The mixture was mechanically stirred at room temperature (23-25° C.) for 48 h under nitrogen atmosphere.

Samples were taken after 24 h and 48 h before the mixture was filtered and air-dried on the filter for 1 h. The material was transferred to a drying tray and dried at room temperature (23-25° C.) for 24 h. KF analysis on the dried material showed water content of 11.9%. The material was submitted for XRPD, TGA, DSC and HPLC analysis. Analysis showed the material was pure polymorph E.

For a large scale preparation of polymorph B (5274-104), a 2 L-3-necked round bottom flask was charged with 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione (polymorph mixture, 100 g, 0.386 mol) and water (1000 mL, 10.0 vol). The mixture was heated to 75° C. over approximately 30 minutes with mechanical stirring under nitrogen atmosphere.

Samples were taken after 6 h and 24 h before the mixture was allowed to cool to 60-65° C., filtered and the material washed with warm (50-60° C.) water (50 mL, 0.5 vol). The material was transferred to a drying tray and dried at 30° C., 152 mm Hg for 8 h. KF analysis on the dried material showed water content of 3.6%. After grinding the material was submitted for XRPD, TGA, DSC and HPLC analysis. Analysis showed the material was pure polymorph B. The results of the analyses are shown in FIGS. **32-46**.

6.3 X-Ray Powder Diffraction Measurements

X-ray powder diffraction analyses were carried out on a Shimadzu XRD-6000 X-ray powder diffractometer using Cu Kα radiation. The instrument is equipped with a fine-focus X-ray tube. The tube voltage and amperage were set at 40 kB and 40 mA, respectively. The divergence and scattering slits were set at 1° and the receiving slit was set at 0.15 mm. Diffracted radiation was detected by a NaI scintillation detector. A theta-two theta continuous scan at 3°/min (0.4 sec/0.02° step) from 2.5 degrees 2θ to 40 degrees 2θ was used. A silicon standard was analyzed each day to check the instrument alignment.

X-ray powder diffraction analyses were also carried out using Cu Kα radiation on an Inel XRG-3000 diffractometer equipped with a curved position-sensitive detector. Data were collected in real time over a theta-two theta range of 120° at a resolution of 0.030°. The tube voltage and current were 40 kV and 30 mA, respectively. A silicon standard was analyzed each day to check for instrument alignment. Only the region between 2.5 and 40 degrees 2θ is shown in the figures.

6.4 Thermal Analysis

TG analyses were carried out on a TA Instrument TGA 2050 or 2950. The calibration standards were nickel and alumel. Approximately 5 mg of sample was placed on a pan, accurately weighed, and inserted into the TG furnace. The samples were heated in nitrogen at a rate of 10° C./min, up to a final temperature of 300 or 350° C.

DSC data were obtained on a TA 2920 instrument. The calibration standard was indium. Approximately 2-5 mg samples were placed into a DSC pan and the weight accurately recorded. Crimped pans with one pinhole were used for analysis and the samples were heated under nitrogen at a rate of 10° C./min, up to a final temperature of 350° C.

Hot-stage microscopy was carried out using a Kofler hot stage mounted on a Leica Microscope. The instrument was calibrated using USP standards.

A TA Instruments TGA 2050 interfaced with a Nicolet model 560 Fourier transform IR spectrophotometer, equipped with a globar source, XT/KBr beamsplitter, and deuterated triglycine sulfate (DTGS) detector, was utilized for TG-IR experiments. The IR spectrometer was wavelength calibrated with polystyrene on the day of use while the TG was temperature and weight calibrated biweekly, using indium for the temperature calibration. A sample of approximately 10 mg of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione was weighed into an aluminum pan and heated from 25 to 30° C. to 200° C. at a rate of 20° C./min with a helium purge. IR spectra were obtained in series, with each spectrum representing 32 co-added scans at a resolution of 4 cm^{-1}. Spectra were collected with a 17-second repeat time. TG/IR analysis data are presented as Gram-Schmidt plots and IR spectra linked to the time. Gram-Schmidt plots show total IR intensity vs. time; hence, the volatiles can be identified at each time point. They also show when the volatiles are detected. From the Gram-Schmidt plots, time points were selected and the IR spectra of these time points are presented in the stacked linked spectra. Each spectrum identifies volatiles evolving at that time point. Volatiles were identified from a search of the HR Nicolet TGA vapor phase spectral library. The library match results are also presented to show the identified vapor.

6.5 Spectroscopy Measurements

Raman spectra were acquired on a Nicloet model 750 Fourier transform Raman spectrometer utilizing an excitation wavelength of 1064 nm and approximately 0.5 W of Nd:YAG laser power. The spectra represent 128 to 256 co-added scans acquired at 4 cm^{-1} resolution. The samples were prepared for analysis by placing the material in a sample holder and positioning this in the spectrometer. The spectrometer was wavelength calibrated using sulfur and cyclohexane at the time of use.

The mid-IR spectra were acquired on a Nicolet model 860 Fourier transform IR spectrophotmeter equipped with a glo-

bar source XT/KBr beamsplitter and a deuterated triglycine sulfate (DTGS) detector. A Spectra-Tech, Inc. diffuse reflectance accessory was utilized for sampling. Each spectrum represents 128 co-added scans at a spectral resolution of 4 cm^{-1}. A background data set was acquired with an alignment mirror in place. A single beam sample data set was then acquired. Subsequently, a log 1/R (where R=reflectance) spectrum was acquired by rationing the two data sets against each other. The spectrophotometer was calibrated (wavelength) with polystyrene at the time of use.

6.6 Moisture Sorption/Desorption Measurements

Moisture sorption/desorption data were collected on a VTI SGA-100 moisture balance system. For sorption isotherms, a sorption range of 5 to 95% relative humidity (RH) and a desorption range of 95 to 5% RH in 10% RH increments was used for analysis. The sample was not dried prior to analysis. Equilibrium criteria used for analysis were less than 0.0100 weight percent change in 5 minutes with a maximum equilibration time of 3 hours if the weight criterion was not met. Data were not corrected for the initial moisture content of the samples.

6.7 Solution Proton NMR Measurements

NMR spectra not previously reported were collected at SSCI, Inc, 3065 Kent Avenue, West Lafayette, Ind. Solution phase ^1H NMR spectra were acquired at ambient temperature on a Bruker model AM spectrometer. The ^1H NMR spectrum represents 128 co-added transients collected with a 4 μsec pulse and a relaxation delay time of 5 seconds. The free induction decay (FID) was exponentially multiplied with a 0.1 Hz Lorentzian line broadening factor to improve the signal-to-noise ratio. The NMR spectrum was processed utilizing GRAMS software, version 5.24. Samples were dissolved in dimethyl sulfoxide-d_6.

The scope of this invention can be understood with reference to the appended claims.

6.8 Intrinsic Dissolution and Solubility Studies

Intrinsic dissolution experiments were conducted on Form A (anhydrous), Form B (hemihydrate), and Form E (dihydrate) of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Equilibrium solubility experiments were conducted on Forms A and B. Aliquots were analyzed by ultraviolet-visible spectrophotometry, and the solids remaining from each experiment were analyzed by X-ray powder diffraction (XRPD).

6.8.1 Experimental

6.8.1.1 Dissolution

Dissolution experiments were carried out in a VanKel VK6010-8 dissolution apparatus equipped with a VK650A heater/circulator. An intrinsic dissolution apparatus (Woods apparatus) was used. Samples were compressed at 1.5 metric tons (1000 psi) for 1 min using the Woods apparatus in a hydraulic press, giving a sample surface of 0.50 cm^2. A dissolution medium consisting of 900 mL HCl buffer, pH 1.8, with 1% sodium lauryl sulfate, was used for each experiment. The medium was degassed by vacuum filtration through a 0.22-μm nylon filter disk and maintained at 37° C. The apparatus was rotated at 50 rpm for each experiment. Aliquots were filtered immediately using 0.2-μm nylon syringe filters. In some cases, the undissolved solids were recovered and analyzed by X-ray powder diffraction (XRPD).

6.8.1.2 Solubility

Equilibrium solubility experiments were conducted in a 100-mL, three-neck, round-bottom flask immersed in a constant temperature oil bath maintained at 25° C. A solid sample of 400-450 mg was stirred in 50 mL of dissolution medium (HCl buffer, pH 1.8, with 1% sodium lauryl sulfate) using a mechanical stir rod. Aliquots were filtered using 0.2-μm nylon syringe filters and immediately diluted 1 mL→50 mL, then 5 mL→25 mL with dissolution medium in Class A glassware, a final dilution factor of 250.

6.8.1.3 UV-Vis Spectrophotometry

Dissolution and solubility samples solutions were analyzed by a Beckman DU 640 single-beam spectrophotometer. A 1.000-cm quartz cuvette and an analysis wavelength of 228.40 nm were utilized. The detector was zeroed with a cuvette filled with dissolution medium.

6.8.1.4 X-Ray Powder Diffraction

XRPD analyses were carried out on a Shimadzu XRD-6000 X-ray powder diffractometer using Cu Kα radiation. The instrument is equipped with a fine focus X-ray tube. The tube power and amperage were set at 40 kV and 40 mA, respectively. The divergence and scattering slits were set at 1° and the receiving slit was set at 0.15 mm. Diffracted radiation was detected by a NaI scintillation detector. A theta-two theta continuous scan at 3°/min (0.4 sec/0.02° step) from 2.5 to 40° 2θ was used. A silicon standard was analyzed each day to check the instrument alignment. Samples were packed in an aluminum holder with silicon insert.

6.8.2 Results

The results of these solubility and intrinsic studies are summarized in Table 6. Both the solubility and dissolution experiments were conducted in a medium of HCl buffer, pH 1.8, containing 1% sodium lauryl sulfate. Form A was found to be unstable in the medium, converting to Form E. The solubilities of Forms A, B, and E were estimated to be 6.2, 5.8, and 4.7 mg/mL, respectively. The dissolution rates of Forms A, B, and E were estimated to be 0.35, 0.34, and 0.23 mg/mL, respectively.

6.8.2.1 UV-Vis Spectrophotometry Method Development

A UV-Vis scan of the dissolution medium (blanked with an empty cuvette) was done to identify any interfering peaks. A small peak at 225 nm was present as shown in FIG. **47**.

Solutions of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione at varying concentrations were analyzed by UV-Vis spectrophotometry. A preliminary scan of a 1.0 mg/mL solution was done, with the instrument blanked with dissolution medium. The solution was highly absorbing and noisy from 200-280 nm, making dilution necessary.

A 0.04 mg/mL solution of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione was then scanned from 200-300 nm. The plot was still noisy between 200 and 230 nm as shown in FIG. **48**. The sample was further diluted to 0.008 mg/mL. A wavelength scan of 200-350 nm for this sample showed a peak a 228.4 nm with no interference, as shown in FIG. **49**. Therefore, a wavelength of 228.4 was chosen for analysis of the solubility and dissolution samples.

A six-point calibration curve was generated with standards of the following concentrations: 0.001 mg/mL, 0.002 mg/mL, 0.005 mg/mL, 0.010 mg/mL, 0.015 mg/mL, and 0.020 mg/mL (Notebook 569-90). A linearity coefficient of R^2=0.9999 was obtained as shown in FIG. **50**.

6.8.2.2 Solubility

A sample consisting of 449.4 mg Form A was slurried in dissolution medium. Particle size was not controlled. Aliquots were taken at 7, 15, 30, 60, 90, and 150 min. The concentration reached 6.0 mg/mL by the first time point. The highest concentration reached was 6.2 mg/mL, at 30 min. From that point the concentration decreased, reaching 4.7 mg/mL at 150 min as in FIG. **51**. The solids remaining at the final time point were analyzed by XRPD and found to be Form E as shown in Table 7. No peaks attributed to Form A can be seen in the pattern. Since the concentration did not plateau at 4.7 mg/mL, the solubility of Form E may be lower than that.

A sample consisting of 401.4 mg Form B was slurried in dissolution medium. Particle size was not controlled. Aliquots were taken at 7, 15, 30, 60, 90, 180, 420, and 650 min. Form B dissolved much more slowly than Form A, reaching 3.3 mg/mL in 90 min. The concentration stabilized at 5.6-5.7 mg/mL at the final three time points as in FIG. **52**. The remaining solids were shown to be Form B as in Table 7, suggesting Form B has good stability in water.

A summary of the solubilities is given in Table 6. The amounts dissolved at each time point are shown in Tables 8 and 9.

TABLE 6

Summary of Results

Form	Solubility	Intrinsic Dissolution #1	Intrinsic Dissolution #2	Average Intrinsic Dissolution Rate
Form A	6.2 mg/mL	0.35	0.22[a]	0.29[a]
Form B	5.8 mg/mL	0.35	0.32	0.34
Form E	4.7 mg/mL	0.21	0.25	0.23

[a]The Form A dissolution experiment #2 may have converted to Form E on the surface of the disk, skewing the average rate lower.

TABLE 7

Experimental Details

Experiment	Final Form
Pressed Form A	A
Pressed Form B	B
Form A Solubility	E
Form B Solubility	B
Form A Dissolution	—
Form A Dissolution	A
Form B Dissolution	—
Form B Dissolution	B
Form E Dissolution	E
Form E Dissolution	—

TABLE 8

Form A Solubility

Time Point (min)	Concentration (mg/mL)
7	6.00
15	6.11
30	6.16
60	6.10
90	5.46
150	4.73

TABLE 9

Form B Solubility

Time Point (min)	Concentration (mg/mL)
7	1.63
15	2.14
30	2.33
60	2.94
90	3.34
180	5.67
420	5.76
650	5.61

6.8.2.3 Intrinsic Dissolution

Approximately 200 mg each of Forms A and B were compressed into disks in the Woods apparatus using 2 metric tons of pressure. The samples were subsequently scraped out, ground gently, and analyzed by XRPD. The study showed that compression and grinding does not cause a form change in either case. (See Table 7).

Two preliminary dissolution runs were performed. The disks fractured to some extent in both experiments, compromising the requirement of constant surface area.

The first experiment of intrinsic dissolution that strictly followed the USP chapter on intrinsic dissolution utilized approximately 150 mg each of Forms A and B. Seven aliquots, beginning at 5 min and ending at 90 min, were taken to maintain sink conditions. The experiment resulted in linear dissolution profiles, with a rate of 0.35 mg per cm^2 per minute for both forms. The Form E experiment was done later under the same conditions and added to the graph for comparison. (See FIG. **53**). The Form E dissolution rate was 0.21 mg per cm^2 per minute, significantly lower than the dissolution rate of Forms A and B. This is in line with expectations based on the solubility data. The crystal form of the remaining solids did not change in any case.

The second experiment utilized approximately 250 mg each of Forms A and B. The Form E experiment (135 mg) was done later and added to the graph for comparison. (See FIG. **54**). Nine aliquots were taken, beginning at 5 min and ending at 150 min. The dissolution rates were 0 22, 0.32, and 0.25 mg per cm^2 per minute, respectively, for Forms A, B, and E. The dissolution rate for Form A in this experiment was low, while the rates for Forms B and E were similar to those found in the first experiment. It is believed that in this case, a thin layer of the Form A sample disk may have converted to Form E upon exposure to water. This is supported by the evidence of rapid conversion of Form A to Form E in the solubility experiment. The diffraction pattern of the undissolved solids does not indicate a form change. However, the bulk of the sample disk is not exposed to water. Therefore, the true intrinsic dissolution rate of Form A is believed to be close to 0.35 mg per cm^2 per minute. An insufficient quantity of Form A was available to repeat the experiment.

A summary of the intrinsic dissolution rates is given in Table 6. The amounts dissolved at each time point are summarized in Tables 10 and 11.

TABLE 10

Intrinsic Dissolution Experiment #1 Results

Time Point	Form A[a]	Form B[a]	Form E[a]
5 min	5.76	10.80[b]	2.70
10 min	7.73	6.85	4.13
20 min	11.31	10.25	6.96
30 min	15.59	14.35	9.60
45 min	21.98	20.57	12.57
60 min	27.11	25.70	15.16
90 min	34.17	34.34	20.82

[a]Results are reported as Cumulative Amount Dissolved per Unit Area (mg/cm2)
[b]This date point not included in graph since the value is higher than the next two data points.

TABLE 11

Intrinsic Dissolution Experiment #2 Results

Time Point	Form A[a]	Form B[a]	Form E[a]
5 min	4.50	5.04	3.06
10 min	5.22	6.12	4.31
20 min	7.54	7.73	11.40
30 min	11.46	12.72	11.93
45 min	15.01	17.33	14.72
60 min	18.38	21.93	18.52
90 min	24.38	31.64	26.24
120 min	30.35	41.31	33.56
150 min	35.26	49.54	40.82

[a]Results are reported as Cumulative Amount Dissolved per Unit Area (mg/cm2)

6.9 Analyses of Mixtures of Polymorphs

This invention encompasses mixtures of different polymorphs. For example, an X-ray diffraction analysis of one production sample yielded a pattern that contained two small peaks seen at approximately 12.6° and 25.8° 2θ in addition to those representative of Form B. In order to determine the composition of that sample, the following steps were performed:

1) Matching of the new production pattern to known forms along with common pharmaceutical excipients and contaminants;
2) Cluster analysis of the additional peaks to identify if any unknown phase is mixed with the original Form B;
3) Harmonic analysis of the additional peaks to identify if any preferred orientation may be present or if any changes in the crystal habit may have occurred; and
4) Indexing of the unit cells for both Form B and the new production sample to identify any possible crystallographic relationships.

Based on these tests, which can be adapted for the analysis of any mixture of polymorphs, it was determined that the sample contained a mixture of polymorph forms B and E.

6.10 Dosage Form

Table 12 illustrates a batch formulation and single dosage formulation for a 25 mg single dose unit of a polymorphic form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

TABLE 12

Formulation for a 25 mg capsule

Material	Percent By Weight	Quantity (mg/tablet)	Quantity (kg/batch)
Polymorphic Form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione	40.0%	25 mg	16.80 kg
Pregelatinized Corn Starch, NF	59.5%	37.2 mg	24.99 kg
Magnesium Stearate	0.5%	0.31 mg	0.21 kg
Total	100.0%	62.5 mg	42.00 kg

The pregelatinized corn starch (SPRESS B-820) and polymorphic form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione components are passed through a screen (i.e., a 710 μm screen) and then loaded into a Diffusion Mixer with a baffle insert and blended for about 15 minutes. The magnesium stearate is passed through a screen (i.e., a 210 μm screen) and added to the Diffusion Mixer. The blend is then encapsulated in capsules using a Dosator type capsule filling machine.

The entire scope of this invention is not limited by the specific examples described herein, but is more readily understood with reference to the appended claims.

What is claimed is:

1. Crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate.

2. The hemihydrate of claim **1** having an X-ray powder diffraction pattern comprising peaks at approximately 16, 22 and 27 degrees 2θ.

3. The hemihydrate of claim **2** wherein the pattern further comprises a peak at approximately 18 degrees 2θ.

4. The hemihydrate of claim **1** having an X-ray powder diffraction pattern comprising peaks at 15.8, 22.2 and 26.7 degrees 2θ.

5. The hemihydrate of claim **4** wherein the pattern further comprises a peak at 18.2 degrees 2θ.

6. The hemihydrate of claim **1** having an X-ray powder diffraction pattern corresponding to the representative X-ray powder diffraction patterns depicted in FIG. **6**, FIG. **32**, FIG. **33** and FIG. **34**.

7. The hemihydrate of claim **1** having a differential scanning calorimetry thermogram comprising an endotherm with a maximum at about 268° C.

8. The hemihydrate of claim **7** wherein the thermogram further comprises an endotherm corresponding to dehydration.

9. The hemihydrate of claim **1** having a differential scanning calorimetry thermogram corresponding to the representative differential scanning calorimetry thermograms depicted in FIG. **9**, FIG. **42**, FIG. **43** and FIG. **44**.

10. The hemihydrate of claim **1** having between approximately 0.46 and approximately 0.59 moles of water per mole of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

11. The hemihydrate of claim **1** having a thermogravimetric analysis thermogram comprising a weight loss of between about 3.1% and about 4.0% when heated from about 30° C. to about 175° C.

12. The hemihydrate of claim **1** having an infrared spectrum comprising peaks at approximately 3513 and 1960 cm^{-1}.

13. The hemihydrate of claim **1** having an infrared spectrum corresponding to the representative infrared spectrum depicted in FIG. **7**.

14. The hemihydrate of claim **1** having a Raman spectrum corresponding to the representative Raman spectrum depicted in FIG. **8**.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,465,800 B2
APPLICATION NO. : 10/934863
DATED : December 16, 2008
INVENTOR(S) : Jaworsky et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Please replace Drawing Sheets 15, 26, 31, 32, 33, 35, 36, 38, 39, and 40 (of 48) with the Replacement Drawing Sheets on the following pages of this Certificate of Correction:

Page 2 of 11: Replacement Drawing Sheet 15 of 48 (Fig. 15);

Page 3 of 11: Replacement Drawing Sheet 26 of 48 (Fig. 26);

Page 4 of 11: Replacement Drawing Sheet 31 of 48 (Fig. 31);

Page 5 of 11: Replacement Drawing Sheet 32 of 48 (Figs. 32 and 33);

Page 6 of 11: Replacement Drawing Sheet 33 of 48 (Figs. 34 and 35);

Page 7 of 11: Replacement Drawing Sheet 35 of 48 (Figs. 37 and 38);

Page 8 of 11: Replacement Drawing Sheet 36 of 48 (Figs. 39 and 40);

Page 9 of 11: Replacement Drawing Sheet 38 of 48 (Figs. 42 and 43);

Page 10 of 11: Replacement Drawing Sheet 39 of 48 (Figs. 44 and 45);

Page 11 of 11: Replacement Drawing Sheet 40 of 48 (Fig. 46).

Signed and Sealed this
Nineteenth Day of April, 2011

David J. Kappos
Director of the United States Patent and Trademark Office

TGA (TOP) AND DSC (BOTTOM) OF FORM C
TGA
10.02%
(0.4908mg)
Weight (%)
Deriv. Weight (%/°C)
Temperature (°C)
DSC
150.26°C
269.39°C
Heat Flow (W/g)
Temperature (°C)

FIG.15

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FIG.26

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FIG.31

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FIG.32

FIG.33

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XRPD PATTERN OF POLYMORPH B

File: Process 5222-157-C
Date: 06/04/04 15:07 Step: 0.020° Cnt Time: 0.500 Sec.
Range: 1.50-40.00 (Deg) Step Scan Rate: 2.40 Deg/min.

FIG.34

XRPD PATTERN OF POLYMORPH E

File: Process 5222-152-B Form E
Date: 05/21/04 10:46 Step: 0.020° Cnt Time: 0.500 Sec.
Range: 1.50-40.00 (Deg) Step Scan Rate: 2.40 Deg/min.

FIG.35

TGA CURVE OF POLYMORPH B
Sample: 5274-104-B
Size 7.8320mg
Method: Ramp
TGA
Run Date: 09-Jun-04 17:04
Instrument: TGA 0.500 V5.3 Build 171
3.712%
(0.2907mg)
Weight (%)
Temperature (°C)

FIG.37

TGA CURVE OF POLYMORPH B
Sample: 5274-100-C
Size 10.9430mg
Method: Ramp
Comment: Evotec Batch 1675C H20
TGA
Run Date: 03-Jun-04 11:20
Instrument: TGA 0.500 V5.3 Build 171
3.952%
(0.4324mg)
Weight (%)
Temperature (°C)

FIG.38

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FIG.39

FIG.40

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DSC OF POLYMORPH B

Sample: 5274-104-B
Size: 0.0000mg
Method: Cell constant calibration
Comment: OAI batch 15 22b

DSC
Run Date: 07-Jun-04 11:30
Instrument: DSC Q 1000 V7.3 Build 249

FIG.42

DSC OF POLYMORPH B

Sample: 5274-100-C
Size: 0.0000mg
Method: Cell constant calibration
Comment: Evotec Batch 1675C 10vol H20 24h 3h dry

DSC
Run Date: 02-Jun-04 17:01
Instrument: DSC Q 1000 V7.3 Build 249

FIG.43

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FIG.44

FIG.45

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FIG.46

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,465,800 B2
APPLICATION NO. : 10/934863
DATED : December 16, 2008
INVENTOR(S) : Jaworsky et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 966 days.

Signed and Sealed this
Fifteenth Day of May, 2012

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office

EXHIBIT B

US007855217B2

(12) **United States Patent**
Jaworsky et al.

(10) **Patent No.: US 7,855,217 B2**
(45) **Date of Patent: *Dec. 21, 2010**

(54) **POLYMORPHIC FORMS OF 3-(4-AMINO-1-OXO-1,3 DIHYDRO-ISOINDOL-2-YL)-PIPERIDINE-2,6-DIONE**

(75) Inventors: **Markian S. Jaworsky**, Hopewell, NJ (US); **Roger Shen-Chu Chen**, Edison, NJ (US); **George W. Muller**, Bridgewater, NJ (US)

(73) Assignee: **Celgene Corporation**, Summit, NJ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 82 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/335,395**

(22) Filed: **Dec. 15, 2008**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(60) Provisional application No. 60/499,723, filed on Sep. 4, 2003.

(51) **Int. Cl.**
A61K 31/454 (2006.01)
C07D 401/04 (2006.01)

(52) **U.S. Cl.** **514/323**; 546/200

(58) **Field of Classification Search** 514/323; 546/200

See application file for complete search history.

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(57) **ABSTRACT**

Polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione are disclosed. Compositions comprising the polymorphic forms, methods of making the polymorphic forms and methods of their use are also disclosed.

10 Claims, 48 Drawing Sheets

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XRPD PATTERN OF FORM A
1500
1000
500
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 1

IR SPECTRUM OF FORM A

Fig. 2

RAMAN SPECTRUM OF FORM A

Fig. 3

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Fig. 4

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Fig. 5

XRPD PATTERN OF FORM B
10000
5000
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 6

IR SPECTRUM OF FORM B

Fig. 7

RAMAN SPECTRUM OF FORM B

Fig. 8

TGA (TOP) AND DSC (BOTTOM) OF FORM B
TGA
Weight (%)
Deriv.Weight (%/°C)
3.100%
(0.2519mg)
Temperature (°C)
DSC
Heat Flow (W/g)
146.16°C
268.32°C
Temperature (°C)

Fig. 9

TG-IR RESULTS FOR FORM B

Fig. 10

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Fig. 11

XRPD PATTERN OF FORM C
6000
4000
2000
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 12

IR SPECTRUM OF FORM C

Fig. 13

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RAMAN SPECTRUM OF FORM C

Fig. 14

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Fig. 15

TG-IR RESULTS FOR FORM C

Fig. 16

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Fig. 17

XRPD PATTERN OF FORM D
4000
3000
2000
1000
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 18

IR SPECTRUM OF FORM D

Fig. 19

RAMAN SPECTRUM OF FORM D

Fig. 20

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TGA (TOP) AND DSC (BOTTOM) OF FORM D

Fig. 21

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Fig. 22

XRPD PATTERN OF FORM E
3000
2000
1000
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 23

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Fig. 24

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Fig. 25

XRPD PATTERN OF FORM F

Fig. 26

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DSC THERMOGRAM FOR FORM F

Fig. 27

XRPD PATTERN OF FORM G
400
300
200
100
0
5
10
15
20
25
30
35
40
Theta-2Theta (deg)

Fig. 28

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Fig. 29

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Fig. 30

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TGA (TOP) AND DSC (BOTTOM) OF FORM H

Fig. 31

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Fig. 32

Fig. 33

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Fig. 34

Fig. 35

XRPD PATTERN OF POLYMORPH MIXTURE
File: Process 5222-161-A
Date: 06-11-04 12:39 Step: 0.020° Cnt Time: 0.500 Sec.
Range: 1.50 - 40.00 (Deg) Step Scan Rate: 2.40 Deg/min
CPS
4600
4200
3800
3400
3000
2600
2200
1800
1400
1000
600
200
2.0
5.0
8.0
11.0
14.0
17.0
20.0
23.0
26.0
29.0
32.0
35.0
38.0
Deg.

Fig. 36

TGA CURVE OF POLYMORPH B
Sample: 5274-104-B
Size: 7.8320 mg
Method: Ramp
TGA
Run Date: 509-Jun-04 17:04
Instrument: TGA 0.500 V5.3 Build 171
3.712%
(0.2907 mg)
Weight (%)
Temperature (°C)

Fig. 37

TGA CURVE OF POLYMORPH B
Sample: 5274-100-C
Size: 10.9430 mg
Method: Ramp
Comment: Evotec Batch 1675C H2O
TGA
Run Date: 509-Jun-04 11:20
Instrument: TGA 0.500 V5.3 Build 171
3.952%
(0.4324 mg)
Weight (%)
Temperature (°C)

Fig. 38

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Fig. 39

Fig. 40

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TGA CURVE OF POLYMORPH MIXTURE

Fig. 41

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Fig. 42

Fig. 43

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Fig. 44

Fig. 45

DSC OF POLYMORPH MIXTURE
Sample: 5222-161-A
Size: 0.0000 mg
Method: Cell constant calibration
Comment: OAI batch 15
DSC
Run Date: 11-JUN-04 12:44
Instrument: DSC Q 1000 V7.3 Build 249
91.17°C
(30.91 mJ)
151.30°C
(189.7 mJ)
267.93°C
(424.9 mJ)
107.01°C
153.91°C
269.86°C
Heat Flow (mW)
2
0
-2
-4
-6
-8
0
50
100
150
200
250
300
Temperature (°C)

Fig. 46

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Fig. 47

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Fig. 48

UV-VIS SCAN OF 0.008MG/ML SOLUTION
0.008mg/mL in Dissolution Medium
Absorbance
2.0000
1.5000
1.0000
0.5000
0.0000
-0.5000
200.0
250.0
300.0
350.0
Wavelength (nm)

Fig. 49

CALIBRATION CURVE FOR
3-(4-AMINO-1-OXO-1,3 DIHYDROISOINDOL-2-YL)-PIPERIDINE-2,6-DIONE
y=46.962x -0.0062
R2=0.9999
Absorbance
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
0.0000
0.0050
0.0100
0.0150
0.0200
0.0250
Concentration (mg/mL)

Fig. 50

SOLUBILITY OF FORM A
Concentration (mg/mL)
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
0
15
30
45
60
75
90
105
120
135
150
Time (min)

Fig. 51

SOLUBILITY OF FORM B
Concentration (mg/mL)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0
60
120
180
240
300
360
420
480
540
600
660
Time (min)

Fig. 52

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FIG.53

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FIG.54

POLYMORPHIC FORMS OF 3-(4-AMINO-1-OXO-1,3 DIHYDRO-ISOINDOL-2-YL)-PIPERIDINE-2,6-DIONE

This application is a divisional application of U.S. patent application Ser. No. 10/934,863, filed Sep. 3, 2004, now U.S. Pat. No. 7,465,800 presently pending, which claims the benefit of U.S. provisional application 60/499,723, filed Sep. 4, 2003, the contents of each of which are incorporated by reference herein in their entireties.

1. FIELD OF THE INVENTION

This invention relates to polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione, compositions comprising the polymorphic forms, methods of making the polymorphic forms and methods of their use for the treatment of diseases and conditions including, but not limited to, inflammatory diseases, autoimmune diseases, and cancer.

2. BACKGROUND OF THE INVENTION

Many compounds can exist in different crystal forms, or polymorphs, which exhibit different physical, chemical, and spectroscopic properties. For example, certain polymorphs of a compound may be more readily soluble in particular solvents, may flow more readily, or may compress more easily than others. See, e.g., P. DiMartino, et al., *J. Thermal Anal.,* 48:447-458 (1997). In the case of drugs, certain solid forms may be more bioavailable than others, while others may be more stable under certain manufacturing, storage, and biological conditions. This is particularly important from a regulatory standpoint, since drugs are approved by agencies such as the U.S. Food and Drug Administration only if they meet exacting purity and characterization standards. Indeed, the regulatory approval of one polymorph of a compound, which exhibits certain solubility and physico-chemical (including spectroscopic) properties, typically does not imply the ready approval of other polymorphs of that same compound.

Polymorphic forms of a compound are known in the pharmaceutical arts to affect, for example, the solubility, stability, flowability, fractability, and compressibility of the compound, as well as the safety and efficacy of drug products comprising it. See, e.g., Knapman, K. *Modern Drug Discoveries,* 2000, 53. Therefore, the discovery of new polymorphs of a drug can provide a variety of advantages.

U.S. Pat. Nos. 5,635,517 and 6,281,230, both to Muller et al., disclose 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione, which is useful in treating and preventing a wide range of diseases and conditions including, but not limited to, inflammatory diseases, autoimmune diseases, and cancer. New polymorphic forms of 3-(4 amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione can further the development of formulations for the treatment of these chronic illnesses, and may yield numerous formulation, manufacturing and therapeutic benefits.

3. SUMMARY OF THE INVENTION

This invention encompasses polymorphs of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. In certain aspects, the invention provides polymorphs of the compound identified herein as forms A, B, C, D, E, F, G, and H. The invention also encompasses mixtures of these forms. In further embodiments, this invention provides methods of making, isolating and characterizing the polymorphs.

This invention also provides pharmaceutical compositions and single unit dosage forms comprising a polymorph of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. The invention further provides methods for the treatment or prevention of a variety of diseases and disorders, which comprise administering to a patient in need of such treatment or prevention a therapeutically effective amount of a polymorph of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

4. BRIEF DESCRIPTION OF THE DRAWINGS

Specific aspects of the invention can be understood with reference to the attached figures:

FIG. **1** provides a representative X-ray powder diffraction (XRPD) pattern of Form A;

FIG. **2** provides a representative IR spectrum of Form A;

FIG. **3** provides a representative Raman spectrum of Form A;

FIG. **4** provides a representative thermogravimetric analysis (TGA) curve and a representative differential scanning calorimeter (DSC) thermogram of Form A;

FIG. **5** provides a representative moisture sorption/desorption isotherm of Form A;

FIG. **6** provides a representative XRPD pattern of Form B;

FIG. **7** provides a representative IR spectrum of Form B;

FIG. **8** provides a representative Raman spectrum of Form B;

FIG. **9** provides a representative TGA curve and a representative DSC thermogram of Form B;

FIG. **10** provides representative TG-IR results of Form B;

FIG. **11** provides a representative moisture sorption/desorption isotherm of Form B;

FIG. **12** provides a representative XRPD pattern of Form C;

FIG. **13** provides a representative IR spectrum of Form C;

FIG. **14** provides a representative Raman spectrum of Form C;

FIG. **15** provides a representative TGA curve and a representative DSC thermogram of Form C;

FIG. **16** provides representative TG-IR results of Form C;

FIG. **17** provides a representative moisture sorption/desorption isotherm of Form C;

FIG. **18** provides a representative XRPD pattern of Form D;

FIG. **19** provides a representative IR spectrum of Form D;

FIG. **20** provides a representative Raman spectrum of Form D;

FIG. **21** provides a representative TGA curve and a representative DSC thermogram of Form D;

FIG. **22** provides a representative moisture sorption/desorption isotherm of Form D;

FIG. **23** provides a representative XRPD pattern of Form E;

FIG. **24** provides a representative TGA curve and a representative DSC thermogram of Form E;

FIG. **25** provides a representative moisture sorption/desorption isotherm of Form E;

FIG. **26** provides a representative XRPD pattern for a sample of Form F;

FIG. **27** provides a representative thermogram of Form F;

FIG. **28** provides a representative XRPD pattern of Form G;

FIG. **29** provides a representative DSC thermogram for a sample of Form G;

FIG. **30** provides a representative XRPD pattern of Form H;

FIG. **31** provides a representative TGA curve and a representative DSC thermogram of Form H;

FIG. **32** provides a representative XRPD pattern of Form B;

FIG. **33** provides a representative XRPD pattern of Form B;

FIG. **34** provides a representative XRPD pattern of Form B;

FIG. **35** provides a representative XRPD pattern of Form E;

FIG. **36** provides a representative XRPD pattern of polymorph mixture;

FIG. **37** provides a representative TGA curve of Form B;

FIG. **38** provides a representative TGA curve of Form B;

FIG. **39** provides a representative TGA curve of Form B;

FIG. **40** provides a representative TGA curve of Form E;

FIG. **41** provides a representative TGA curve of polymorph mixture;

FIG. **42** provides a representative DSC thermogram of Form B;

FIG. **43** provides a representative DSC thermogram of Form B;

FIG. **44** provides a representative DSC thermogram of Form B;

FIG. **45** provides a representative DSC thermogram of Form E;

FIG. **46** provides a representative DSC thermogram of polymorph mixture;

FIG. **47** provides a UV-V is scan of dissolution medium;

FIG. **48** provides a UV-Vis scan of 0.04 mg/ml of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in dissolution medium;

FIG. **49** provides a UV-Vis scan of 0.008 mg/ml of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in dissolution medium;

FIG. **50** provides a calibration curve for 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione;

FIG. **51** provides a solubility curve of Form A;

FIG. **52** provides a solubility curve of Form B;

FIG. **53** provides an intrinsic dissolution of Forms A, B and E; and

FIG. **54** provides an intrinsic dissolution of Forms A, B and E.

5. DETAILED DESCRIPTION OF THE INVENTION

5.1 Definitions

As used herein and unless otherwise indicated, the terms "treat," "treating" and "treatment" refer to the alleviation of a disease or disorder and/or at least one of its attendant symptoms.

As used herein and unless otherwise indicated, the terms "prevent," "preventing" and "prevention" refer to the inhibition of a symptom of a disease or disorder or the disease itself.

As used herein and unless otherwise indicated, the terms "polymorph" and "polymorphic form" refer to solid crystalline forms of a compound or complex. Different polymorphs of the same compound can exhibit different physical, chemical and/or spectroscopic properties. Different physical properties include, but are not limited to stability (e.g., to heat or light), compressibility and density (important in formulation and product manufacturing), and dissolution rates (which can affect bioavailability). Differences in stability can result from changes in chemical reactivity (e.g., differential oxidation, such that a dosage form discolors more rapidly when comprised of one polymorph than when comprised of another polymorph) or mechanical characteristics (e.g., tablets crumble on storage as a kinetically favored polymorph converts to thermodynamically more stable polymorph) or both (e.g., tablets of one polymorph are more susceptible to breakdown at high humidity). Different physical properties of polymorphs can affect their processing. For example, one polymorph might be more likely to form solvates or might be more difficult to filter or wash free of impurities than another due to, for example, the shape or size distribution of particles of it.

Polymorphs of a molecule can be obtained by a number of methods known in the art. Such methods include, but are not limited to, melt recrystallization, melt cooling, solvent recrystallization, desolvation, rapid evaporation, rapid cooling, slow cooling, vapor diffusion and sublimation. Polymorphs can be detected, identified, classified and characterized using well-known techniques such as, but not limited to, differential scanning calorimetry (DSC), thermogravimetry (TGA), X-ray powder diffractometry (XRPD), single crystal X-ray diffractometry, vibrational spectroscopy, solution calorimetry, solid state nuclear magnetic resonance (NMR), infrared (IR) spectroscopy, Raman spectroscopy, hot stage optical microscopy, scanning electron microscopy (SEM), electron crystallography and quantitative analysis, particle size analysis (PSA), surface area analysis, solubility, and rate of dissolution.

As used herein to refer to the spectra or data presented in graphical form (e.g., XRPD, IR, Raman and NMR spectra), and unless otherwise indicated, the term "peak" refers to a peak or other special feature that one skilled in the art would recognize as not attributable to background noise. The term "significant peaks" refers to peaks at least the median size (e.g., height) of other peaks in the spectrum or data, or at least 1.5, 2, or 2.5 times the median size of other peaks in the spectrum or data.

As used herein and unless otherwise indicated, the term "substantially pure" when used to describe a polymorph of a compound means a solid form of the compound that comprises that polymorph and is substantially free of other polymorphs of the compound. A representative substantially pure polymorph comprises greater than about 80% by weight of one polymorphic form of the compound and less than about 20% by weight of other polymorphic forms of the compound, more preferably greater than about 90% by weight of one polymorphic form of the compound and less than about 10% by weight of the other polymorphic forms of the compound, even more preferably greater than about 95% by weight of one polymorphic form of the compound and less than about 5% by weight of the other polymorphic forms of the compound, and most preferably greater than about 97% by weight of one polymorphic forms of the compound and less than about 3% by weight of the other polymorphic forms of the compound.

5.2 Polymorphic Forms

This invention is directed to polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione, which has the structure shown below:

This compound can be prepared according to the methods described in U.S. Pat. Nos. 6,281,230 and 5,635,517, the entireties of which are incorporated herein by reference. For

example, the compound can be prepared through catalytic hydrogenation of 3-(4-nitro-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. 3-(4-Nitro-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione can be obtained by allowing 2,6-dioxopiperidin-3-ammonium chloride to react with methyl 2-bromomethyl-4-nitrobenzoate in dimethylformamide in the presence of triethylamine. The methyl 2-bromomethyl-4-nitrobenzoate in turn is obtained from the corresponding methyl ester of nitro-ortho-toluic acid by conventional bromination with N-bromosuccinimide under the influence of light.

Polymorphs of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione can be obtained by techniques known in the art, including solvent recrystallization, desolvation, vapor diffusion, rapid evaporation, slow evaporation, rapid cooling and slow cooling. Polymorphs can be made by dissolving a weighed quantity of 3-(4-amino-1-oxo-1,3 dihydro isoindol-2-yl)-piperidine-2,6-dione in various solvents at elevated temperatures. The solutions of the compound can then be filtered and allowed to evaporate either in an open vial (for fast hot evaporation) or in a vial covered with aluminum foil containing pinholes (hot slow evaporation). Polymorphs can also be obtained from slurries. Polymorphs can be crystallized from solutions or slurries using several methods. For example, a solution created at an elevated temperature (e.g., 60° C.) can be filtered quickly then allowed to cool to room temperature. Once at room temperature, the sample that did not crystallize can be moved to a refrigerator then filtered. Alternatively, the solutions can be crash cooled by dissolving the solid in a solvent at an increased temperature (e.g., 45-65° C.) followed by cooling in a dry ice/solvent bath.

One embodiment of the invention encompasses Form A of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form A is an unsolvated, crystalline material that can be obtained from non-aqueous solvent systems. Another embodiment of the invention encompasses Form B of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form B is a hemihydrated, crystalline material that can be obtained from various solvent systems. Another embodiment of the invention encompasses Form C of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form C is a hemisolvated crystalline material that can be obtained from solvents such as, but not limited to, acetone. Another embodiment of the invention encompasses Form D of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form D is a crystalline, solvated polymorph prepared from a mixture of acetonitrile and water. Another embodiment of the invention encompasses Form E of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form E is a dihydrated, crystalline material. Another embodiment of the invention encompasses Form F of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form F is an unsolvated, crystalline material that can be obtained from the dehydration of Form E. Another embodiment of the invention encompasses Form G of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form G is an unsolvated, crystalline material that can be obtained from slurrying forms B and E in a solvent such as, but not limited to, tetrahydrofuran (THF). Another embodiment of the invention encompasses Form H of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Form H is a partially hydrated crystalline material that can be obtained by exposing Form E to 0% relative humidity. Each of these forms is discussed in detail below.

Another embodiment of the invention encompasses a composition comprising amorphous 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione and crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione of form A, B, C, D, E, F, G or H. Specific compositions can comprise greater than about 50, 75, 90 or 95 weight percent crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

Another embodiment of the invention encompasses a composition comprising at least two crystalline forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione (e.g., a mixture of polymorph forms B and E).

5.2.1 Form A

The data described herein for Form A, as well as for Forms B-H, were obtained using the experimental methods described in Examples 6.3-6.7, provided below.

Form A can be obtained from various solvents, including, but not limited to 1-butanol, butyl acetate, ethanol, ethyl acetate, methanol, methyl ethyl ketone, and THF. FIG. **1** shows a representative XRPD pattern of Form A. The pattern is characterized by peaks, preferably significant peaks, at approximately 8, 14.5, 16, 17.5, 20.5, 24, and 26 degrees 2θ. Representative IR and Raman spectra data are provided in FIGS. **2** and **3**.

Representative thermal characteristics of Form A are shown in FIG. **4**. TGA data show a small weight increase up to about 150° C., indicating an unsolvated material. Weight loss above 150° C. is attributed to decomposition. The DSC curve of Form A exhibits an endotherm at about 270° C.

Representative moisture sorption and desorption data are plotted in FIG. **5**. Form A does not exhibit a significant weight gain from 5 to 95% relative humidity. Equilibrium can be obtained at each relative humidity step. As the form dries from 95% back down to 5% relative humidity, it tends to maintain its weight such that at 5% relative humidity it has typically lost only about 0.003% by weight from start to finish Form A is capable of remaining a crystalline solid for about 11 days when stored at about 22, 45, 58, and 84% relative humidity.

Interconversion studies show that Form A can convert to Form B in aqueous solvent systems and can convert to Form C in acetone solvent systems. Form A tends to be stable in anhydrous solvent systems. In water systems and in the presence of Form E, Form A tends to convert to Form E.

When stored for a period of about 85 days under two different temperature/relative humidity stress conditions (room temperature/0% relative humidity (RH) and 40° C./93% RH), Form A typically does not convert to a different form.

In sum, Form A is a crystalline, unsolvated solid that melts at approximately 270° C. Form A is weakly or not hygroscopic and appears to be the most thermodynamically stable anhydrous polymorph of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione discovered thus far.

5.2.2 Form B

Form B can be obtained from many solvents, including, but not limited to, hexane, toluene, and water. FIG. **6** shows a representative XRPD pattern of Form B, characterized by peaks at approximately 16, 18, 22 and 27 degrees 2θ.

Solution proton NMR confirm that Form B is a form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Representative IR and Raman spectra are shown in FIGS. **7** and **8**, respectively. Compared to Form A, the IR spectrum for Form B has peaks at approximately 3513 and 1960 cm^{-1}.

Representative DSC and TGA data for Form B are shown in FIG. **9**. The DSC curve exhibits endotherms at about 146 and 268° C. These events are identified as dehydration and melting by hot stage microscopy experiments. Form B typically loses about 3.1% volatiles up to about 175° C. (per

approximately 0.46 moles of water). Comparison of the IR spectrum of the volatiles with that of water indicates that they are water (See FIG. **10**). Calculations from TGA data indicate that Form B is a hemihydrate. Karl Fischer water analysis also supports this conclusion.

Representative moisture sorption and desorption data are shown in FIG. **11**. Form B typically does not exhibit a significant weight gain from 5% to 95% relative humidity, when equilibrium is obtained at each relative humidity step. As Form B dries from 95% back down to 5% relative humidity, it tends to maintain its weight such that at 5% relative humidity it typically has gained only about 0.022% by weight (about 0.003 mg) from start to finish Form B does not convert to a different form upon exposure to about 84% relative humidity for about ten days.

Interconversion studies show that Form B typically converts to Form A in a THF solvent system, and typically converts to Form C in an acetone solvent system. In aqueous solvent systems such as pure water and 10% water solutions, Form B is the most stable of the polymorphic forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. However, it can convert to Form E in the presence of water. Desolvation experiments show that upon heating at about 175° C. for about five minutes, Form B typically converts to Form A.

When stored for a period of about 85 days under two different temperature/relative humidity stress conditions (room temperature/0% RH and 40° C./93% RH), Form B does not convert to a different form.

In sum, Form B is a hemihydrated, crystalline solid which has a DSC thermogram exhibiting endotherms at about 146 and about 268° C. Interconversion studies show that Form B converts to Form E in aqueous solvent systems, and converts to other forms in acetone and other anhydrous systems.

5.2.3 Form C

Form C can be obtained from evaporations, slurries and slow cools in acetone solvent systems. A representative XRPD pattern of this form is shown in FIG. **12**. The data are characterized by peaks at approximately 15.5 and 25 degrees 2θ.

Solution proton NMR indicates that the 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione molecule is intact. Representative IR and Raman spectra are shown in FIGS. **13** and **14**, respectively. The IR spectrum of Form C is characterized by peaks at approximately 3466, 3373, and 3318 cm^{-1}. The Raman spectrum of Form C is characterized by peaks at about 3366, 3321, 1101, and 595 cm^{-1}.

Representative thermal characteristics for Form C are plotted in FIG. **15**. Form C loses about 10.02% volatiles up to about 175° C., indicating it is a solvated material. Weight loss above about 175° C. is attributed to decomposition. Identification of volatiles in Form C can be accomplished with TG-IR experiments. The representative IR spectrum captured after several minutes of heating, as depicted in FIG. **13**, when compared with a spectral library, shows acetone to be the best match. Calculations from TGA data show that Form C is a hemisolvate (approximately 0.497 moles of acetone). The DSC curve for Form C, shown in FIG. **15**, exhibits endotherms at about 150 and about 269° C. The endotherm at about 150° C. is attributed to solvent loss based on observations made during hot stage microscopy experiments. The endotherm at about 269° C. is attributed to the melt based on hot stage experiments.

Representative moisture sorption and desorption balance data are shown in FIG. **17**. Form C does not exhibit a significant weight gain from 5 to 85% relative humidity, when equilibrium is obtained at each relative humidity step up to 85% relative humidity. At 95% relative humidity, Form C experiences a significant weight loss of about 6.03%. As the sample dries from 95% back down to 5% relative humidity, the sample maintains the weight achieved at the end of the adsorption phase at each step down to 5% relative humidity. Form C is capable of converting to Form B when stored at about 84% relative humidity for approximately ten days.

Interconversion studies show that Form C typically converts to Form A in a THF solvent system and typically converts to Form E in an aqueous solvent system. In an acetone solvent system, Form C is the most stable form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Desolvation experiments performed on Form C show that upon heating at about 150° C. for about five minutes, Form C will typically convert to Form A.

In sum, Form C is a crystalline, hemisolvated solid, which has a DSC thermogram exhibiting endotherms at about 150 and about 269° C. Form C is not hygroscopic below about 85% RH, but can convert to Form B at higher relative humidities.

5.2.4 Form D

Form D can be obtained from evaporation in acetonitrile solvent systems. A representative XRPD pattern of the form is shown in FIG. **18**. The pattern is characterized by peaks at approximately 27 and 28 degrees 2θ.

Solution proton NMR indicates that the 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione molecule is intact. Representative IR and Raman spectra are shown in FIGS. **19** and **20**, respectively. The IR spectrum of Form D is characterized by peaks at approximately 3509, 2299, and 2256 cm^{-1}. The Raman spectrum of Form D is characterized by peaks at approximately 2943, 2889, 2297, 2260, 1646, and 1150 cm^{-1}.

Representative thermal characteristics for Form D are plotted in FIG. **21**. Form D loses about 6.75% volatiles up to about 175° C., indicating a solvated material. Weight loss above about 175° C. is attributed to decomposition. TG-IR experiments indicate that the volatiles are water and acetonitrile. Calculations from TG data show that about one mole of water is present in the sample. A representative DSC curve for Form D exhibits endotherms at about 122 and about 270° C. The endotherm at about 122° C. is attributed to loss of volatiles based on observations made during hot stage microscopy experiments. The endotherm at about 270° C. is attributed to the melt based on hot stage experiments.

Representative moisture sorption and desorption data are plotted in FIG. **22**. Form D does not exhibit a significant weight gain from 5 to 95% relative humidity when equilibrium is obtained at each relative humidity step. As the form dries from 95% back down to 5% relative humidity, it maintains its weight such that at 5% relative humidity the form has typically gained only about 0.39% by weight (about 0.012 mg) from start to finish. Form A is capable of converting to Form B when stored at about 84% relative humidity for approximately ten days.

Interconversion studies show that Form D is capable of converting to Form A in a THF solvent system, to Form E in an aqueous solvent system, and to Form C in an acetone solvent system. Desolvation experiments performed on Form D show that upon heating at about 150° C. for about five minutes Form D will typically convert to Form A.

In sum, Form D is a crystalline solid, solvated with both water and acetonitrile, which has a DSC thermogram exhibiting endotherms at about 122 and about 270° C. Form D is either weakly or not hygroscopic, but will typically convert to Form B when stressed at higher relative humidities.

5.2.5 Form E

Form E can be obtained by slurrying 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in water and by a slow evaporation of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in a solvent system with a ratio of about 9:1 acetone:water. A representative XRPD pattern is shown in FIG. **23**. The data are characterized by peaks at approximately 20, 24.5 and 29 degrees 2θ.

Representative thermal characteristics of Form E are plotted in FIG. **24**. Form E typically loses about 10.58% volatiles up to about 125° C., indicating that it is a solvated material. A second weight loss of an additional about 1.38% was observed between about 125° C. and about 175° C. Weight loss above about 175° C. is attributed to decomposition. Karl Fischer and TG-IR experiments support the conclusion that the volatile weight loss in Form E is due to water. The representative DSC curve for Form E exhibits endotherms at about 99, 161 and 269° C. Based on observations made during hot stage microscopy experiments, the endotherms at about 99 and about 161° C. are attributed to loss of volatiles. The endotherm at about 269° C. is attributed to the melt based on hot stage experiments.

Representative moisture sorption and desorption data are plotted in FIG. **25**. Form E typically does not exhibit a significant weight change from 5 to 95% relative humidity when equilibrium is obtained at each relative humidity step. As the sample dried from 95% back down to 5% relative humidity, the sample continues to maintain weight such that at 5% relative humidity the sample has lost only about 0.0528% by weight from start to finish.

Interconversion studies show that Form E can convert to Form C in an acetone solvent system and to Form G in a THF solvent system. In aqueous solvent systems, Form E appears to be the most stable form. Desolvation experiments performed on Form E show that upon heating at about 125° C. for about five minutes, Form E can convert to Form B. Upon heating at 175° C. for about five minutes, Form B can convert to Form F.

When stored for a period of 85 days under two different temperature/relative humidity stress conditions (room temperature/0% RH and 40° C./93% RH) Form E typically does not convert to a different form. When stored for seven days at room temperature/0% RH, Form E can convert to a new form, Form H.

5.2.6 Form F

Form F can be obtained by complete dehydration of Form E. A representative XRPD pattern of Form F, shown in FIG. **26**, is characterized by peaks at approximately 19, 19.5 and 25 degrees 2θ.

Representative thermal characteristics of Form F are shown in FIG. **27**. The representative DSC curve for Form F exhibits an endotherm at about 269° C. preceded directly by two smaller endotherms indicative of a crystallized form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. The DSC thermogram does not show any thermal events prior to the melt, suggesting that it is an unsolvated material.

5.2.7 Form G

Form G can be obtained by slurrying forms B and E in THF. A representative XRPD pattern of this form, shown in FIG. **28**, is characterized by a peak at approximately 23 degrees 2θ. Two other peaks unique to Form G appear at approximately 21 and 24.5 degrees 2θ.

Representative thermal characteristics of Form G are plotted in FIG. **29**. A representative DSC curve for Form G exhibits an endotherm at about 248° C. followed by a small, broad exotherm at about 267° C. No thermal events are seen in the DSC thermogram at lower temperatures, suggesting that it is an unsolvated material.

5.2.8 Form H

Form H can be obtained by storing Form E at room temperature and 0% RH for about 7 days. A representative XRPD pattern is shown in FIG. **30**. The pattern is characterized by a peak at 15 degrees 2θ, and two other peaks at 26 and 31 degrees 2θ.

Representative thermal characteristics are shown in FIG. **31**. Form H loses about 1.67% volatiles up to about 150° C. Weight loss above about 150° C. is attributed to decomposition. Karl Fischer data shows that Form H typically contains about 1.77% water (about 0.26 moles), suggesting that the weight loss seen in the TG is due to dehydration. The DSC thermogram shows a broad endotherm between about 50° C. and about 125° C., corresponding to the dehydration of Form H and a sharp endotherm at about 269° C., which is likely due to a melt.

When slurried in water with either Forms A or B, after about 14 days Form H can convert to Form E. When slurried in THF, Form H can convert to Form A. When slurried in acetone, Form H can convert to Form C.

In sum, Form H is a crystalline solid, hydrated with about 0.25 moles of water, which has a DSC thermogram exhibiting an endotherm between about 50 and 125° C. and an endotherm at about 269° C.

5.3 Methods of Use and Pharmaceutical Compositions

Polymorphs of the invention exhibit physical characteristics that are beneficial for drug manufacture, storage or use. All polymorphs of the invention have utility as pharmaceutically active ingredients or intermediates thereof.

This invention encompasses methods of treating and preventing a wide variety of diseases and conditions using polymorphs of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione. In each of the methods, a therapeutically or prophylactically effective amount of the compound is administered to a patient in need of such treatment or prevention. Examples of such disease and conditions include, but are not limited to, diseases associated with undesired angiogenesis, cancer (e.g., solid and blood borne tumors), inflammatory diseases, autoimmune diseases, and immune diseases. Examples of cancers and pre-cancerous conditions include those described in U.S. Pat. Nos. 6,281,230 and 5,635,517 to Muller et al. and in various U.S. patent applications to Zeldis, including application Ser. Nos. 10/411,649, filed Apr. 11, 2003 (Treatment of Myelodisplastic Syndrome); 10/438,213 filed May 15, 2003 (Treatment of Various Types of Cancer); 10/411,656, filed Apr. 11, 2003 (Treatment of Myeloproliferative Diseases). Examples of other diseases and disorders that can be treated or prevented using compositions of the invention are described in U.S. Pat. Nos. 6,235,756 and 6,114,335 to D'Amato and in other U.S. patent applications to Zeldis, including Ser. Nos. 10/693,794, filed Oct. 23, 2003 (Treatment of Pain Syndrome) and 10/699,154, filed Oct. 30, 2003 (Treatment of Macular Degeneration). The entirety of each of the patents and patent applications cited herein is incorporated herein by reference.

Depending on the disease to be treated and the subject's condition, polymorphs of the invention can be administered by oral, parenteral (e.g., intramuscular, intraperitoneal, intravenous, ICV, intracisternal injection or infusion, subcutaneous injection, or implantation), inhalation spray, nasal, vaginal, rectal, sublingual, or topical routes of administration and may be formulated, alone or together, in suitable dosage unit

formulations containing conventional non-toxic pharmaceutically acceptable carriers, adjuvants and vehicles appropriate for each route of administration. Because individual polymorphs have different dissolution, stability, and other properties, the optimal polymorph used in methods of treatment may depend on the route of administration. For example, forms that are readily soluble in aqueous solutions are preferably used to provide liquid dosage forms, whereas forms that exhibit great thermal stability may be preferred in the manufacture of solid dosage forms (e.g., tablets and capsules).

Although the physical characteristics of polymorphs can, in some cases, affect their bioavailability, amounts of the polymorphs that are therapeutically or prophylactically effective in the treatment of various disease and conditions can be readily determined by those of ordinary skill in the pharmacy or medical arts. In certain embodiments of the invention, a polymorph is administered orally and in a single or divided daily doses in an amount of from about 0.10 to about 150 mg/day, or from about 5 to about 25 mg/day. In other embodiments, a polymorph is administered every other day in an amount of from about 0.10 to about 150 mg/day, or from about 5 to about 25 mg/day.

The invention encompasses pharmaceutical compositions and single unit dosage forms that can be used in methods of treatment and prevention, which comprise one or more polymorphs of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione and optionally one or more excipients or diluents. Specific compositions and dosage forms are disclosed in the various patents and patent applications incorporated herein by reference. In one embodiment, a single dosage form comprises a polymorph (e.g., Form B) in an amount of about 5, 10, 25 or 50 mg.

6. EXAMPLES

6.1 Polymorph Screen

A polymorph screen to generate the different solid forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione was carried out as follows.

A weighed sample of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione (usually about 10 mg) was treated with aliquots of the test solvent. Solvents were either reagent or HPLC grade. The aliquots were usually about 200 μL. Between additions, the mixture was usually shaken or sonicated. When the solids dissolved, as judged by visual inspection, estimated solubilities were calculated. Solubilities were estimated from these experiments based on the total solvent used to provide a solution. Actual solubilities may have been greater than those calculated due to the use of too-large solvent aliquots or to a slow rate of dissolution.

Samples were created by generating solutions (usually about 30 mg in 20 mL) at elevated temperatures, filtering, and allowing the solution to evaporate whether in an open vial (hot fast evaporation) or in a vial covered with aluminum foil containing pinholes (hot slow evaporation).

Slurry experiments were also performed. Usually about 25 mg of solid was placed in either 3 or 5 mL of solvent. The samples were then placed on orbital shakers at either ambient temperature or 40° C. for 410 days.

Crystallizations were performed using various cooling methods. Solid was dissolved in a solvent at an elevated temperature (e.g., about 60° C.), filtered quickly and allowed to cool to room temperature. Once at room temperature, samples that did not crystallize were moved to a refrigerator. Solids were removed by filtration or decantation and allowed to dry in the air. Crash cools were performed by dissolving solid in a solvent at an increased temperature (e.g., about 45-65° C.) followed by cooling in a dry ice/acetone bath.

Hygroscopicity studies were performed by placing portions of each polymorph in an 84% relative humidity chamber for approximately one week.

Desolvation studies were carried out by heating each polymorph in a 70° C. oven for approximately one week.

Interconversion experiments were carried out by making slurries containing two forms in a saturated solvent. The slurries were agitated for approximately 7-20 days at ambient temperature. The insoluble solids were recovered by filtration and analyzed using XRPD.

6.2 Preparation of Polymorphic Forms

Eight solid forms of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione were prepared as described below.

Form A was obtained by crystallization from various non-aqueous solvents including 1-butanol, butyl acetate, ethanol, ethyl acetate, methanol, methyl ethyl ketone, and tetrahydrofuran. Form B was also obtained by crystallization from the solvents hexane, toluene and water. Form C was obtained from evaporations, slurries, and slow cools in acetone solvent systems. Form D was obtained from evaporations in acetonitrile solvent systems. Form E was obtained most readily by slurrying 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione in water. Form F was obtained by complete desolvation of Form E. It is found to be an unsolvated, crystalline material that melts at about 269° C. Form G was obtained by slurrying forms B and E in THF. Form H was obtained by stressing Form E at room temperature and 0% RH for 7 days.

6.2.1 Synthesis of Polymorphs B and E

Form B is the desired polymorph for the active pharmaceutical ingredient (API) of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. This form has been used in the formulation of API into drug product for clinical studies. Three batches were produced as apparent mixtures of polymorphs in the non-micronized API of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

Development work was carried out to define a process that would generate polymorph B from this mixture of polymorphs and could be implemented for strict polymorphic controls in the validation batches and future manufacturing of API of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Characterization of polymorphic forms produced during the work was performed by XRPD, DSC, TGA and KF.

A process was also developed for the large-scale preparation of Form E. Polymorph E material was prepared in order to carry out a comparison with polymorph B drug product in capsule dissolution testing of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. 150 g of a mixture of polymorphs in 3 L of water was stirred at room temperature for 48 hours. The product was collected by filtration and dried at 25° C. for 24 hours under vacuum. XRPD, DSC, TGA, KF and HPLC analyses confirmed that the material isolated was polymorph E.

In a preliminary work, it was demonstrated that stirring a suspension of a mixture of polymorphs of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione with water at high temperature (75° C.) for an extended period of time converted this mixture of polymorphs exclusively to form B. Several specific parameters were identified including temperature, solvent volume and drying parameters (temperature

and vacuum). XRPD, DSC, TGA, KF and HPLC analyses were used to characterize all of the batches. After completing the optimization work, the optimized process was scaled-up to 100-200 g on three lots of API. Drying studies were carried out at 20° C., 30° C. and 40° C., and 65° C. with a vacuum of 150 mm of Hg. The results are shown in Tables 1-5.

The cooling and holding periods of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione slurry were studied. The experimental laboratory data suggests that polymorph B seems to be forming first, and overtime equilibration to polymorph E at RT conditions occurs, therefore generating a mixture of polymorphs B and E. This result supports the fact that polymorph B seems to be a kinetic product, and that prolonged processing time converts the material to polymorph E resulting in a mixture of polymorphs B and E.

A laboratory procedure was developed to exclusively produce polymorph B of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. The procedure includes a stirred 10 volume water slurry at ~75° C. for 6-24 hours. The following preferred process parameters have been identified:

1. Hot slurry temperature of 70-75° C.
2. Product filtration of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)piperidine-2,6-dione at 65-75° C.
3. Drying under vacuum at 60-70° C. is preferred for an efficient removal of unbound water in 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione wet cake.
4. The filtration step of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione may be a time sensitive operation. The use of efficient solid-liquid separation equipment is preferred.
5. Holding periods of water-wet cake of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione at KF higher than 5% may cause the kinetic equilibrations of polymorph B to mixed polymorphs of E and B.

Drying to KF<4.0% water was achieved in ~3 hours (30-70° C., 152 mm Hg). Polymorphs B and E were distinguished by the water levels as measured by KF and TGA. The reference sample of polymorph B is micronized API. In order to make accurate comparison by XRPD samples were gently grinded before submission for analysis. This increases the clarity of the identification of the polymorphic form. All samples were analyzed for XRPD, DSC, TGA, KF and HPLC.

TABLE 1

Preliminary Studies

Amount	Reaction conditions	Analysis	Results/conclusion
2 g	Water, rt, 48 h	XRPD, DSC, TGA, KF	Polymorph E
25 g	Water, rt, 48 h	XRPD, DSC, TGA, KF	Polymorph E
5 g	Water, 70-75° C., 24 h then rt 24 h	XRPD, DSC, TGA, KF	Polymorph B
1 g	9:1 Acetone - water, Slow evpo.	XRPD, DSC, TGA, KF	Polymorph Mixture
1 g	175° C. 1 h in an oven	XRPD, DSC, TGA, KF	Polymorph A
0.5 g (polymorph A)	Water, rt, 24 h	XRPD, DSC, TGA, KF	Polymorph E
1 g polymorph B	Water, rt, 48 h	XRPD, DSC, TGA, KF	Polymorph E
1 g polymorph E	Water, 70-75° C., 24 h	XRPD, DSC, TGA, KF	Polymorph B
1 g	Slurry in heptane	XRPD, DSC, TGA, KF	No change

TABLE 2

Optimization of Temperature, Time and Solvent Volume

Amount	Amount Water (mL)	Temp (° C.)	Time (h)	Results/ conclusion
10 g	50	75	6	Mix
10 g	50	75	24	Polymorph B
10 g	100	70	6	Polymorph B
10 g	100	70	14	Polymorph B
10 g	100	70	21	Polymorph B
10 g	100	75	6	Polymorph B
10 g	100	75	24	Polymorph B
10 g	100	75	6	Polymorph B
10 g	100	75	19	Polymorph B
10 g	100	75	14	Polymorph B
10 g	100	75	24	Polymorph B
5 g	100	75	18	Polymorph B
10 g	100	80	6	Polymorph B
10 g	100	80	20	Polymorph B
10 g	200	45	6	Polymorph B + E
10 g	200	45	24	Polymorph E
10 g	200	60	48	Polymorph B
10 g	200	75	6	Mix
10 g	200	75	24	Polymorph B
10 g	200	75	13	Polymorph B
10 g	200	75	24	Polymorph B

Optimum conditions were determined to be 10 volumes of solvent (H_2O), 70-80° C. for 6-24 hours.

TABLE 3

Holding Time

Amount	Reaction Conditions	Holding Time (h)	Holding Temp (° C.)	Results/ Conclusion
5 g	Water, 70-75° C., 24 h	24	23-25	Polymorph B
1 g Polymorph B	Water, 70-75° C., 24 h	48	23-25	Polymorph E
2 g	Water, 40 mL	16	23-25	Polymorph E
150 g	Water, 3.0 L	24	23-25	Polymorph E
150 g	Water, 3.0 L	48	23-25	Polymorph E
10 g	Water, 100 mL, 24 h, 75° C.	18	23-25	Polymorph B
10 g	Water, 100 mL, 24 h, 75° C.	18	40	Polymorph B
10 g	Water, 200 mL, 24 h, 75° C.	14	−5	Mix
10 g	Water, 200 mL, 24 h, 75° C.	14	23-25	Polymorph E
10 g	Water, 200 mL, 24 h, 75° C.	14	40	Mix
10 g	Water, 100 mL, 24 h, 75° C.	21	23-25	Polymorph E
10 g	Water, 100 mL, 24 h, 75° C.	21	40	Mix
10 g	Water, 100 mL, 14 h, 75° C.	2	23-25	Mix

Holding time gave mixed results and it was determined that the material should be filtered at 60-65° C. and the material washed with 0.5 volume of warm (50-60° C.) water.

TABLE 4

Scale-up Experiments

Amount	Amount Water (L)	Temp (° C.)	Time (h)	Results/Conclusion
100 g	1.0	75	6	Polymorph B
100 g	1.0	75	22	Polymorph B

TABLE 4-continued

Scale-up Experiments				
Amount	Amount Water (L)	Temp (° C.)	Time (h)	Results/Conclusion
100 g	1.0	75	6	Polymorph B
100 g	1.0	75	24	Polymorph B
100 g	1.0	75	6	Polymorph B
100 g	1.0	75	22	Polymorph B

TABLE 5

Drying Studies					
Amount	Drying Time (h)	Drying Temp (° C.)	Vacuum (mm Hg)	KF§ (%)	Results/ Conclusion
100 g	0	—	—	3.690	Polymorph B
100 g	3	30	152	3.452	Polymorph B
100 g	8	30	152	3.599	Polymorph B
100 g	0	—	—	3.917	Polymorph B
100 g	5	40	152	3.482	Polymorph B
100 g	22	40	152	3.516	Polymorph B
100 g	3	40	152	3.67	Polymorph B
100 g	22	40	152	3.55	Polymorph B

*Reaction Conditions: Water 1 L, 75° C., 22-24 h;
§Average of 2 runs.

Drying studies determined that the material should be dried at 35-40° C., 125-152 mm Hg for 3 to 22 h or until the water content reaches ≦4% w/w.

For a large scale preparation of polymorph E (5222-152-B), a 5-L round bottom flask was charged with 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione (150 g, 0.579 mol) and water (3000 mL, 20 vol). The mixture was mechanically stirred at room temperature (23-25° C.) for 48 h under nitrogen atmosphere.

Samples were taken after 24 h and 48 h before the mixture was filtered and air-dried on the filter for 1 h The material was transferred to a drying tray and dried at room temperature (23-25° C.) for 24 h. KF analysis on the dried material showed water content of 11.9%. The material was submitted for XRPD, TGA, DSC and HPLC analysis. Analysis showed the material was pure polymorph E.

For a large scale preparation of polymorph B (5274-104), a 2 L-3-necked round bottom flask was charged with 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione (polymorph mixture, 100 g, 0.386 mol) and water (1000 mL, 10.0 vol). The mixture was heated to 75° C. over approximately 30 minutes with mechanical stirring under nitrogen atmosphere.

Samples were taken after 6 h and 24 h before the mixture was allowed to cool to 60-65° C., filtered and the material washed with warm (50-60° C.) water (50 mL, 0.5 vol). The material was transferred to a drying tray and dried at 30° C., 152 mm Hg for 8 h. KF analysis on the dried material showed water content of 3.6%. After grinding the material was submitted for XRPD, TGA, DSC and HPLC analysis. Analysis showed the material was pure polymorph B. The results of the analyses are shown in FIGS. **32-46**.

6.3 X-Ray Powder Diffraction Measurements

X-ray powder diffraction analyses were carried out on a Shimadzu XRD 6000 X-ray powder diffractometer using Cu Kα radiation. The instrument is equipped with a fine-focus X-ray tube. The tube voltage and amperage were set at 40 kB and 40 mA, respectively. The divergence and scattering slits were set at 1° and the receiving slit was set at 0.15 mm. Diffracted radiation was detected by a NaI scintillation detector. A theta-two theta continuous scan at 3°/min (0.4 sec/0.02° step) from 2.5 degrees 2θ to 40 degrees 2θ was used. A silicon standard was analyzed each day to check the instrument alignment.

X-ray powder diffraction analyses were also carried out using Cu Kα radiation on an Inel XRG-3000 diffractometer equipped with a curved position-sensitive detector. Data were collected in real time over a theta-two theta range of 120° at a resolution of 0.03°. The tube voltage and current were 40 kV and 30 mA, respectively. A silicon standard was analyzed each day to check for instrument alignment. Only the region between 2.5 and 40 degrees 2θ is shown in the figures.

6.4 Thermal Analysis

TG analyses were carried out on a TA Instrument TGA 2050 or 2950. The calibration standards were nickel and alumel. Approximately 5 mg of sample was placed on a pan, accurately weighed, and inserted into the TG furnace. The samples were heated in nitrogen at a rate of 10° C./min, up to a final temperature of 300 or 350° C.

DSC data were obtained on a TA 2920 instrument. The calibration standard was indium. Approximately 2-5 mg samples were placed into a DSC pan and the weight accurately recorded. Crimped pans with one pinhole were used for analysis and the samples were heated under nitrogen at a rate of 10° C./min, up to a final temperature of 350° C.

Hot-stage microscopy was carried out using a Kofler hot stage mounted on a Leica Microscope. The instrument was calibrated using USP standards.

A TA Instruments TGA 2050 interfaced with a Nicolet model 560 Fourier transform IR spectrophotometer, equipped with a globar source, XT/KBr beamsplitter, and deuterated triglycine sulfate (DTGS) detector, was utilized for TG-IR experiments. The IR spectrometer was wavelength calibrated with polystyrene on the day of use while the TG was temperature and weight calibrated biweekly, using indium for the temperature calibration. A sample of approximately 10 mg of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione was weighed into an aluminum pan and heated from 25 to 30° C. to 200° C. at a rate of 20° C./min with a helium purge. IR spectra were obtained in series, with each spectrum representing 32 co-added scans at a resolution of 4 cm^{-1}. Spectra were collected with a 17-second repeat time. TG/IR analysis data are presented as Gram-Schmidt plots and IR spectra linked to the time. Gram-Schmidt plots show total IR intensity vs. time; hence, the volatiles can be identified at each time point. They also show when the volatiles are detected. From the Gram-Schmidt plots, time points were selected and the IR spectra of these time points are presented in the stacked linked spectra Each spectrum identifies volatiles evolving at that time point. Volatiles were identified from a search of the HR Nicolet TGA vapor phase spectral library. The library match results are also presented to show the identified vapor.

6.5 Spectroscopy Measurements

Raman spectra were acquired on a Nicolet model 750 Fourier transform Raman spectrometer utilizing an excitation wavelength of 1064 nm and approximately 0.5 W of Nd:YAG laser power. The spectra represent 128 to 256 co-added scans acquired at 4 cm^{-1} resolution. The samples were prepared for analysis by placing the material in a sample holder and posi-

tioning this in the spectrometer. The spectrometer was wavelength calibrated using sulfur and cyclohexane at the time of use.

The mid-IR spectra were acquired on a Nicolet model 860 Fourier transform IR spectrophotometer equipped with a globar source XT/KBr beamsplitter and a deuterated triglycine sulfate (DTGS) detector. A Spectra-Tech, Inc. diffuse reflectance accessory was utilized for sampling. Each spectrum represents 128 co-added scans at a spectral resolution of 4 cm^{-1}. A background data set was acquired with an alignment mirror in place. A single beam sample data set was then acquired. Subsequently, a log 1/R (where R=reflectance) spectrum was acquired by rationing the two data sets against each other. The spectrophotometer was calibrated (wavelength) with polystyrene at the time of use.

6.6 Moisture Sorption/Desorption Measurements

Moisture sorption/desorption data were collected on a VTI SGA-100 moisture balance system. For sorption isotherms, a sorption range of 5 to 95% relative humidity (RH) and a desorption range of 95 to 5% RH in 10% RH increments was used for analysis. The sample was not dried prior to analysis. Equilibrium criteria used for analysis were less than 0.0100 weight percent change in 5 minutes with a maximum equilibration time of 3 hours if the weight criterion was not met. Data were not corrected for the initial moisture content of the samples.

6.7 Solution Proton NMR Measurements

NMR spectra not previously reported were collected at SSCI, Inc, 3065 Kent Avenue, West Lafayette, Ind. Solution phase ^1H NMR spectra were acquired at ambient temperature on a Bruker model AM spectrometer. The ^1H NMR spectrum represents 128 co added transients collected with a 4 μsec pulse and a relaxation delay time of 5 seconds. The free induction decay (FID) was exponentially multiplied with a 0.1 Hz Lorentzian line broadening factor to improve the signal-to-noise ratio. The NMR spectrum was processed utilizing GRAMS software, version 5.24. Samples were dissolved in dimethyl sulfoxide-d_6.

The scope of this invention can be understood with reference to the appended claims.

6.8 Intrinsic Dissolution and Solubility Studies

Intrinsic dissolution experiments were conducted on Form A (anhydrous), Form B (hemihydrate), and Form E (dihydrate) of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione. Equilibrium solubility experiments were conducted on Forms A and B. Aliquots were analyzed by ultraviolet-visible spectrophotometry, and the solids remaining from each experiment were analyzed by X-ray powder diffraction (XRPD).

6.8.1 Experimental

6.8.1.1 Dissolution

Dissolution experiments were carried out in a VanKel VK6010-8 dissolution apparatus equipped with a VK650A heater/circulator. An intrinsic dissolution apparatus (Woods apparatus) was used. Samples were compressed at 1.5 metric tons (1000 psi) for 1 min using the Woods apparatus in a hydraulic press, giving a sample surface of 0.50 cm^2. A dissolution medium consisting of 900 mL HCl buffer, pH 1.8, with 1% sodium lauryl sulfate, was used for each experiment. The medium was degassed by vacuum filtration through a 0.22-μm nylon filter disk and maintained at 37° C. The apparatus was rotated at 50 rpm for each experiment. Aliquots were filtered immediately using 0.2-μM nylon syringe filters. In some cases, the undissolved solids were recovered and analyzed by X-ray powder diffraction (XRPD).

6.8.1.2 Solubility

Equilibrium solubility experiments were conducted in a 100-mL, three-neck, round-bottom flask immersed in a constant temperature oil bath maintained at 25° C. A solid sample of 400-450 mg was stirred in 50 mL of dissolution medium (HCl buffer, pH 1.8, with 1% sodium lauryl sulfate) using a mechanical stir rod. Aliquots were filtered using 0.2-μm nylon syringe filters and immediately diluted 1 mL→50 mL, then 5 mL→25 mL with dissolution medium in Class A glassware, a final dilution factor of 250.

6.8.1.3 UV-Vis Spectrophotometry

Dissolution and solubility samples solutions were analyzed by a Beckman DU 640 single-beam spectrophotometer. A 1.000-cm quartz cuvette and an analysis wavelength of 228.40 nm were utilized. The detector was zeroed with a cuvette filled with dissolution medium.

6.8.1.4 X-Ray Powder Diffraction

XRPD analyses were carried out on a Shimadzu XRD-6000 X-ray powder diffractometer using Cu Kα radiation. The instrument is equipped with a fine focus X-ray tube. The tube power and amperage were set at 40 kV and 40 mA, respectively. The divergence and scattering slits were set at 1° and the receiving slit was set at 0.15 mm. Diffracted radiation was detected by a NaI scintillation detector. A theta-two theta continuous scan at 3°/min (0.4 sec/0.02° step) from 2.5 to 40° 2θ was used. A silicon standard was analyzed each day to check the instrument alignment. Samples were packed in an aluminum holder with silicon insert.

6.8.2 Results

The results of these solubility and intrinsic studies are summarized in Table 6. Both the solubility and dissolution experiments were conducted in a medium of HCl buffer, pH 1.8, containing 1% sodium lauryl sulfate. Form A was found to be unstable in the medium, converting to Form E. The solubilities of Forms A, B, and E were estimated to be 6.2, 5.8, and 4.7 mg/mL, respectively. The dissolution rates of Forms A, B, and E were estimated to be 0.35, 0.34, and 0.23 mg/mL, respectively.

6.8.2.1 UV-Vis Spectrophotometry Method Development

A UV-V is scan of the dissolution medium (blanked with an empty cuvette) was done to identify any interfering peaks. A small peak at 225 nm was present as shown in FIG. **47**.

Solutions of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione at varying concentrations were analyzed by UV-V is spectrophotometry. A preliminary scan of a 1.0 mg/mL solution was done, with the instrument blanked with dissolution medium. The solution was highly absorbing and noisy from 200-280 nm, making dilution necessary.

A 0.04 mg/mL solution of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione was then scanned from 200-300 nm. The plot was still noisy between 200 and 230 nm as shown in FIG. **48**. The sample was further diluted to 0.008 mg/mL. A wavelength scan of 200-350 nm for this sample showed a peak a 228.4 nm with no interference, as shown in FIG. **49**. Therefore, a wavelength of 228.4 was chosen for analysis of the solubility and dissolution samples.

A six-point calibration curve was generated with standards of the following concentrations: 0.001 mg/mL, 0.002 mg/mL, 0.005 mg/mL, 0.010 mg/mL, 0.015 mg/mL, and 0.020 mg/mL (Notebook 569-90). A linearity coefficient of R^2=0.9999 was obtained as shown in FIG. **50**.

6.8.2.2 Solubility

A sample consisting of 449.4 mg Form A was slurried in dissolution medium. Particle size was not controlled. Aliquots were taken at 7, 15, 30, 60, 90, and 150 min. The concentration reached 6.0 mg/mL by the first time point The highest concentration reached was 6.2 mg/mL, at 30 min. From that point the concentration decreased, reaching 4.7 mg/mL at 150 min as in FIG. **51**. The solids remaining at the final time point were analyzed by XRPD and found to be Form E as shown in Table 7. No peaks attributed to Form A can be seen in the pattern. Since the concentration did not plateau at 4.7 mg/mL, the solubility of Form E may be lower than that.

A sample consisting of 401.4 mg Form B was slurried in dissolution medium. Particle size was not controlled. Aliquots were taken at 7, 15, 30, 60, 90, 180, 420, and 650 min. Form B dissolved much more slowly than Form A, reaching 3.3 mg/mL in 90 min. The concentration stabilized at 5.6-5.7 mg/mL at the final three time points as in FIG. **52**. The remaining solids were shown to be Form B as in Table 7, suggesting Form B has good stability in water.

A summary of the solubilities is given in Table 6. The amounts dissolved at each time point are shown in Tables 8 and 9.

TABLE 6

Summary of Results

Form	Solubility	Intrinsic Dissolution #1	Intrinsic Dissolution #2	Average Intrinsic Dissolution Rate
Form A	6.2 mg/mL	0.35	0.22[a]	0.29[a]
Form B	5.8 mg/mL	0.35	0.32	0.34
Form E	4.7 mg/mL	0.21	0.25	0.23

[a]The Form A dissolution experiment #2 may have converted to Form E on the surface of the disk, skewing the average rate lower.

TABLE 7

Experimental Details

Experiment	Final Form
Pressed Form A	A
Pressed Form B	B
Form A Solubility	E
Form B Solubility	B
Form A Dissolution	—
Form A Dissolution	A
Form B Dissolution	—
Form B Dissolution	B
Form E Dissolution	E
Form E Dissolution	—

TABLE 8

Form A Solubility

Time Point (min)	Concentration (mg/mL)
7	6.00
15	6.11
30	6.16
60	6.10
90	5.46
150	4.73

TABLE 9

Form B Solubility

Time Point (min)	Concentration (mg/mL)
7	1.63
15	2.14
30	2.33
60	2.94
90	3.34
180	5.67
420	5.76
650	5.61

6.8.2.3 Intrinsic Dissolution

Approximately 200 mg each of Forms A and B were compressed into disks in the Woods apparatus using 2 metric tons of pressure. The samples were subsequently scraped out, ground gently, and analyzed by XRPD. The study showed that compression and grinding does not cause a form change in either case. (See Table 7).

Two preliminary dissolution runs were performed. The disks fractured to some extent in both experiments, compromising the requirement of constant surface area.

The first experiment of intrinsic dissolution that strictly followed the USP chapter on intrinsic dissolution utilized approximately 150 mg each of Forms A and B. Seven aliquots, beginning at 5 min and ending at 90 min, were taken to maintain sink conditions. The experiment resulted in linear dissolution profiles, with a rate of 0.35 mg per cm^2 per minute for both forms. The Form E experiment was done later under the same conditions and added to the graph for comparison. (See FIG. **53**). The Form E dissolution rate was 0.21 mg per cm^2 per minute, significantly lower than the dissolution rate of Forms A and B. This is in line with expectations based on the solubility data The crystal form of the remaining solids did not change in any case.

The second experiment utilized approximately 250 mg each of Forms A and B. The Form E experiment (135 mg) was done later and added to the graph for comparison. (See FIG. **54**). Nine aliquots were taken, beginning at 5 min and ending at 150 min. The dissolution rates were 0 22, 0.32, and 0.25 mg per cm^2 per minute, respectively, for Forms A, B, and E. The dissolution rate for Form A in this experiment was low, while the rates for Forms B and E were similar to those found in the first experiment It is believed that in this case, a thin layer of the Form A sample disk may have converted to Form E upon exposure to water. This is supported by the evidence of rapid conversion of Form A to Form E in the solubility experiment. The diffraction pattern of the undissolved solids does not indicate a form change. However, the bulk of the sample disk is not exposed to water. Therefore, the true intrinsic dissolution rate of Form A is believed to be close to 0.35 mg per cm^2 per minute. An insufficient quantity of Form A was available to repeat the experiment.

A summary of the intrinsic dissolution rates is given in Table 6. The amounts dissolved at each time point are summarized in Tables 10 and 11.

TABLE 10

Intrinsic Dissolution Experiment #1 Results

Time Point	Form A[a]	Form B[a]	Form E[a]
5 min	5.76	10.80[b]	2.70
10 min	7.73	6.85	4.13

TABLE 10-continued

Intrinsic Dissolution Experiment #1 Results			
Time Point	Form A[a]	Form B[a]	Form E[a]
20 min	11.31	10.25	6.96
30 min	15.59	14.35	9.60
45 min	21.98	20.57	12.57
60 min	27.11	25.70	15.16
90 min	34.17	34.34	20.82

[a]Results are reported as Cumulative Amount Dissolved per Unit Area (mg/cm2)

[b]This date point not included in graph since the value is higher than the next two data points.

TABLE 11

Intrinsic Dissolution Experiment #2 Results			
Time Point	Form A[a]	Form B[a]	Form E[a]
5 min	4.50	5.04	3.06
10 min	5.22	6.12	4.31
20 min	7.54	7.73	11.40
30 min	11.46	12.72	11.93
45 min	15.01	17.33	14.72
60 min	18.38	21.93	18.52
90 min	24.38	31.64	26.24
120 min	30.35	41.31	33.56
150 min	35.26	49.54	40.82

[a]Results are reported as Cumulative Amount Dissolved per Unit Area (mg/cm2)

6.9 Analyses of Mixtures of Polymorphs

This invention encompasses mixtures of different polymorphs. For example, an X-ray diffraction analysis of one production sample yielded a pattern that contained two small peaks seen at approximately 12.6° and 25.8° 2θ in addition to those representative of Form B. In order to determine the composition of that sample, the following steps were performed.

1) Matching of the new production pattern to known forms along with common pharmaceutical excipients and contaminants;
2) Cluster analysis of the additional peaks to identify if any unknown phase is mixed with the original Form B;
3) Harmonic analysis of the additional peaks to identify if any preferred orientation may be present or if any changes in the crystal habit may have occurred; and
4) Indexing of the unit cells for both Form B and the new production sample to identify any possible crystallographic relationships.

Based on these tests, which can be adapted for the analysis of any mixture of polymorphs, it was determined that the sample contained a mixture of polymorph forms B and E.

6.10 Dosage Form

Table 12 illustrates a batch formulation and single dosage formulation for a 25 mg single dose unit of a polymorphic form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione.

TABLE 12

Formulation for a 25 mg capsule			
Material	Percent By Weight	Quantity (mg/tablet)	Quantity (kg/batch)
Polymorphic Form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione	40.0%	25 mg	16.80 kg
Pregelatinized Corn Starch, NF	59.5%	37.2 mg	24.99 kg
Magnesium Stearate	0.5%	0.31 mg	0.21 kg
Total	100.0%	62.5 mg	42.00 kg

The pregelatinized corn starch (SPRESS B-820) and polymorphic form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione components are passed through a screen (i.e., a 710 μm screen) and then loaded into a Diffusion Mixer with a baffle insert and blended for about 15 minutes. The magnesium stearate is passed through a screen (i.e., a 210 μm screen) and added to the Diffusion Mixer. The blend is then encapsulated in capsules using a Dosator type capsule filling machine.

The entire scope of this invention is not limited by the specific examples described herein, but is more readily understood with reference to the appended claims.

What is claimed is:

1. A solid form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione comprising crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate, wherein the crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate is present at greater than about 80% by weight of the solid form.

2. A solid form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione comprising crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate, wherein the crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate is present at greater than about 90% by weight of the solid form.

3. A solid form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione comprising crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate, wherein the crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate is present at greater than about 95% by weight of the solid form.

4. A solid form of 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione comprising crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate, wherein the crystalline 3-(4-amino-1-oxo-1,3 dihydro-isoindol-2-yl)-piperidine-2,6-dione hemihydrate is present at greater than about 97% by weight of the solid form.

5. A pharmaceutical composition comprising a therapeutically effective amount of the solid form of claim **1**, **2**, **3**, or **4**, and a pharmaceutically acceptable excipient or carrier.

6. The pharmaceutical composition of claim **5**, which is a single unit dosage form.

7. The pharmaceutical composition of claim **5**, wherein the therapeutically effective amount is about 5 mg.

8. The pharmaceutical composition of claim **5**, wherein the therapeutically effective amount is about 10 mg.

9. The pharmaceutical composition of claim **5**, wherein the therapeutically effective amount is about 25 mg.

10. The pharmaceutical composition of claim **5**, wherein the therapeutically effective amount is about 50 mg.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,855,217 B2
APPLICATION NO. : 12/335395
DATED : December 21, 2010
INVENTOR(S) : Jaworsky et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Please replace Drawing Sheets 15, 26, 31, 32, 33, 35, 36, 38, 39, and 40 (of 48) with the Replacement Drawing Sheets on the following pages of this Certificate of Correction:

Page 2 of 11: Replacement Drawing Sheet 15 of 48 (Fig. 15);

Page 3 of 11: Replacement Drawing Sheet 26 of 48 (Fig. 26);

Page 4 of 11: Replacement Drawing Sheet 31 of 48 (Fig. 31);

Page 5 of 11: Replacement Drawing Sheet 32 of 48 (Figs. 32 and 33);

Page 6 of 11: Replacement Drawing Sheet 33 of 48 (Figs. 34 and 35);

Page 7 of 11: Replacement Drawing Sheet 35 of 48 (Figs. 37 and 38);

Page 8 of 11: Replacement Drawing Sheet 36 of 48 (Figs. 39 and 40);

Page 9 of 11: Replacement Drawing Sheet 38 of 48 (Figs. 42 and 43);

Page 10 of 11: Replacement Drawing Sheet 39 of 48 (Figs. 44 and 45);

Page 11 of 11: Replacement Drawing Sheet 40 of 48 (Fig. 46).

Signed and Sealed this
Third Day of May, 2011

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office

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FIG.15

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FIG.26

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FIG.31

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FIG.32

FIG.33

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XRPD PATTERN OF POLYMORPH B

File: Process 5222-157-C
Date: 06/04/04 15:07 Step: 0.020° Cnt Time: 0.500 Sec.
Range: 1.50-40.00 (Deg) Step Scan Rate: 2.40 Deg/min.

FIG.34

XRPD PATTERN OF POLYMORPH E

File: Process 5222-152-B Form E
Date: 05/21/04 10:46 Step: 0.020° Cnt Time: 0.500 Sec.
Range: 1.50-40.00 (Deg) Step Scan Rate: 2.40 Deg/min.

FIG.35

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FIG.37

FIG.38

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FIG.39

FIG.40

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DSC OF POLYMORPH B
DSC

Sample: 5274-104-B
Size: 0.0000mg
Method: Cell constant calibration
Comment: OAI batch 15 22b

Run Date: 07-Jun-04 11:30
Instrument: DSC Q 1000 V7.3 Build 249

FIG.42

DSC OF POLYMORPH B
DSC

Sample: 5274-100-C
Size: 0.0000mg
Method: Cell constant calibration
Comment: Evotec Batch 1675C 10vol H2O 24h 3h dry

Run Date: 02-Jun-04 17:01
Instrument: DSC Q 1000 V7.3 Build 249

FIG.43

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DSC OF POLYMORTH B
DSC

Sample: 5222-157-C
Size: 0.0000mg
Method: Cell constant calibration
Comment: OAI batch 17

Run Date: 07-Jun-04 09:45
Instrument: DSC Q 1000 V7.3 Build 249

FIG.44

DSC OF POLYMORPH E
DSC

Sample: 5222-152-B
Size: 3.4500mg
Method: Cell constant calibration
Comment: Evotec batch 15 Form E

Run Date: 21-May-04 09:32
Instrument: DSC Q 1000 V7.3 Build 249

FIG.45

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FIG.46

EXHIBIT C

US008741929B2

(12) **United States Patent**
Zeldis

(10) **Patent No.: US 8,741,929 B2**
(45) **Date of Patent: *Jun. 3, 2014**

(54) **METHODS USING 3-(4-AMINO-1-OXO-1,3-DIHYDRO-ISOINDOL-2-YL)-PIPERIDINE-2,6-DIONE FOR TREATMENT OF MANTLE CELL LYMPHOMAS**

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(73) Assignee: **Celgene Corporation**, Summit, NJ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 220 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/621,502**

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A61K 31/445 (2006.01)

(52) **U.S. Cl.**
USPC **514/323**

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

Methods of treating, preventing or managing mantle cell lymphomas are disclosed. The methods encompass the administration of an immunomodulatory compound of the invention known as Revlimid® or lenalidomide. The invention further relates to methods of treatment using this compound with chemotherapy, radiation therapy, hormonal therapy, biological therapy or immunotherapy. Pharmaceutical compositions and single unit dosage forms suitable for use in the methods of the invention are also disclosed.

24 Claims, No Drawings

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METHODS USING 3-(4-AMINO-1-OXO-1,3-DIHYDRO-ISOINDOL-2-YL)-PIPERIDINE-2,6-DIONE FOR TREATMENT OF MANTLE CELL LYMPHOMAS

1. CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of U.S. non-provisional application Ser. No. 11/888,881, filed Aug. 1, 2007, which claims the benefit of U.S. provisional application 60/835,752, filed Aug. 3, 2006, both of which are incorporated by reference herein in their entirety.

2. FIELD OF THE INVENTION

This invention relates to methods of treating, preventing or managing certain types of lymphomas with an immunomodulatory compound having the chemical name of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione, which is also known as or lenalidomide, Revlimid® or Revimid®. In particular, this invention encompasses methods of treating, preventing or managing non-Hodgkin's lymphomas, including but not limited to, mantle cell lymphoma (MCL), lymphocytic lymphoma of intermediate differentiation, intermediate lymphocytic lymphoma, ILL, diffuse poorly differentiated lymphocytic lymphoma, PDL, centrocytic lymphoma, diffuse small-cleaved cell lymphoma, DSCCL, and mentle zone lymphoma, using the compound alone as a therapeutic.

The invention also encompasses the use of specific combinations or "cocktails" of Revlimid® and other therapy, e.g., radiation or other chemotherapeutics, including but not limited to, anti-cancer agents, immunosuppressive agents, and anti-inflammatories such as steroids. The invention also relates to pharmaceutical compositions and dosing regimens with said compound alone that is as a therapeutic.

3. BACKGROUND OF THE INVENTION

Cancer is characterized primarily by an increase in the number of abnormal cells derived from a given normal tissue, invasion of adjacent tissues by these abnormal cells, or lymphatic or blood-borne spread of malignant cells to regional lymph nodes and to distant sites (metastasis). Clinical data and molecular biologic studies indicate that cancer is a multistep process that begins with minor preneoplastic changes, which may under certain conditions progress to neoplasia. The neoplastic lesion may evolve clonally and develop an increasing capacity for invasion, growth, metastasis, and heterogeneity, especially under conditions in which the neoplastic cells escape the host's immune surveillance. Roitt, I., Brostoff, J. and Kale, D., *Immunology,* 17.1-17.12 (3rd ed., Mosby, St. Louis, Mo., 1993).

There is an enormous variety of cancers which are described in detail in the medical literature. Examples includes cancer of the blood, lung, colon, rectum, prostate, breast, brain, and intestine. The various forms of the cancers such as lymphomas are described in U.S. provisional application No. 60/380,842, filed May 17, 2002, the entireties of which are incorporated herein by reference (see, e.g., Section 2.2. Types of Cancers).

Lymphoma is a heterogenous group of neoplasms arising in the reticuloendothelial and lymphatic systems. *The Merck Manual,* 955 (17th ed. 1999). Non-Hodgkin's lymphoma (NHL) refers to malignant monoclonal proliferation of lymphoid cells in the immune system, including lymph nodes, bone marrow, spleen, liver and gastrointestinal (GI) tract. *The Merck Manual*, at 958.

Mantle cell lymphoma (MCL) is a distinct entity among the non-Hodgkin's lymphomas. Drach J.; et al., *Expert Review of Anticancer Therapy,* 2005, 5(3), pp. 477-485. In the International Lymphoma Classification Project, MCL accounted for 8% of all non-Hodgkin lymphomas. MCL is recognized in the Revised European-American Lymphoma and World Health Organization classifications as a distinct clinicopathologic entity. MCL was not recognized by previous lymphoma classification schemes; and it was frequently categorized as diffuse small-cleaved cell lymphoma by the International Working Formulation or centrocytic lymphoma by the Kiel classification. *The Merck Manual*, at 958-959.

MCL is a lymphoproliferative disorder derived from a subset of naive pregerminal center cells localized in primary follicles or in the mantle region of secondary follicles. MCL is characterized by a specific chromosomal translocation, the t(11; 14)(q13;q32). Drach J.; et al., *Expert Review of Anticancer Therapy,* 2005, 5(3), pp. 477-485. This translocation involves the immunoglobulin heavy-chain gene on chromosome 14 and the BCL1 locus on chromosome 11. Drach J.; et al., p 477. The molecular consequence of translocation is overexpression of the protein cyclin D1 (coded by the PRAD1 gene located close to the breakpoint). Id. Cyclin D1 plays a key role in cell cycle regulation and progression of cells from G1 phase to S phase by activation of cyclin-dependent kinases. Id.

NHL has been associated with viral infection (Ebstein-Barr virus, HIV, human T-lymphotropic virus type 1, human herpesvirus 6), environmental factors (pesticides, hair dyes), and primary and secondary immunodeficiency. No causative factor has been identified for MCL or for most patients with NHL of other types.

MCL has poor clinical outcome and is an incurable lymphoma with limited therapeutic options for patients with relapsed or refractory disease. Drach J.; et al., p. 477. Therefore, a tremendous demand exists for new methods and compositions that can be used to treat patients with MCL.

4. SUMMARY OF THE INVENTION

This invention encompasses methods of treating, preventing or managing certain types of lymphomas, including primary and metastatic cancer, as well as cancers that are relapsed, refractory or resistant to conventional chemotherapy. In particular, methods of this invention encompass methods of treating, preventing or managing various forms of lymphomas such as mantle cell lymphoma, MCL, lymphocytic lymphoma of intermediate differentiation, intermediate lymphocytic lymphoma, ILL, diffuse poorly differentiated lymphocytic lymphoma, PDL, centrocytic lymphoma, diffuse small-cleaved cell lymphoma, DSCCL, follicular lymphoma, and mentle zone lymphoma, including lymphomas that are relapsed, refractory or resistant.

The methods comprise administering to a patient in need of such treatment, prevention or management a therapeutically or prophylactically effective amount of an immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof. In a preferred embodiment, the immunomodulatory compound is used alone, that is without other chemotherapeutics.

In another methods of the invention, an immunomodulatory compound of the invention is administered in combination with a therapy conventionally used to treat, prevent or

manage lymphomas. Examples of such conventional therapies include, but are not limited to, surgery, chemotherapy, radiation therapy, hormonal therapy, biological therapy, immunotherapy and combinations thereof.

This invention also encompasses pharmaceutical compositions, single unit dosage forms, and dosing regimens which comprise an immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof, and a second, or additional, active agent or ingredient. Second active agents or ingredients include specific combinations, or "cocktails," of drugs or therapy, or both. In certain embodiments, the second active agent is selected from a hematopoietic growth factor, cytokine, anti-cancer agent, antibiotic, cox-2 inhibitor, corticosteroid, rituximab, or a combination thereof. In other embodiments, the second active agent is rituximab, dexamethasone or prednisone.

The preferred compound to be used in the methods and composition is 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (Revlimid®). In some embodiments, the amount of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione is from about 5 mg to about 50 mg or from about 5 mg to about 25 mg.

5. DETAILED DESCRIPTION OF THE INVENTION

A first embodiment of the invention encompasses methods of treating, managing, or preventing certain types of lymphomas which comprises administering to a patient in need of such treatment, management or prevention a therapeutically or prophylactically effective amount of an immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof. In particular, methods of this invention encompass methods of treating, preventing or managing various forms of lymphomas, including but not limited to, mantle cell lymphoma, MCL, lymphocytic lymphoma of intermediate differentiation, intermediate lymphocytic lymphoma, ILL, diffuse poorly differentiated lymphocytic lymphoma, PDL, centrocytic lymphoma, diffuse small-cleaved cell lymphoma, DSCCL, follicular lymphoma, and any type of the mantle cell lymphomas that can be seen under the microscope (nodular, diffuse, blastic and mentle zone lymphoma). In one embodiment, the lymphoma is refractory, relapsed,or is resistant to chemotherapy other than an immunomodulatory compound of the invention.

In a separate and distinct embodiment of the invention, the immunomodulatory compound of the invention is administered in combination with another drug ("second active agent or ingredient") or another therapy for treating, managing, or preventing cancer. Second active agents include small molecules and large molecules (e.g., proteins and antibodies), examples of which are provided herein, as well as stem cells or cord blood. Methods, or therapies, that can be used in combination with the administration of an immunomodulatory compound of the invention include, but are not limited to, surgery, blood transfusions, immunotherapy, biological therapy, radiation therapy, and other non-drug based therapies presently used to treat, prevent or manage cancer.

The invention also encompasses pharmaceutical compositions (e.g., single unit dosage forms) that can be used in methods disclosed herein. Particular pharmaceutical compositions comprise an immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof, and a second active agent or ingredient.

5.1 Immunomodulatory Compounds

Compounds used in the invention include compounds that are racemic, stereomerically enriched or stereomerically pure. In some embodiments, pharmaceutically acceptable salts, solvates (e.g., hydrate), clathrates, and prodrugs thereof are included. Preferred compounds used in the invention are small organic molecules having a molecular weight less than about 1,000 g/mol, and are not proteins, peptides, oligonucleotides, oligosaccharides or other macromolecules.

As used herein and unless otherwise indicated, the terms "immunomodulatory compounds" and "IMiDs®" (Celgene Corporation) encompasses small organic molecules that markedly inhibit TNF-α, LPS induced monocyte IL1β and IL12, and partially inhibit IL6 production. Specific immunomodulatory compounds of the invention are discussed below.

In the most preferred embodiment, "an immunomodulatory compound of the invention" refers to 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (lenalidomide, also known as Revlimid® or Revimid®). The compound 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione has the following chemical structure:

Specific examples of immunomodulatory compounds, include, but are not limited to, cyano and carboxy derivatives of substituted styrenes such as those disclosed in U.S. Pat. No. 5,929,117; 1-oxo-2-(2,6-dioxo-3-fluoropiperidin-3yl)isoindolines and 1,3-dioxo-2-(2,6-dioxo-3-fluoropiperidine-3-yl) isoindolines such as those described in U.S. Pat. No. 5,874,448; the tetra substituted 2-(2,6-dioxopiperdin-3-yl)-1-oxoisoindolines described in U.S. Pat. No. 5,798,368; 1-oxo and 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)isoindolines, including, but not limited to, those disclosed in U.S. Pat. No. 5,635,517; substituted 2-(2,6-dioxopiperidin-3-yl)phthalimides and substituted 2-(2,6-dioxopiperidin-3-yl)-1-oxoisoindoles such as those described in U.S. Pat. Nos. 6,281,230 and 6,316,471; a class of non-polypeptide cyclic amides disclosed in U.S. Pat. Nos. 5,698,579 and 5,877,200; thalidomide analogs, including hydrolysis products, metabolites, and precursors of thalidomide, such as those described in U.S. Pat. Nos. 5,593,990, 5,629,327, and 6,071,948 to D'Amato; and isoindole-imide compounds such as those described in U.S. patent publication no. 2003/0096841, and International Application No. PCT/US01/50401 (International Publication No. WO 02/059106). The entireties of each of the patents and patent applications identified herein are incorporated herein by reference. Immunomodulatory compounds of the invention do not include thalidomide.

The immunomodulatory compounds of the invention can either be commercially purchased or prepared according to the methods described in the patents or patent publications disclosed herein (see e.g., U.S. Pat. No. 5,635,517, incorporated herein by reference). Further, optically pure compounds can be asymmetrically synthesized or resolved using known

resolving agents or chiral columns as well as other standard synthetic organic chemistry techniques.

As used herein and unless otherwise indicated, the term "pharmaceutically acceptable salt" encompasses non-toxic acid and base addition salts of the compound to which the term refers. Acceptable non-toxic acid addition salts include those derived from organic and inorganic acids or bases know in the art, which include, for example, hydrochloric acid, hydrobromic acid, phosphoric acid, sulfuric acid, methanesulphonic acid, acetic acid, tartaric acid, lactic acid, succinic acid, citric acid, malic acid, maleic acid, sorbic acid, aconitic acid, salicylic acid, phthalic acid, embolic acid, enanthic acid, and the like.

Compounds that are acidic in nature are capable of forming salts with various pharmaceutically acceptable bases. The bases that can be used to prepare pharmaceutically acceptable base addition salts of such acidic compounds are those that form non-toxic base addition salts, i.e., salts containing pharmacologically acceptable cations such as, but not limited to, alkali metal or alkaline earth metal salts and the calcium, magnesium, sodium or potassium salts in particular. Suitable organic bases include, but are not limited to, N,N-dibenzylethylenediamine, chloroprocaine, choline, diethanolamine, ethylenediamine, meglumaine (N-methylglucamine), lysine, and procaine.

As used herein and unless otherwise indicated, the term "prodrug" means a derivative of a compound that can hydrolyze, oxidize, or otherwise react under biological conditions (in vitro or in vivo) to provide the compound. Examples of prodrugs include, but are not limited to, derivatives of immunomodulatory compounds of the invention that comprise biohydrolyzable moieties such as biohydrolyzable amides, biohydrolyzable esters, biohydrolyzable carbamates, biohydrolyzable carbonates, biohydrolyzable ureides, and biohydrolyzable phosphate analogues. Other examples of prodrugs include derivatives of immunomodulatory compounds of the invention that comprise —NO, —NO_2, —ONO, or —ONO_2 moieties. Prodrugs can typically be prepared using well-known methods, such as those described in 1 *Burger's Medicinal Chemistry and Drug Discovery,* 172-178, 949-982 (Manfred E. Wolff ed., 5th ed. 1995), and *Design of Prodrugs* (H. Bundgaard ed., Elselvier, New York 1985).

As used herein and unless otherwise indicated, the terms "biohydrolyzable amide," "biohydrolyzable ester," "biohydrolyzable carbamate," "biohydrolyzable carbonate," "biohydrolyzable ureide," "biohydrolyzable phosphate" mean an amide, ester, carbamate, carbonate, ureide, or phosphate, respectively, of a compound that either: 1) does not interfere with the biological activity of the compound but can confer upon that compound advantageous properties in vivo, such as uptake, duration of action, or onset of action; or 2) is biologically inactive but is converted in vivo to the biologically active compound. Examples of biohydrolyzable esters include, but are not limited to, lower alkyl esters, lower acyloxyalkyl esters (such as acetoxylmethyl, acetoxyethyl, aminocarbonyloxymethyl, pivaloyloxymethyl, and pivaloyloxyethyl esters), lactonyl esters (such as phthalidyl and thiophthalidyl esters), lower alkoxyacyloxyalkyl esters (such as methoxycarbonyl-oxymethyl, ethoxycarbonyloxyethyl and isopropoxycarbonyloxyethyl esters), alkoxyalkyl esters, choline esters, and acylamino alkyl esters (such as acetamidomethyl esters). Examples of biohydrolyzable amides include, but are not limited to, lower alkyl amides, α-amino acid amides, alkoxyacyl amides, and alkylaminoalkylcarbonyl amides. Examples of biohydrolyzable carbamates include, but are not limited to, lower alkylamines, substituted ethylenediamines, amino acids, hydroxyalkylamines, heterocyclic and heteroaromatic amines, and polyether amines.

The immunomodulatory compound of the invention contains a chiral center, and thus can exist as a racemic mixture of R and S enantiomers. This invention encompasses the use of stereomerically pure forms of this compound, as well as the use of mixtures of those forms. For example, mixtures comprising equal or unequal amounts of the enantiomers may be used in methods and compositions of the invention. These isomers may be asymmetrically synthesized or resolved using standard techniques such as chiral columns or chiral resolving agents. See, e.g., Jacques, J., et al., *Enantiomers, Racemates and Resolutions* (Wiley-Interscience, New York, 1981); Wilen, S. H., et al., *Tetrahedron* 33:2725 (1977); Eliel, E. L., *Stereochemistry of Carbon Compounds* (McGraw-Hill, NY, 1962); and Wilen, S. H., *Tables of Resolving Agents and Optical Resolutions* p. 268 (E. L. Eliel, Ed., Univ. of Notre Dame Press, Notre Dame, Ind., 1972).

As used herein and unless otherwise indicated, the term "stereomerically pure" means a composition that comprises one stereoisomer of a compound and is substantially free of other stereoisomers of that compound. For example, a stereomerically pure composition of a compound having one chiral center will be substantially free of the opposite enantiomer of the compound. A stereomerically pure composition of a compound having two chiral centers will be substantially free of other diastereomers of the compound. A typical stereomerically pure compound comprises greater than about 80% by weight of one stereoisomer of the compound and less than about 20% by weight of other stereoisomers of the compound, more preferably greater than about 90% by weight of one stereoisomer of the compound and less than about 10% by weight of the other stereoisomers of the compound, even more preferably greater than about 95% by weight of one stereoisomer of the compound and less than about 5% by weight of the other stereoisomers of the compound, and most preferably greater than about 97% by weight of one stereoisomer of the compound and less than about 3% by weight of the other stereoisomers of the compound. As used herein and unless otherwise indicated, the term "stereomerically enriched" means a composition that comprises greater than about 60% by weight of one stereoisomer of a compound, preferably greater than about 70% by weight, more preferably greater than about 80% by weight of one stereoisomer of a compound. As used herein and unless otherwise indicated, the term "enantiomerically pure" means a stereomerically pure composition of a compound having one chiral center. Similarly, the term "stereomerically enriched" means a stereomerically enriched composition of a compound having one chiral center. In other words, the invention encompasses the use of the R or S enantiomer of immunomodulatory compound in the methods.

It should be noted that if there is a discrepancy between a depicted structure and a name given that structure, the depicted structure is to be accorded more weight. In addition, if the stereochemistry of a structure or a portion of a structure is not indicated with, for example, bold or dashed lines, the structure or portion of the structure is to be interpreted as encompassing all stereoisomers of it.

5.2 Second Active Agents

An immunomodulatory compound of the invention can be used with or combined with other pharmacologically active compounds ("second active agents or ingredients") in methods and compositions of the invention. It is believed that certain combinations work synergistically in the treatment of

particular types of lymphomas. Immunomodulatory compounds of the invention can also work to alleviate adverse effects associated with certain second active agents, and some second active agents can be used to alleviate adverse effects associated with immunomodulatory compounds of the invention.

One or more second active ingredients or agents can be used in the methods and compositions of the invention together with an immunomodulatory compound of the invention. Second active agents can be large molecules (e.g., proteins) or small molecules (e.g., synthetic inorganic, organometallic, or organic molecules).

Examples of large molecule active agents include, but are not limited to, hematopoietic growth factors, cytokines, and monoclonal and polyclonal antibodies. Typical large molecule active agents are biological molecules, such as naturally occurring or artificially made proteins. Proteins that are particularly useful in this invention include proteins that stimulate the survival and/or proliferation of hematopoietic precursor cells and immunologically active poietic cells in vitro or in vivo. Others stimulate the division and differentiation of committed erythroid progenitors in cells in vitro or in vivo. Particular proteins include, but are not limited to: interleukins, such as IL-2 (including recombinant IL-II ("rIL2") and canarypox IL-2), IL-10, IL-12, and IL-18; interferons, such as interferon alfa-2a, interferon alfa-2b, interferon alfa-n1, interferon alfa-n3, interferon beta-I a, and interferon gamma-I b; GM-CF and GM-CSF; and EPO.

Particular proteins that can be used in the methods and compositions of the invention include, but are not limited to: filgrastim, which is sold in the United States under the trade name Neupogen® (Amgen, Thousand Oaks, Calif.); sargramostim, which is sold in the United States under the trade name Leukine® (Immunex, Seattle, Wash.); and recombinant EPO, which is sold in the United States under the trade name Epogen® (Amgen, Thousand Oaks, Calif.).

Recombinant and mutated forms of GM-CSF can be prepared as described in U.S. Pat. Nos. 5,391,485; 5,393,870; and 5,229,496; all of which are incorporated herein by reference. Recombinant and mutated forms of G-CSF can be prepared as described in U.S. Pat. Nos. 4,810,643; 4,999,291; 5,528,823; and 5,580,755; all of which are incorporated herein by reference.

This invention encompasses the use of native, naturally occurring, and recombinant proteins. The invention further encompasses mutants and derivatives (e.g., modified forms) of naturally occurring proteins that exhibit, in vivo, at least some of the pharmacological activity of the proteins upon which they are based. Examples of mutants include, but are not limited to, proteins that have one or more amino acid residues that differ from the corresponding residues in the naturally occurring forms of the proteins. Also encompassed by the term "mutants" are proteins that lack carbohydrate moieties normally present in their naturally occurring forms (e.g., nonglycosylated forms). Examples of derivatives include, but are not limited to, pegylated derivatives and fusion proteins, such as proteins formed by fusing IgG1 or IgG3 to the protein or active portion of the protein of interest. See, e.g., Penichet, M. L. and Morrison, S. L., *J. Immunol. Methods* 248:91-101 (2001).

Antibodies that can be used in combination with compounds of the invention include monoclonal and polyclonal antibodies. Examples of antibodies include, but are not limited to, trastuzumab (Herceptin®), rituximab (Rituxan®), bevacizumab (Avastin™), pertuzumab (Omnitarg™), tositumomab (Bexxar®), edrecolomab (Panorex®), and G250. Compounds of the invention can also be combined with, or used in combination with, anti-TNF-α antibodies.

Large molecule active agents may be administered in the form of anti-cancer vaccines. For example, vaccines that secrete, or cause the secretion of, cytokines such as IL-2, G-CSF, and GM-CSF can be used in the methods, pharmaceutical compositions, and kits of the invention. See, e.g., Emens, L. A., et al., *Curr. Opinion Mol. Ther.* 3(1):77-84 (2001).

In one embodiment of the invention, the large molecule active agent reduces, eliminates, or prevents an adverse effect associated with the administration of an immunomodulatory compound of the invention. Depending on the particular immunomodulatory compound of the invention and the disease or disorder begin treated, adverse effects can include, but are not limited to, drowsiness and somnolence, dizziness and orthostatic hypotension, neutropenia, infections that result from neutropenia, increased HIV-viral load, bradycardia, Stevens-Johnson Syndrome and toxic epidermal necrolysis, and seizures (e.g., grand mal convulsions). A specific adverse effect is neutropenia.

Second active agents that are small molecules can also be used to alleviate adverse effects associated with the administration of an immunomodulatory compound of the invention. However, like some large molecules, many are believed to be capable of providing a synergistic effect when administered with (e.g., before, after or simultaneously) an immunomodulatory compound of the invention. Examples of small molecule second active agents include, but are not limited to, anti-cancer agents, antibiotics, immunosuppressive agents, and steroids.

Examples of anti-cancer agents include, but are not limited to: acivicin; aclarubicin; acodazole hydrochloride; acronine; adozelesin; aldesleukin; altretamine; ambomycin; ametantrone acetate; amsacrine; anastrozole; anthramycin; asparaginase; asperlin; azacitidine; azetepa; azotomycin; batimastat; benzodepa; bicalutamide; bisantrene hydrochloride; bisnafide dimesylate; bizelesin; bleomycin sulfate; bortezomib (Velcade®); brequinar sodium; bropirimine; busulfan; cactinomycin; calusterone; caracemide; carbetimer; carboplatin; carmustine; carubicin hydrochloride; carzelesin; cedefingol; celecoxib (COX-2 inhibitor); chlorambucil; cirolemycin; cisplatin; cladribine; crisnatol mesylate; cyclophosphamide; cytarabine; dacarbazine; dactinomycin; daunorubicin hydrochloride; decitabine; dexormaplatin; dezaguanine; dezaguanine mesylate; diaziquone; docetaxel; doxorubicin; doxorubicin hydrochloride; droloxifene; droloxifene citrate; dromostanolone propionate; duazomycin; edatrexate; eflornithine hydrochloride; elsamitrucin; enloplatin; enpromate; epipropidine; epirubicin hydrochloride; erbulozole; esorubicin hydrochloride; estramustine; estramustine phosphate sodium; etanidazole; etoposide; etoposide phosphate; etoprine; fadrozole hydrochloride; fazarabine; fenretinide; floxuridine; fludarabine phosphate; fluorouracil; flurocitabine; fosquidone; fostriecin sodium; gemcitabine; gemcitabine hydrochloride; hydroxyurea; idarubicin hydrochloride; ifosfamide; ilmofosine; iproplatin; irinotecan; irinotecan hydrochloride; lanreotide acetate; letrozole; leuprolide acetate; liarozole hydrochloride; lometrexol sodium; lomustine; losoxantrone hydrochloride; masoprocol; maytansine; mechlorethamine hydrochloride; megestrol acetate; melengestrol acetate; melphalan; menogaril; mercaptopurine; methotrexate; methotrexate sodium; metoprine; meturedepa; mitindomide; mitocarcin; mitocromin; mitogillin; mitomalcin; mitomycin; mitosper; mitotane; mitoxantrone hydrochloride; mycophenolic acid; nocodazole; nogalamycin; ormaplatin; oxisuran; paclitaxel; pegas-

pargase; peliomycin; pentamustine; peplomycin sulfate; perfosfamide; pipobroman; piposulfan; piroxantrone hydrochloride; plicamycin; plomestane; porfimer sodium; porfiromycin; prednimustine; procarbazine hydrochloride; puromycin; puromycin hydrochloride; pyrazofurin; riboprine; safingol; safingol hydrochloride; semustine; simtrazene; sparfosate sodium; sparsomycin; spirogermanium hydrochloride; spiromustine; spiroplatin; streptonigrin; streptozocin; sulofenur; talisomycin; tecogalan sodium; taxotere; tegafur; teloxantrone hydrochloride; temoporfin; teniposide; teroxirone; testolactone; thiamiprine; thioguanine; thiotepa; tiazofurin; tirapazamine; toremifene citrate; trestolone acetate; triciribine phosphate; trimetrexate; trimetrexate glucuronate; triptorelin; tubulozole hydrochloride; uracil mustard; uredepa; vapreotide; verteporfin; vinblastine sulfate; vincristine sulfate; vindesine; vindesine sulfate; vinepidine sulfate; vinglycinate sulfate; vinleurosine sulfate; vinorelbine tartrate; vinrosidine sulfate; vinzolidine sulfate; vorozole; zeniplatin; zinostatin; and zorubicin hydrochloride.

Other anti-cancer drugs include, but are not limited to: 20-epi-1,25 dihydroxyvitamin D3; 5-ethynyluracil; abiraterone; aclarubicin; acylfulvene; adecypenol; adozelesin; aldesleukin; ALL-TK antagonists; altretamine; ambamustine; amidox; amifostine; aminolevulinic acid; amrubicin; amsacrine; anagrelide; anastrozole; andrographolide; angiogenesis inhibitors; antagonist D; antagonist G; antarelix; anti-dorsalizing morphogenetic protein-1; antiandrogen, prostatic carcinoma; antiestrogen; antineoplaston; antisense oligonucleotides; aphidicolin glycinate; apoptosis gene modulators; apoptosis regulators; apurinic acid; ara-CDP-DL-PTBA; arginine deaminase; asulacrine; atamestane; atrimustine; axinastatin 1; axinastatin 2; axinastatin 3; azasetron; azatoxin; azatyrosine; baccatin III derivatives; balanol; batimastat; BCR/ABL antagonists; benzochlorins; benzoylstaurosporine; beta lactam derivatives; beta-alethine; betaclamycin B; betulinic acid; bFGF inhibitor; bicalutamide; bisantrene; bisaziridinylspermine; bisnafide; bistratene A; bizelesin; breflate; bropirimine; budotitane; buthionine sulfoximine; calcipotriol; calphostin C; camptothecin derivatives; capecitabine; carboxamide-amino-triazole; carboxyamidotriazole; CaRest M3; CARN 700; cartilage derived inhibitor; carzelesin; casein kinase inhibitors (ICOS); castanospermine; cecropin B; cetrorelix; chlorins; chloroquinoxaline sulfonamide; cicaprost; cis-porphyrin; cladribine; clomifene analogues; clotrimazole; collismycin A; collismycin B; combretastatin A4; combretastatin analogue; conagenin; crambescidin 816; crisnatol; cryptophycin 8; cryptophycin A derivatives; curacin A; cyclopentanthraquinones; cycloplatam; cypemycin; cytarabine ocfosfate; cytolytic factor; cytostatin; dacliximab; decitabine; dehydrodidemnin B; deslorelin; dexamethasone; dexifosfamide; dexrazoxane; dexverapamil; diaziquone; didemnin B; didox; diethylnorspermine; dihydro-5-azacytidine; dihydrotaxol, 9-; dioxamycin; diphenyl spiromustine; docetaxel; docosanol; dolasetron; doxifluridine; doxorubicin; droloxifene; dronabinol; duocarmycin SA; ebselen; ecomustine; edelfosine; edrecolomab; eflornithine; elemene; emitefur; epirubicin; epristeride; estramustine analogue; estrogen agonists; estrogen antagonists; etanidazole; etoposide phosphate; exemestane; fadrozole; fazarabine; fenretinide; filgrastim; finasteride; flavopiridol; flezelastine; fluasterone; fludarabine; fluorodaunorunicin hydrochloride; forfenimex; formestane; fostriecin; fotemustine; gadolinium texaphyrin; gallium nitrate; galocitabine; ganirelix; gelatinase inhibitors; gemcitabine; glutathione inhibitors; hepsulfam; heregulin; hexamethylene bisacetamide; hypericin; ibandronic acid; idarubicin; idoxifene; idramantone; ilmofosine; ilomastat; imatinib (e.g., Gleevec®); imiquimod; immunostimulant peptides; insulin-like growth factor-1 receptor inhibitor; interferon agonists; interferons; interleukins; iobenguane; iododoxorubicin; ipomeanol, 4-; iroplact; irsogladine; isobengazole; isohomohalicondrin B; itasetron; jasplakinolide; kahalalide F; lamellarin-N triacetate; lanreotide; leinamycin; lenograstim; lentinan sulfate; leptolstatin; letrozole; leukemia inhibiting factor; leukocyte alpha interferon; leuprolide+estrogen+progesterone; leuprorelin; levamisole; liarozole; linear polyamine analogue; lipophilic disaccharide peptide; lipophilic platinum compounds; lissoclinamide 7; lobaplatin; lombricine; lometrexol; lonidamine; losoxantrone; loxoribine; lurtotecan; lutetium texaphyrin; lysofylline; lytic peptides; maitansine; mannostatin A; marimastat; masoprocol; maspin; matrilysin inhibitors; matrix metalloproteinase inhibitors; menogaril; merbarone; meterelin; methioninase; metoclopramide; MIF inhibitor; mifepristone; miltefosine; mirimostim; mitoguazone; mitolactol; mitomycin analogues; mitonafide; mitotoxin fibroblast growth factor-saporin; mitoxantrone; mofarotene; molgramostim;Erbitux, human chorionic gonadotrophin; monophosphoryl lipid A+myobacterium cell wall sk; mopidamol; mustard anticancer agent; mycaperoxide B; mycobacterial cell wall extract; myriaporone; N-acetyldinaline; N-substituted benzamides; nafarelin; nagrestip; naloxone+pentazocine; napavin; naphterpin; nartograstim; nedaplatin; nemorubicin; neridronic acid; nilutamide; nisamycin; nitric oxide modulators; nitroxide antioxidant; nitrullyn; oblimersen (Genasense®); O^6-benzylguanine; octreotide; okicenone; oligonucleotides; onapristone; ondansetron; ondansetron; oracin; oral cytokine inducer; ormaplatin; osaterone; oxaliplatin; oxaunomycin; paclitaxel; paclitaxel analogues; paclitaxel derivatives; palauamine; palmitoylrhizoxin; pamidronic acid; panaxytriol; panomifene; parabactin; pazelliptine; pegaspargase; peldesine; pentosan polysulfate sodium; pentostatin; pentrozole; perflubron; perfosfamide; perillyl alcohol; phenazinomycin; phenylacetate; phosphatase inhibitors; picibanil; pilocarpine hydrochloride; pirarubicin; piritrexim; placetin A; placetin B; plasminogen activator inhibitor; platinum complex; platinum compounds; platinum-triamine complex; porfimer sodium; porfiromycin; prednisone; propyl bis-acridone; prostaglandin J2; proteasome inhibitors; protein A-based immune modulator; protein kinase C inhibitor; protein kinase C inhibitors, microalgal; protein tyrosine phosphatase inhibitors; purine nucleoside phosphorylase inhibitors; purpurins; pyrazoloacridine; pyridoxylated hemoglobin polyoxyethylene conjugate; raf antagonists; raltitrexed; ramosetron; ras farnesyl protein transferase inhibitors; ras inhibitors; ras-GAP inhibitor; retelliptine demethylated; rhenium Re 186 etidronate; rhizoxin; ribozymes; RII retinamide; rohitukine; romurtide; roquinimex; rubiginone B1; ruboxyl; safingol; saintopin; SarCNU; sarcophytol A; sargramostim; Sdi 1 mimetics; semustine; senescence derived inhibitor 1; sense oligonucleotides; signal transduction inhibitors; sizofiran; sobuzoxane; sodium borocaptate; sodium phenylacetate; solverol; somatomedin binding protein; sonermin; sparfosic acid; spicamycin D; spiromustine; splenopentin; spongistatin 1; squalamine; stipiamide; stromelysin inhibitors; sulfinosine; superactive vasoactive intestinal peptide antagonist; suradista; suramin; swainsonine; tallimustine; tamoxifen methiodide; tauromustine; tazarotene; tecogalan sodium; tegafur; tellurapyrylium; telomerase inhibitors; temoporfin; teniposide; tetrachlorodecaoxide; tetrazomine; thaliblastine; thiocoraline; thrombopoietin; thrombopoietin mimetic; thymalfasin; thymopoietin receptor agonist; thymotrinan; thyroid stimulating hormone; tin ethyl etiopurpurin; tirapazamine; titanocene bichloride; topsentin; toremifene;

translation inhibitors; tretinoin; triacetyluridine; triciribine; trimetrexate; triptorelin; tropisetron; turosteride; tyrosine kinase inhibitors; tyrphostins; UBC inhibitors; ubenimex; urogenital sinus-derived growth inhibitory factor; urokinase receptor antagonists; vapreotide; variolin B; velaresol; veramine; verdins; verteporfin; vinorelbine; vinxaltine; vitaxin; vorozole; zanoterone; zeniplatin; zilascorb; and zinostatin stimalamer.

Specific second active agents include, but are not limited to, rituximab, bortezomib, oblimersen (Genasense®), remicade, docetaxel, celecoxib, melphalan, dexamethasone (Decadron®), steroids, gemcitabine, cisplatinum, temozolomide, etoposide, cyclophosphamide, temodar, carboplatin, procarbazine, gliadel, tamoxifen, topotecan, methotrexate, Arisa®, taxol, taxotere, fluorouracil, leucovorin, irinotecan, xeloda, CPT-11, interferon alpha, pegylated interferon alpha (e.g., PEG INTRON-A), capecitabine, cisplatin, thiotepa, fludarabine, carboplatin, liposomal daunorubicin, cytarabine, doxetaxol, pacilitaxel, vinblastine, IL-2, GM-CSF, dacarbazine, vinorelbine, zoledronic acid, palmitronate, biaxin, busulphan, prednisone, bisphosphonate, arsenic trioxide, vincristine, doxorubicin (Doxil®), paclitaxel, ganciclovir, adriamycin, estramustine sodium phosphate (Emcyt®), sulindac, and etoposide.

5.3 Methods of Treatments and Prevention

Methods of this invention encompass methods of treating, preventing or managing various types of lymphomas. In a preferred embodiment, methods of this invention encompass methods of treating, preventing or managing various types of lymphomas, including but not limited to, mantle cell lymphoma, MCL, lymphocytic lymphoma of intermediate differentiation, intermediate lymphocytic lymphoma, ILL, diffuse poorly differentiated lymphocytic lymphoma, PDL, centrocytic lymphoma, diffuse small-cleaved cell lymphoma, DSCCL, follicular lymphoma, and any type of the mantle cell lymphomas that can be seen under the microscope (nodular, diffuse, blastic and mentle zone lymphoma).

As used herein, unless otherwise specified, the term "treating" refers to the administration of a compound of the invention, or other additional active agent, after the onset of symptoms of the particular cancer. As used herein, unless otherwise specified, the term "preventing" refers to the administration prior to the onset of symptoms, particularly to patients at risk of cancer, and in particular lymphoma. The term "prevention" includes the inhibition of a symptom of the particular cancer. Patients with familial history of cancer or lymphoma in particular are preferred candidates for preventive regimens. As used herein and unless otherwise indicated, the term "managing" encompasses preventing the recurrence of the particular cancer in a patient who had suffered from it, lengthening the time a patient who had suffered from the cancer remains in remission, and/or reducing mortality rates of the patients.

As used herein, the term "cancer" includes, but is not limited to, solid tumors and blood born tumors. The term "cancer" refers to disease of skin tissues, organs, blood, and vessels, including, but not limited to, cancers of the bladder, bone or blood, brain, breast, cervix, chest, colon, endrometrium, esophagus, eye, head, kidney, liver, lymph nodes, lung, mouth, neck, ovaries, pancreas, prostate, rectum, stomach, testis, throat, and uterus.

The term "lymphoma" refers a heterogenous group of neoplasms arising in the reticuloendothelial and lymphatic systems. Non-Hodgkin's lymphoma (NHL) refers to malignant monoclonal proliferation of lymphoid cells in sites of the immune system, including lymph nodes, bone marrow, spleen, liver and gastrointestinal tract. The NHL includes, but is not limited to, mantle cell lymphoma, MCL, lymphocytic lymphoma of intermediate differentiation, intermediate lymphocytic lymphoma, ILL, diffuse poorly differentiated lymphocytic lymphoma, PDL, centrocytic lymphoma, diffuse small-cleaved cell lymphoma, DSCCL, follicular lymphoma, and any type of the mantle cell lymphomas that can be seen under the microscope (nodular, diffuse, blastic and mentle zone lymphoma).

The term "relapsed" refers to a situation where patients who have had a remission of cancer after therapy have a return of lymphoid cells in the immune systems. The term "refractory or resistant" refers to a circumstance where patients, even after intensive treatment, have residual lymphoid cells in the immune systems.

This invention encompasses methods of treating patients who have been previously treated for cancer, but are non-responsive to standard therapies, as well as those who have not previously been treated. The invention also encompasses methods of treating patients regardless of patient's age, although some cancers are more common in certain age groups. The invention further encompasses methods of treating patients who have undergone surgery in an attempt to treat the cancer at issue, as well as those who have not. Because patients with cancer have heterogenous clinical manifestations and varying clinical outcomes, the treatment given to a patient may vary, depending on his/her prognosis. The skilled clinician will be able to readily determine without undue experimentation specific secondary agents, types of surgery, and types of non-drug based standard therapy that can be effectively used to treat an individual patient with cancer.

Methods encompassed by this invention comprise administering one or more immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof, to a patient (e.g., a human) suffering, or likely to suffer, from cancer, particularly mantle cell lymphoma.

In one embodiment of the invention, an immunomodulatory compound of the invention can be administered orally and in single or divided daily doses in an amount of from about 0.10 to about 150 mg/day. In a preferred embodiment, 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl-piperidine-2,6-dione (Revlimid®) may be administered in an amount of from about 0.10 to 150 mg per day, from about 1 to about 50 mg per day, or from about 5 to about 25 mg per day. Specific doses per day include 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49 or 50 mg per day.

In a preferred embodiment, 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl-piperidine-2,6-dione (Revlimid®) may be administered in an amount of from about 1 to 50 mg per day, or from about 5 to about 25 mg per day to patients with various types of non-Hodgkin's lymphomas such as mantle cell lymphoma, MCL, lymphocytic lymphoma of intermediate differentiation, intermediate lymphocytic lymphoma, ILL, diffuse poorly differentiated lymphocytic lymphoma, PDL, centrocytic lymphoma, diffuse small-cleaved cell lymphoma, DSCCL, diffuse large cell lymphoma, follicular lymphoma, and mentle zone lymphoma.

In particular, 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl-piperidine-2,6-dione (Revlimid®) may be administered to patients with mantle cell lymphoma in an amount of from about 1 to 50 mg per day, or from about 5 to about 25 mg per day. In a specific embodiment, 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl-piperidine-2,6-dione (Revlimid®) may be

administered to patients with mantle cell lymphoma in an amount of about 10, 15, 20, 25 or 50 mg per day. In a specific embodiment, Revlimid® can be administered in an amount of about 25 mg per day to patients with mantle cell lymphoma.

In one embodiment, the recommended starting dose of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (Revlimid®) is 10 mg per day. The dose can be escalated every week to 15, 20, 25, 30, 35, 40, 45 and 50 mg per day. The patients who are dosed initially at 10 mg and who experience thrombocytopenia or neutropenia that develops within or after the first four weeks of starting Revlimid® therapy may have their dosage adjusted according to a platelet count or absolute neutrophil count (ANC).

5.3.1 Combination Therapy with a Second Active Agent

Specific methods of the invention comprise administering an immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof, in combination with one or more second active agents, and/or in combination with radiation therapy, blood transfusions, or surgery. Examples of immunomodulatory compounds of the invention are disclosed herein (see, e.g., section 4.1). Examples of second active agents are also disclosed herein (see, e.g., section 4.2).

Administration of an immunomodulatory compound of the invention and the second active agents to a patient can occur simultaneously or sequentially by the same or different routes of administration. The suitability of a particular route of administration employed for a particular active agent will depend on the active agent itself (e.g., whether it can be administered orally without decomposing prior to entering the blood stream) and the disease being treated. A preferred route of administration for an immunomodulatory compound of the invention is orally. Preferred routes of administration for the second active agents or ingredients of the invention are known to those of ordinary skill in the art. See, e.g., *Physicians' Desk Reference*, (2006).

In one embodiment of the invention, the second active agent is administered intravenously or subcutaneously and once or twice daily in an amount of from about 1 to about 1,000 mg, from about 5 to about 500 mg, from about 10 to about 375 mg, or from about 50 to about 200 mg. The specific amount of the second active agent will depend on the specific agent used, the type of disease being treated or managed, the severity and stage of disease, and the amount(s) of immunomodulatory compounds of the invention and any optional additional active agents concurrently administered to the patient. In a particular embodiment, the second active agent is rituximab, bortezomib, oblimersen (Genasense®), GM-CSF, G-CSF, EPO, taxotere, irinotecan, dacarbazine, transretinoic acid, topotecan, pentoxifylline, ciprofloxacin, dexamethasone, vincristine, doxorubicin, COX-2 inhibitor, IL2, IL8, IL18, IFN, Ara-C, vinorelbine, or a combination thereof.

In a specific embodiment, an immunomodulatory compound of the invention is administered in combination with rituximab to patients with mantle cell lymphomas. In a specific embodiment, Revlimid® is administered to patients with mantle cell lymphoma in an amount of from about 5 to about 25 mg per day in combination with rituximab in an amount of 375 mg/m^2 by intravenous infusion weekly.

In a preferred embodiment, Revlimid® is administered alone or in combination with rituximab to patients with various types of non-Hodgkin's lymphomas, including, but not limited to, mantle cell lymphoma, MCL, lymphocytic lymphoma of intermediate differentiation, intermediate lymphocytic lymphoma, ILL, diffuse poorly differentiated lymphocytic lymphoma, PDL, centrocytic lymphoma, diffuse small-cleaved cell lymphoma, DSCCL, diffuse large cell lymphoma, follicular lymphoma, and mentle zone lymphoma.

In another embodiment, an immunomodulatory compound of the invention is administered alone or in combination with a second active ingredient such as vinblastine or fludarabine to patients with various types of lymphomas, including, but not limited to, Hodgkin's lymphoma, non-Hodgkin's lymphoma, cutaneous T-Cell lymphoma, cutaneous B-Cell lymphoma, diffuse large B-Cell lymphoma or relapsed or refractory low grade follicular lymphoma.

In another embodiment, GM-CSF, G-CSF or EPO is administered subcutaneously during about five days in a four or six week cycle in an amount of from about 1 to about 750 mg/m^2/day, preferably in an amount of from about 25 to about 500 mg/m^2/day, more preferably in an amount of from about 50 to about 250 mg/m^2/day, and most preferably in an amount of from about 50 to about 200 mg/m^2/day. In a certain embodiment, GM-CSF may be administered in an amount of from about 60 to about 500 mcg/m^2 intravenously over 2 hours, or from about 5 to about 12 mcg/m^2/day subcutaneously. In a specific embodiment, G-CSF may be administered subcutaneously in an amount of about 1 mcg/kg/day initially and can be adjusted depending on rise of total granulocyte counts. The maintenance dose of G-CSF may be administered in an amount of about 300 (in smaller patients) or 480 mcg subcutaneously. In a certain embodiment, EPO may be administered subcutaneously in an amount of 10,000 Unit 3 times per week.

This invention also encompasses a method of increasing the dosage of an anti-cancer drug or agent that can be safely and effectively administered to a patient, which comprises administering to a patient (e.g., a human) an immunomodulatory compound of the invention, or a pharmaceutically acceptable derivative, salt, solvate (e.g., hydrate), or prodrug thereof. Patients that can benefit by this method are those likely to suffer from an adverse effect associated with anti-cancer drugs for treating a specific cancer of the blood, skin, subcutaneous tissue, lymph nodes, brain, lung, liver, bone, intestine, colon, heart, pancreas, adrenal, kidney, prostate, breast, colorectal, or combinations thereof. The administration of an immunomodulatory compound of the invention alleviates or reduces adverse effects which are of such severity that it would otherwise limit the amount of anti-cancer drug.

In one embodiment, an immunomodulatory compound of the invention can be administered orally and daily in an amount of from about 0.10 to about 150 mg, and preferably from about 1 to about 50 mg, more preferably from about 5 to about 25 mg prior to, during, or after the occurrence of the adverse effect associated with the administration of an anti-cancer drug to a patient. In a particular embodiment, an immunomodulatory compound of the invention is administered in combination with specific agents such as heparin, aspirin, coumadin, or G-CSF to avoid adverse effects that are associated with anti-cancer drugs such as but not limited to neutropenia or thrombocytopenia.

In another embodiment, this invention encompasses a method of treating, preventing and/or managing lymphoma, which comprises administering an immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof, in conjunction with (e.g., before, during, or after) conventional therapy including, but not limited to, surgery, immunotherapy, biological therapy, radiation therapy, or

other non-drug based therapy presently used to treat, prevent or manage cancer. The combined use of the immunomodulatory compounds of the invention and conventional therapy may provide a unique treatment regimen that is unexpectedly effective in certain patients. Without being limited by theory, it is believed that immunomodulatory compounds of the invention may provide additive or synergistic effects when given concurrently with conventional therapy.

As discussed elsewhere herein, the invention encompasses a method of reducing, treating and/or preventing adverse or undesired effects associated with conventional therapy including, but not limited to, surgery, chemotherapy, radiation therapy, hormonal therapy, biological therapy and immunotherapy. An immunomodulatory compound of the invention and other active ingredient can be administered to a patient prior to, during, or after the occurrence of the adverse effect associated with conventional therapy.

In one embodiment, an immunomodulatory compound of the invention can be administered in an amount of from about 0.10 to about 150 mg, and preferably from about 1 to about 50 mg, more preferably from about 5 to about 25 mg orally and daily alone, or in combination with a second active agent disclosed herein (see, e.g., section 4.2), prior to, during, or after the use of conventional therapy.

5.3.2 Use with Transplantation Therapy

Compounds of the invention can be used to reduce the risk of Graft Versus Host Disease (GVHD). Therefore, the invention encompasses a method of treating, preventing and/or managing cancer, which comprises administering the immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof, in conjunction with transplantation therapy.

As those of ordinary skill in the art are aware, the treatment of cancer is often based on the stages and mechanism of the disease. For example, as inevitable leukemic transformation develops in certain stages of cancer, transplantation of peripheral blood stem cells, hematopoietic stem cell preparation or bone marrow may be necessary. The combined use of the immunomodulatory compound of the invention and transplantation therapy provides a unique and unexpected synergism. In particular, an immunomodulatory compound of the invention exhibits immunomodulatory activity that may provide additive or synergistic effects when given concurrently with transplantation therapy in patients with cancer.

An immunomodulatory compound of the invention can work in combination with transplantation therapy reducing complications associated with the invasive procedure of transplantation and risk of GVHD. This invention encompasses a method of treating, preventing and/or managing cancer which comprises administering to a patient (e.g., a human) an immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof, before, during, or after the transplantation of umbilical cord blood, placental blood, peripheral blood stem cell, hematopoietic stem cell preparation or bone marrow. Examples of stem cells suitable for use in the methods of the invention are disclosed in U.S. patent publication nos. 2002/0123141, 2003/0235909 and 2003/0032179, by R. Hariri et al., the entireties of which are incorporated herein by reference.

In one embodiment of this method, an immunomodulatory compound of the invention is administered to patients with lymphomas before, during, or after the transplantation of autologous peripheral blood progenitor cell.

In another embodiment, an immunomodulatory compound of the invention is administered to patients with relapsed lymphoma after the stem cell transplantation.

5.3.3 Cycling Therapy

In certain embodiments, the prophylactic or therapeutic agents of the invention are cyclically administered to a patient. Cycling therapy involves the administration of an active agent for a period of time, followed by a rest for a period of time, and repeating this sequential administration. Cycling therapy can reduce the development of resistance to one or more of the therapies, avoid or reduce the side effects of one of the therapies, and/or improves the efficacy of the treatment.

Consequently, in one specific embodiment of the invention, an immunomodulatory compound of the invention is administered daily in a single or divided doses in a four to six week cycle with a rest period of about a week or two weeks. The invention further allows the frequency, number, and length of dosing cycles to be increased. Thus, another specific embodiment of the invention encompasses the administration of an immunomodulatory compound of the invention for more cycles than are typical when it is administered alone. In yet another specific embodiment of the invention, an immunomodulatory compound of the invention is administered for a greater number of cycles that would typically cause dose-limiting toxicity in a patient to whom a second active ingredient is not also being administered.

In one embodiment, an immunomodulatory compound of the invention is administered daily and continuously for three or four weeks at a dose of from about 0.10 to about 150 mg/d followed by a break of one or two weeks. In a particular embodiment, an immunomodulatory compound of the invention is administered in an amount of from about 1 to about 50 mg/day, preferably in an amount of about 25 mg/day for three to four weeks, followed by one week or two weeks of rest in a four or six week cycle.

In a preferred embodiment, 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (Revlimid®) is administered to patients with various types of lymphomas such as mantle cell lymphoma, follicullar lymphoma and diffuse large cell lymphoma, in an amount of about 10 mg, 15 mg, 20 mg, 25 mg or 30 mg per day for 21 days followed by seven days rest in a 28 day cycle. In the most preferred embodiment, 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (Revlimid®) is administered to patients with refractory or relapsed mantle cell lymphoma in an amount of about 25 mg per day for 21 days followed by seven days rest in a 28 day cycle.

In one embodiment of the invention, an immunomodulatory compound of the invention and a second active agent or ingredient are administered orally, with administration of an immunomodulatory compound of the invention occurring 30 to 60 minutes prior to a second active ingredient, during a cycle of four to six weeks. In another embodiment of the invention, an immunomodulatory compound of the invention is administered orally and a second active ingredient is administered by intravenous infusion.

In a specific embodiment, one cycle comprises the administration of from about 10 to about 25 mg/day of Revlimid® and from about 50 to about 750 mg/m^2/day of a second active ingredient daily for three to four weeks and then one or two weeks of rest.

In one embodiment, rituximab can be administered in an amount of 375 mg/m^2 as an additional active agent to patients with various types of lymphomas such as mantle cell lym-

phoma, follicullar lymphoma and diffuse large cell lymphoma. In a preferred embodiment, rituximab can be administered in an amount of 375 mg/m^2 as an additional active agent to patients with refractory or relapsed mantle cell lymphoma. In a preferred embodiment, one cycle comprises the administration of Revlimid® given orally daily for 21 days followed by 7 days of rest and 375 mg/m^2 of rituximab by intravenous infusion weekly for four weeks.

Typically, the number of cycles during which the combinatorial treatment is administered to a patient will be from about one to about 24 cycles, more typically from about two to about 16 cycles, and even more typically from about four to about three cycles.

5.4 Pharmaceutical Compositions and Dosage Forms

Pharmaceutical compositions can be used in the preparation of individual, single unit dosage forms. Pharmaceutical compositions and dosage forms of the invention comprise an immunomodulatory compound of the invention, or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof. Pharmaceutical compositions and dosage forms of the invention can further comprise one or more excipients.

Pharmaceutical compositions and dosage forms of the invention can also comprise one or more additional active ingredients. Consequently, pharmaceutical compositions and dosage forms of the invention comprise the active ingredients disclosed herein (e.g., an immunomodulatory compound of the invention and a second active agent). Examples of optional second, or additional, active ingredients are disclosed herein (see, e.g., section 5.2).

Single unit dosage forms of the invention are suitable for oral, mucosal (e.g., nasal, sublingual, vaginal, buccal, or rectal), parenteral (e.g., subcutaneous, intravenous, bolus injection, intramuscular, or intraarterial), topical (e.g., eye drops or other ophthalmic preparations), transdermal or transcutaneous administration to a patient. Examples of dosage forms include, but are not limited to: tablets; caplets; capsules, such as soft elastic gelatin capsules; cachets; troches; lozenges; dispersions; suppositories; powders; aerosols (e.g., nasal sprays or inhalers); gels; liquid dosage forms suitable for oral or mucosal administration to a patient, including suspensions (e.g., aqueous or non-aqueous liquid suspensions, oil-in-water emulsions, or a water-in-oil liquid emulsions), solutions, and elixirs; liquid dosage forms suitable for parenteral administration to a patient; eye drops or other ophthalmic preparations suitable for topical administration; and sterile solids (e.g., crystalline or amorphous solids) that can be reconstituted to provide liquid dosage forms suitable for parenteral administration to a patient.

The composition, shape, and type of dosage forms of the invention will typically vary depending on their use. For example, a dosage form used in the acute treatment of a disease may contain larger amounts of one or more of the active ingredients it comprises than a dosage form used in the chronic treatment of the same disease. Similarly, a parenteral dosage form may contain smaller amounts of one or more of the active ingredients it comprises than an oral dosage form used to treat the same disease. These and other ways in which specific dosage forms encompassed by this invention will vary from one another will be readily apparent to those skilled in the art. See, e.g., *Remington's Pharmaceutical Sciences,* 18th ed., Mack Publishing, Easton Pa. (1990).

Typical pharmaceutical compositions and dosage forms comprise one or more excipients. Suitable excipients are well known to those skilled in the art of pharmacy, and non-limiting examples of suitable excipients are provided herein. Whether a particular excipient is suitable for incorporation into a pharmaceutical composition or dosage form depends on a variety of factors well known in the art including, but not limited to, the way in which the dosage form will be administered to a patient. For example, oral dosage forms such as tablets may contain excipients not suited for use in parenteral dosage forms. The suitability of a particular excipient may also depend on the specific active ingredients in the dosage form. For example, the decomposition of some active ingredients may be accelerated by some excipients such as lactose, or when exposed to water. Active ingredients that comprise primary or secondary amines are particularly susceptible to such accelerated decomposition. Consequently, this invention encompasses pharmaceutical compositions and dosage forms that contain little, if any, lactose other mono- or disaccharides. As used herein, the term "lactose-free" means that the amount of lactose present, if any, is insufficient to substantially increase the degradation rate of an active ingredient.

Lactose-free compositions of the invention can comprise excipients that are well known in the art and are listed, for example, in the *U.S. Pharmacopeia* (USP) 25-NF20 (2002). In general, lactose-free compositions comprise active ingredients, a binder/filler, and a lubricant in pharmaceutically compatible and pharmaceutically acceptable amounts. Preferred lactose-free dosage forms comprise active ingredients, microcrystalline cellulose, pre-gelatinized starch, and magnesium stearate.

This invention further encompasses anhydrous pharmaceutical compositions and dosage forms comprising active ingredients, since water can facilitate the degradation of some compounds. For example, the addition of water (e.g., 5%) is widely accepted in the pharmaceutical arts as a means of simulating long-term storage in order to determine characteristics such as shelf-life or the stability of formulations over time. See, e.g., Jens T. Carstensen, *Drug Stability: Principles & Practice,* 2d. Ed., Marcel Dekker, NY, N.Y., 1995, pp. 379-80. In effect, water and heat accelerate the decomposition of some compounds. Thus, the effect of water on a formulation can be of great significance since moisture and/or humidity are commonly encountered during manufacture, handling, packaging, storage, shipment, and use of formulations.

Anhydrous pharmaceutical compositions and dosage forms of the invention can be prepared using anhydrous or low moisture containing ingredients and low moisture or low humidity conditions. Pharmaceutical compositions and dosage forms that comprise lactose and at least one active ingredient that comprises a primary or secondary amine are preferably anhydrous if substantial contact with moisture and/or humidity during manufacturing, packaging, and/or storage is expected.

An anhydrous pharmaceutical composition should be prepared and stored such that its anhydrous nature is maintained. Accordingly, anhydrous compositions are preferably packaged using materials known to prevent exposure to water such that they can be included in suitable formulary kits. Examples of suitable packaging include, but are not limited to, hermetically sealed foils, plastics, unit dose containers (e.g., vials), blister packs, and strip packs.

The invention further encompasses pharmaceutical compositions and dosage forms that comprise one or more compounds that reduce the rate by which an active ingredient will decompose. Such compounds, which are referred to herein as "stabilizers," include, but are not limited to, antioxidants such as ascorbic acid, pH buffers, or salt buffers.

Like the amounts and types of excipients, the amounts and specific types of active ingredients in a dosage form may differ depending on factors such as, but not limited to, the route by which it is to be administered to patients. However, typical dosage forms of the invention comprise an immunomodulatory compound of the invention or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof in an amount of from about 0.10 to about 150 mg. Typical dosage forms comprise an immunomodulatory compound of the invention or a pharmaceutically acceptable salt, solvate (e.g., hydrate), stereoisomer, clathrate, or prodrug thereof in an amount of about 0.1, 1, 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20, 25, 50, 100, 150 or 200 mg. Ina specific embodiment, a preferred dosage form comprises 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (Revlimid®) in an amount of about 1, 2.5, 5, 10, 15, 20, 25 or 50 mg. Typical dosage forms comprise the second active ingredient in an amount of 1 to about 1000 mg, from about 5 to about 500 mg, from about 10 to about 350 mg, or from about 50 to about 200 mg. Of course, the specific amount of the anti-cancer drug will depend on the specific agent used, the type of cancer being treated or managed, and the amount(s) of an immunomodulatory compound of the invention and any optional additional active agents concurrently administered to the patient.

5.4.1 Oral Dosage Forms

Pharmaceutical compositions of the invention that are suitable for oral administration can be presented as discrete dosage forms, such as, but are not limited to, tablets (e.g., chewable tablets), caplets, capsules, and liquids (e.g., flavored syrups). Such dosage forms contain predetermined amounts of active ingredients, and may be prepared by methods of pharmacy well known to those skilled in the art. See generally, *Remington's Pharmaceutical Sciences,* 18th ed., Mack Publishing, Easton Pa. (1990).

In one embodiment, a preferred dosage form is a capsule or tablet comprising 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (Revlimid®) in an amount of about 1, 2.5, 5, 10, 15, 20, 25 or 50 mg. In a specific embodiment, a preferred capsule or tablet dosage form comprises 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (Revlimid®) in an amount of about 5 or 10 mg.

Typical oral dosage forms of the invention are prepared by combining the active ingredients in an intimate admixture with at least one excipient according to conventional pharmaceutical compounding techniques. Excipients can take a wide variety of forms depending on the form of preparation desired for administration. For example, excipients suitable for use in oral liquid or aerosol dosage forms include, but are not limited to, water, glycols, oils, alcohols, flavoring agents, preservatives, and coloring agents. Examples of excipients suitable for use in solid oral dosage forms (e.g., powders, tablets, capsules, and caplets) include, but are not limited to, starches, sugars, micro-crystalline cellulose, diluents, granulating agents, lubricants, binders, and disintegrating agents.

Because of their ease of administration, tablets and capsules represent the most advantageous oral dosage unit forms, in which case solid excipients are employed. If desired, tablets can be coated by standard aqueous or nonaqueous techniques. Such dosage forms can be prepared by any of the methods of pharmacy. In general, pharmaceutical compositions and dosage forms are prepared by uniformly and intimately admixing the active ingredients with liquid carriers, finely divided solid carriers, or both, and then shaping the product into the desired presentation if necessary.

For example, a tablet can be prepared by compression or molding. Compressed tablets can be prepared by compressing in a suitable machine the active ingredients in a free-flowing form such as powder or granules, optionally mixed with an excipient. Molded tablets can be made by molding in a suitable machine a mixture of the powdered compound moistened with an inert liquid diluent.

Examples of excipients that can be used in oral dosage forms of the invention include, but are not limited to, binders, fillers, disintegrants, and lubricants. Binders suitable for use in pharmaceutical compositions and dosage forms include, but are not limited to, corn starch, potato starch, or other starches, gelatin, natural and synthetic gums such as acacia, sodium alginate, alginic acid, other alginates, powdered tragacanth, guar gum, cellulose and its derivatives (e.g., ethyl cellulose, cellulose acetate, carboxymethyl cellulose calcium, sodium carboxymethyl cellulose), polyvinyl pyrrolidone, methyl cellulose, pre-gelatinized starch, hydroxypropyl methyl cellulose, (e.g., Nos. 2208, 2906, 2910), microcrystalline cellulose, and mixtures thereof.

Suitable forms of microcrystalline cellulose include, but are not limited to, the materials sold as AVICEL-PH-101, AVICEL-PH-103 AVICEL RC-581, AVICEL-PH-105 (available from FMC Corporation, American Viscose Division, Avicel Sales, Marcus Hook, Pa.), and mixtures thereof. An specific binder is a mixture of microcrystalline cellulose and sodium carboxymethyl cellulose sold as AVICEL RC-581. Suitable anhydrous or low moisture excipients or additives include AVICEL-PH-103™ and Starch 1500 LM.

Examples of fillers suitable for use in the pharmaceutical compositions and dosage forms disclosed herein include, but are not limited to, talc, calcium carbonate (e.g., granules or powder), microcrystalline cellulose, powdered cellulose, dextrates, kaolin, mannitol, silicic acid, sorbitol, starch, pre-gelatinized starch, and mixtures thereof. The binder or filler in pharmaceutical compositions of the invention is typically present in from about 50 to about 99 weight percent of the pharmaceutical composition or dosage form.

Disintegrants are used in the compositions of the invention to provide tablets that disintegrate when exposed to an aqueous environment. Tablets that contain too much disintegrant may disintegrate in storage, while those that contain too little may not disintegrate at a desired rate or under the desired conditions. Thus, a sufficient amount of disintegrant that is neither too much nor too little to detrimentally alter the release of the active ingredients should be used to form solid oral dosage forms of the invention. The amount of disintegrant used varies based upon the type of formulation, and is readily discernible to those of ordinary skill in the art. Typical pharmaceutical compositions comprise from about 0.5 to about 15 weight percent of disintegrant, preferably from about 1 to about 5 weight percent of disintegrant.

Disintegrants that can be used in pharmaceutical compositions and dosage forms of the invention include, but are not limited to, agar-agar, alginic acid, calcium carbonate, microcrystalline cellulose, croscarmellose sodium, crospovidone, polacrilin potassium, sodium starch glycolate, potato or tapioca starch, other starches, pre-gelatinized starch, other starches, clays, other algins, other celluloses, gums, and mixtures thereof.

Lubricants that can be used in pharmaceutical compositions and dosage forms of the invention include, but are not limited to, calcium stearate, magnesium stearate, mineral oil, light mineral oil, glycerin, sorbitol, mannitol, polyethylene glycol, other glycols, stearic acid, sodium lauryl sulfate, talc, hydrogenated vegetable oil (e.g., peanut oil, cottonseed oil, sunflower oil, sesame oil, olive oil, corn oil, and soybean oil),

zinc stearate, ethyl oleate, ethyl laureate, agar, and mixtures thereof. Additional lubricants include, for example, a syloid silica gel (AEROSIL200, manufactured by W.R. Grace Co. of Baltimore, Md.), a coagulated aerosol of synthetic silica (marketed by Degussa Co. of Plano, Tex.), CAB-O-SIL (a pyrogenic silicon dioxide product sold by Cabot Co. of Boston, Mass.), and mixtures thereof. If used at all, lubricants are typically used in an amount of less than about 1 weight percent of the pharmaceutical compositions or dosage forms into which they are incorporated.

A preferred solid oral dosage form of the invention comprises an immunomodulatory compound of the invention, anhydrous lactose, microcrystalline cellulose, polyvinylpyrrolidone, stearic acid, colloidal anhydrous silica, and gelatin.

5.4.2 Delayed Release Dosage Forms

Active ingredients of the invention can be administered by controlled release means or by delivery devices that are well known to those of ordinary skill in the art. Examples include, but are not limited to, those described in U.S. Pat. Nos. 3,845,770; 3,916,899; 3,536,809; 3,598,123; and 4,008,719, 5,674,533, 5,059,595, 5,591,767, 5,120,548, 5,073,543, 5,639,476, 5,354,556, and 5,733,566, each of which is incorporated herein by reference. Such dosage forms can be used to provide slow or controlled-release of one or more active ingredients using, for example, hydropropylmethyl cellulose, other polymer matrices, gels, permeable membranes, osmotic systems, multilayer coatings, microparticles, liposomes, microspheres, or a combination thereof to provide the desired release profile in varying proportions. Suitable controlled-release formulations known to those of ordinary skill in the art, including those described herein, can be readily selected for use with the active ingredients of the invention. The invention thus encompasses single unit dosage forms suitable for oral administration such as, but not limited to, tablets, capsules, gelcaps, and caplets that are adapted for controlled-release.

All controlled-release pharmaceutical products have a common goal of improving drug therapy over that achieved by their non-controlled counterparts. Ideally, the use of an optimally designed controlled-release preparation in medical treatment is characterized by a minimum of drug substance being employed to cure or control the condition in a minimum amount of time. Advantages of controlled-release formulations include extended activity of the drug, reduced dosage frequency, and increased patient compliance. In addition, controlled-release formulations can be used to affect the time of onset of action or other characteristics, such as blood levels of the drug, and can thus affect the occurrence of side (e.g., adverse) effects.

Most controlled-release formulations are designed to initially release an amount of drug (active ingredient) that promptly produces the desired therapeutic effect, and gradually and continually release of other amounts of drug to maintain this level of therapeutic or prophylactic effect over an extended period of time. In order to maintain this constant level of drug in the body, the drug must be released from the dosage form at a rate that will replace the amount of drug being metabolized and excreted from the body. Controlled-release of an active ingredient can be stimulated by various conditions including, but not limited to, pH, temperature, enzymes, water, or other physiological conditions or compounds.

5.4.3 Parenteral Dosage Forms

Parenteral dosage forms can be administered to patients by various routes including, but not limited to, subcutaneous, intravenous (including bolus injection), intramuscular, and intraarterial. Because their administration typically bypasses patients' natural defenses against contaminants, parenteral dosage forms are preferably sterile or capable of being sterilized prior to administration to a patient. Examples of parenteral dosage forms include, but are not limited to, solutions ready for injection, dry products ready to be dissolved or suspended in a pharmaceutically acceptable vehicle for injection, suspensions ready for injection, and emulsions.

Suitable vehicles that can be used to provide parenteral dosage forms of the invention are well known to those skilled in the art. Examples include, but are not limited to: Water for Injection USP; aqueous vehicles such as, but not limited to, Sodium Chloride Injection, Ringer's Injection, Dextrose Injection, Dextrose and Sodium Chloride Injection, and Lactated Ringer's Injection; water-miscible vehicles such as, but not limited to, ethyl alcohol, polyethylene glycol, and polypropylene glycol; and non-aqueous vehicles such as, but not limited to, corn oil, cottonseed oil, peanut oil, sesame oil, ethyl oleate, isopropyl myristate, and benzyl benzoate.

Compounds that increase the solubility of one or more of the active ingredients disclosed herein can also be incorporated into the parenteral dosage forms of the invention. For example, cyclodextrin and its derivatives can be used to increase the solubility of an immunomodulatory compound of the invention and its derivatives. See, e.g., U.S. Pat. No. 5,134,127, which is incorporated herein by reference.

6. EXAMPLES

Certain embodiments of the invention are illustrated by the following non-limiting example.

6.1 Clinical Studies in Patients

6.1.1 Treatment of Mantle Cell Lymphomas

A single-center, open label, phase I/II study was conducted to determine the maximum tolerated dose (MTD) and to evaluate the efficacy of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidin-2,6-dione (lenalidomide or Revlimid®) in combination with rituximab for relapsed or refractory mantle cell lymphoma (MCL). Patients with one to four lines of prior therapy were eligible. Patients with prior treatment using thalidomide or rituximab, regardless of resistance, were eligible. Each cycle (28 days) of treatment comprises administration of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidin-2,6-dione (Revlimid®) given orally daily for 21 days followed by 7 days of rest and 375 mg/m^2 of rituximab by intravenous infusion weekly for four weeks. A standard phase I dose escalation was used to determine MTD with dose levels at 10 mg, 15 mg, 20 mg, and 25 mg of Revlimid®. Dose-limiting toxicity (DLT) was defined as grade 3 or 4 non-hematologic or grade 4 hematologic toxicity during the first cycle.

Ten patients were enrolled with seven evaluable. Median age was 73, range 56-84; median prior lines of therapy were 3, range 1-4. Each cohort had 3 patients. No DLT was encountered and maximum dose of Revlimid® was up to 20 mg. The number of cycles given ranged from one to five cycles. There were no grade 3 or 4 toxicities during the cycle. Grade 1 non-hematologic toxic events included fatigue in 4, stomatitis in 3, pruritis in 3, and myalgias in 2. Grade 2 non-hematologic toxic events included rash in 2 and myalgias in 2. Grade 1 hematologic events included leukopenia in 3, thrombocytopenia in 2 and anemia in 1. There was one episode of grade 2 anemia. Beyond the first cycle, there was only 1 grade 3

toxicity (thrombocytopenia) during cycle 2. Therefore, the MTD has not been reached. Two patients had stable disease at cycle 3 and cycle 5, respectively. Four patients had progressive disease and were taken off the study. One patient progressed in the first cycle.

The study result shows that Revlimid® is effective in treating mantle cell lymphoma, particularly relapsed or refractory mantle cell lymphoma.

6.1.2 Treatment of Aggressive NHL

A multi-center, open-label, Phase II study was conducted in patients with relapsed and refractory aggressive non-Hodgkin's lymphoma (NHL). The trial was designed to evaluate the therapeutic potential and safety of oral monotherapy with 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidin-2,6-dione (Revlimid® or lenalidomide) in 40 patients with relapsed and refractory aggressive NHL following one or more prior treatment regimen with measurable disease. Patients in the study received lenalidomide in an amount of 25mg orally once daily for days one to 21 in a 28-day cycle and continued therapy for 52 weeks as tolerated or until disease progression.

Twenty-five patients age 45 to 80 years (median age 63), with relapsed and refractory aggressive NHL, and who had received a median of 2.5 prior treatments (range: 1-6 prior treatments), were administered with lenalidomide in an amount of 25 mg orally once daily for 21 days in the treatment cycle. Sixteen patients with aggressive NHL were evaluable for tumour assessment. Of the 16 patients, eight had diffuse large cell lymphoma, three had mantle cell lymphoma, two patients had follicular lymphoma, one had transformed lymphoma, and two had aggressive lymphoma of unknown histology.

There were five (31 per cent) patients who experienced objective responses to lenalidomide monotherapy. One patient achieved complete response and four patients achieved partial responses. One patient with diffuse large cell lymphoma achieved complete response with progression free survival of more than 180 days. One patient with diffuse large cell lymphoma achieved partial response with progression free survival for 135 days. One patient with diffuse large cell lymphoma achieved partial response with progression free survival for 242 days. One patient with follicular lymphoma achieved partial response with progression free survival for more than 55 days. One patient with mantle cell lymphoma achieved partial response with progression free survival for more than 57 days. Four patients exhibited stable disease. Seven patients had disease progression after a median follow-up of two months (range one to seven months).

Grade 3 and 4 adverse events occurred in ten of 22 patients. These were predominately haematological and Grade 3 adverse reaction, with only three patients experiencing a Grade 4 adverse reaction.

The embodiments of the invention described above are intended to be merely exemplary, and those skilled in the art will recognize, or will be able to ascertain using no more than routine experimentation, numerous equivalents of specific compounds, materials, and procedures. All such equivalents are considered to be within the scope of the invention and are encompassed by the appended claims.

What is claimed is:

1. A method of treating mantle cell lymphoma in a human, which comprises (a) administering to a human having mantle cell lymphoma from about 5 mg to about 25 mg per day of 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione or a pharmaceutically acceptable salt or hydrate thereof for 21 days followed by seven days rest in a 28 day cycle; and (b) repeating step (a), wherein the mantle cell lymphoma is relapsed, refractory, or relapsed and refractory to conventional therapy.

2. The method of claim **1**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 5, 10, 15, 20 or 25 mg per day.

3. The method of claim **2**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 10, 15, 20, or 25 mg per day.

4. The method of claim **3**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 25 mg per day.

5. The method of claim **2**, wherein 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is enantiomerically pure.

6. The method of claim **5**, wherein 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is S enantiomer.

7. The method of claim **5**, wherein 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is R enantiomer.

8. The method of claim **2**, wherein 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione is administered orally.

9. The method of claim **8**, wherein 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione is administered in the form of a capsule or tablet.

10. The method of claim **1**, further comprising administration of rituximab in an amount of 375 mg/m^2 by intravenous infusion weekly.

11. A method of treating mantle cell lymphoma, which comprises (a) administering to a patient having mantle cell lymphoma from about 5 mg to about 25 mg per day of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione or a pharmaceutically acceptable salt or hydrate thereof for 21 days followed by a seven days rest in a 28 day cycle; (b) repeating step (a); (c) administering to the patient a therapeutically effective amount of a second active agent selected from a hematopoietic growth factor, a cytokine, an anticancer agent, an antibiotic, a cox-2 inhibitor, a corticosteroid, rituximab, or a combination thereof for a period of time followed by a period of rest; and (d) repeating step (c), wherein the mantle cell lymphoma is relapsed, refractory, or relapsed and refractory to conventional therapy.

12. The method of claim **11**, wherein the second active agent is rituximab.

13. The method of claim **11**, wherein the second active agent is dexamethasone.

14. The method of claim **11**, wherein the second active agent is prednisone.

15. The method of claim **1** or **11**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 5 mg to about 25 mg per day.

16. The method of claim **15**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 5 mg per day.

17. The method of claim **15**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 10 mg per day.

18. The method of claim **15**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 15 mg per day.

19. The method of claim **15**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 20 mg per day.

20. The method of claim **15**, wherein the amount of 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione administered is about 25 mg per day.

21. The method of claim **11**, wherein 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione is administered orally.

22. The method of claim **21**, wherein 3-(4-amino-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione is administered in the form of a capsule or tablet.

23. The method of claim **12**, wherein the rituximab is administered in an amount of 375 mg/m^2 by intravenous infusion weekly.

24. The method of claim **11**, wherein the anticancer agent is a proteasome inhibitor.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,741,929 B2
APPLICATION NO. : 12/621502
DATED : June 3, 2014
INVENTOR(S) : Jerome B. Zeldis

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 352 days.

Signed and Sealed this
Thirtieth Day of May, 2017

Michelle K. Lee
Director of the United States Patent and Trademark Office