Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2595711 A1 2006/08/03

(21) 2 595 711

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2006/01/24
(87) Date publication PCT/PCT Publication Date: 2006/08/03
(85) Entrée phase nationale/National Entry: 2007/07/24
(86) N° demande PCT/PCT Application No.: US 2006/002503
(87) N° publication PCT/PCT Publication No.: 2006/081251
(30) Priorité/Priority: 2005/01/25 (US60/646,505)

(51) Cl.Int./Int.Cl. *A61K 31/454* (2006.01), *A61P 19/02* (2006.01), *A61P 35/00* (2006.01), *A61P 43/00* (2006.01)

(71) Demandeur/Applicant:
CELGENE CORPORATION, US

(72) Inventeurs/Inventors:
MULLER, GEORGE W., US;
CHEN, ROGER S., US

(74) Agent: SMART & BIGGAR

(54) Titre : METHODES ET COMPOSITIONS UTILISANT 4-AMINO-2-(3-METHYL-2,6-DIOXOPIPERIDIN-3-YL)-ISOINDOLE-1-3-DIONE

(54) Title: METHODS AND COMPOSITIONS USING 4-AMINO-2-(3-METHYL-2,6-DIOXOPIPERIDIN-3-YL)-ISOINDOLE-1-3-DIONE

(57) Abrégé/Abstract:
This invention relates to racemic and stereomerically pure 4-amino-2-(3-methyl- 2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, and prodrugs, salts and solvates thereof. Synthesis, methods of use, and pharmaceutical compositions of racemic and stereomerically pure 4-amino-2-(3-methyl-2,6-dioxo-piperidine-3-yl)-isoindole-1,3-dione, and prodrugs, salts and solvates thereof, are disclosed.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 August 2006 (03.08.2006)

PCT

(10) International Publication Number
WO 2006/081251 A3

(51) International Patent Classification:
A61K 31/454 (2006.01) *A61P 35/00* (2006.01)
A61P 19/02 (2006.01) *A61P 43/00* (2006.01)

(21) International Application Number:
PCT/US2006/002503

(22) International Filing Date: 24 January 2006 (24.01.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/646,505 25 January 2005 (25.01.2005) US

(71) Applicant *(for all designated States except US)*: **CELGENE CORPORATION** [US/US]; 86 Morris Avenue, Summit, NJ 07901 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **MULLER, George, W.** [US/US]; 250 Windmill Court, Bridgewater, NJ 08807 (US). **CHEN, Roger, S.** [US/US]; 110 Christie St., Edison, NJ 08820 (US).

(74) Agents: **INSOGNA, Anthony, M.** et al.; Jones Day, 222 East 41st Street, New York, NY 10017-6702 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report:
28 December 2006

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2006/081251 A3

(54) Title: METHODS AND COMPOSITIONS USING 4-AMINO-2-(3-METHYL-2,6-DIOXOPIPERIDIN-3-YL)-ISOINDOLE-1-3-DIONE

(57) Abstract: This invention relates to racemic and stereomerically pure 4-amino-2-(3-methyl- 2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, and prodrugs, salts and solvates thereof. Synthesis, methods of use, and pharmaceutical compositions of racemic and stereomerically pure 4-amino-2-(3-methyl-2,6-dioxo-piperidine-3-yl)-isoindole-1,3-dione, and prodrugs, salts and solvates thereof, are disclosed.

METHODS AND COMPOSITIONS USING 4-AMINO-2-(3-METHYL-2,6-DIOXOPIPERIDIN-3-YL)-ISOINDOLE-1,3-DIONE

This application claims priority to U.S. Provisional Application No. 60/646,505, filed January 25, 2005, the entirety of which is incorporated herein by reference.

1. FIELD OF THE INVENTION

This invention relates to methods of treating, preventing and/or managing various disease and disorders using 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione and its stereoisomers and prodrugs. The invention also relates to pharmaceutical compositions comprising them.

2. BACKGROUND OF THE INVENTION

2.1 PATHOBIOLOGY OF CANCER AND OTHER DISEASES

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 lung, colon, rectum, prostate, breast, brain, and intestine. The incidence of cancer continues to climb as the general population ages, as new cancers develop, and as susceptible populations (*e.g.*, people infected with AIDS or excessively exposed to sunlight) grow. A tremendous demand therefore exists for new methods and compositions that can be used to treat patients with cancer.

Many types of cancers are associated with new blood vessel formation, a process known as angiogenesis. Several of the mechanisms involved in tumor-induced angiogenesis have been elucidated. The most direct of these mechanisms is the secretion by the tumor cells of cytokines with angiogenic properties. Examples of these cytokines include acidic and basic fibroblastic growth factor (a,b-FGF), angiogenin, vascular endothelial growth factor (VEGF), and TNF-α. Alternatively, tumor cells can release

angiogenic peptides through the production of proteases and the subsequent breakdown of the extracellular matrix where some cytokines are stored (*e.g.*, b-FGF). Angiogenesis can also be induced indirectly through the recruitment of inflammatory cells (particularly macrophages) and their subsequent release of angiogenic cytokines (*e.g.*, TNF-α, bFGF).

A variety of other diseases and disorders are also associated with, or characterized by, undesired angiogenesis. For example, enhanced or unregulated angiogenesis has been implicated in a number of diseases and medical conditions including, but not limited to, ocular neovascular diseases, choroidal neovascular diseases, retina neovascular diseases, rubeosis (neovascularization of the angle), viral diseases, genetic diseases, inflammatory diseases, allergic diseases, and autoimmune diseases. Examples of such diseases and conditions include, but are not limited to: diabetic retinopathy; retinopathy of prematurity; corneal graft rejection; neovascular glaucoma; retrolental fibroplasia; and proliferative vitreoretinopathy.

Accordingly, compounds that can control angiogenesis or inhibit the production of certain cytokines, including TNF-α, may be useful in the treatment and prevention of various diseases and conditions.

2.2 METHODS OF TREATING CANCER

Current cancer therapy may involve surgery, chemotherapy, hormonal therapy and/or radiation treatment to eradicate neoplastic cells in a patient (*see*, *e.g.*, Stockdale, 1998, *Medicine*, vol. 3, Rubenstein and Federman, eds., Chapter 12, Section IV). Recently, cancer therapy could also involve biological therapy or immunotherapy. All of these approaches pose significant drawbacks for the patient. Surgery, for example, may be contraindicated due to the health of a patient or may be unacceptable to the patient. Additionally, surgery may not completely remove neoplastic tissue. Radiation therapy is only effective when the neoplastic tissue exhibits a higher sensitivity to radiation than normal tissue. Radiation therapy can also often elicit serious side effects. Hormonal therapy is rarely given as a single agent. Although hormonal therapy can be effective, it is often used to prevent or delay recurrence of cancer after other treatments have removed the majority of cancer cells. Biological therapies and immunotherapies are limited in number and may produce side effects such as rashes or swellings, flu-like symptoms, including fever, chills and fatigue, digestive tract problems or allergic reactions.

With respect to chemotherapy, there are a variety of chemotherapeutic agents available for treatment of cancer. A majority of cancer chemotherapeutics act by inhibiting DNA synthesis, either directly, or indirectly by inhibiting the biosynthesis of

deoxyribonucleotide triphosphate precursors, to prevent DNA replication and concomitant cell division. Gilman et al., *Goodman and Gilman's: The Pharmacological Basis of Therapeutics*, Tenth Ed. (McGraw Hill, New York).

Despite availability of a variety of chemotherapeutic agents, chemotherapy has many drawbacks. Stockdale, *Medicine*, vol. 3, Rubenstein and Federman, eds., ch. 12, sect. 10, 1998. Almost all chemotherapeutic agents are toxic, and chemotherapy causes significant, and often dangerous side effects including severe nausea, bone marrow depression, and immunosuppression. Additionally, even with administration of combinations of chemotherapeutic agents, many tumor cells are resistant or develop resistance to the chemotherapeutic agents. In fact, those cells resistant to the particular chemotherapeutic agents used in the treatment protocol often prove to be resistant to other drugs, even if those agents act by different mechanism from those of the drugs used in the specific treatment. This phenomenon is referred to as pleiotropic drug or multidrug resistance. Because of the drug resistance, many cancers prove refractory to standard chemotherapeutic treatment protocols.

Other diseases or conditions associated with, or characterized by, undesired angiogenesis are also difficult to treat. However, some compounds such as protamine, hepain and steroids have been proposed to be useful in the treatment of certain specific diseases. Taylor et al., *Nature* 297:307 (1982); Folkman et al., *Science* 221:719 (1983); and U.S. Pat. Nos. 5,001,116 and 4,994,443.

Still, there is a significant need for safe and effective methods of treating, preventing and managing cancer and other diseases and conditions, particularly for diseases that are refractory to standard treatments, such as surgery, radiation therapy, chemotherapy and hormonal therapy, while reducing or avoiding the toxicities and/or side effects associated with the conventional therapies.

3. SUMMARY OF THE INVENTION

This invention is directed, in part, to the compound 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione and its stereoisomers and prodrugs.

This invention also encompasses methods of treating and managing various diseases or disorders. The methods comprise administering to a patient in need of such treatment or management a therapeutically effective amount of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, clathrate, or prodrug thereof. In particular embodiments, the 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione is stereomerically pure (3*R*)-4-amino-

2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, stereomerically pure (3*S*)- 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a mixture thereof.

The invention also encompasses methods of preventing various diseases and disorders, which comprise administering to a patient in need of such prevention a prophylactically effective amount of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, clathrate, or prodrug thereof. In particular embodiments, the 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione is stereomerically pure (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, stereomerically pure (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a mixture thereof.

This invention also encompasses pharmaceutical compositions, single unit dosage forms, dosing regimens and kits which comprise 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, clathrate, or prodrug thereof. In particular embodiments, the 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione is stereomerically pure (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, stereomerically pure (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a mixture thereof.

4. DETAILED DESCRIPTION OF THE INVENTION

In one embodiment, this invention encompasses 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, and pharmaceutically acceptable salts, solvates, stereoisomers and prodrugs thereof. In another embodiment, this invention encompasses stereomerically pure (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, and pharmaceutically acceptable salts, solvates, and prodrugs thereof. In another embodiment, this invention encompasses stereomerically pure (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, and pharmaceutically acceptable salts, solvates, and prodrugs thereof.

In another embodiment, this invention encompasses methods of treating, managing, and preventing various diseases and disorders, which comprises administering to a patient in need of such treatment or prevention a therapeutically or prophylactically effective amount of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof. In particular embodiments, the 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione is stereomerically pure (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, stereomerically pure (3*S*)- 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-

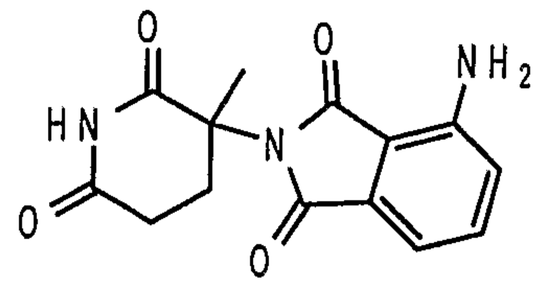
1,3-dione, or a mixture thereof. In another embodiment, this invention encompasses methods of treating, managing, and preventing various diseases and disorders, which comprises administering to a patient in need of such treatment or prevention a therapeutically or prophylactically effective amount of a prodrug of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof. Examples of diseases and disorders are described below.

In particular embodiments, 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof, is administered in combination with another drug ("second active agent") or treatment. 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. Methods, or therapies, that can be used in combination with the administration of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione 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 various disorders described herein.

This invention also encompasses pharmaceutical compositions (*e.g.*, single unit dosage forms) that can be used in methods disclosed herein. Particular pharmaceutical compositions comprise 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer, or prodrug thereof, and optionally a second active agent.

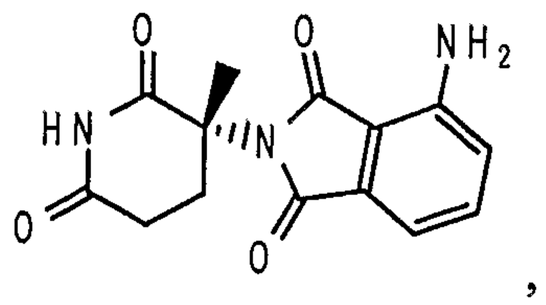
4.1 COMPOUNDS

In one embodiment, this invention is directed to 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione which has the following structure:



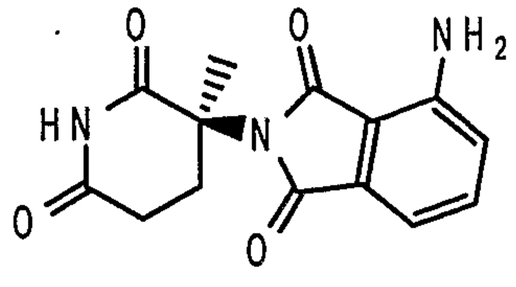
or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof.

In a specific embodiment, this invention is directed to (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione:



or a pharmaceutically acceptable salt, solvate, or prodrug thereof.

In another specific embodiment, this invention is directed to (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione:

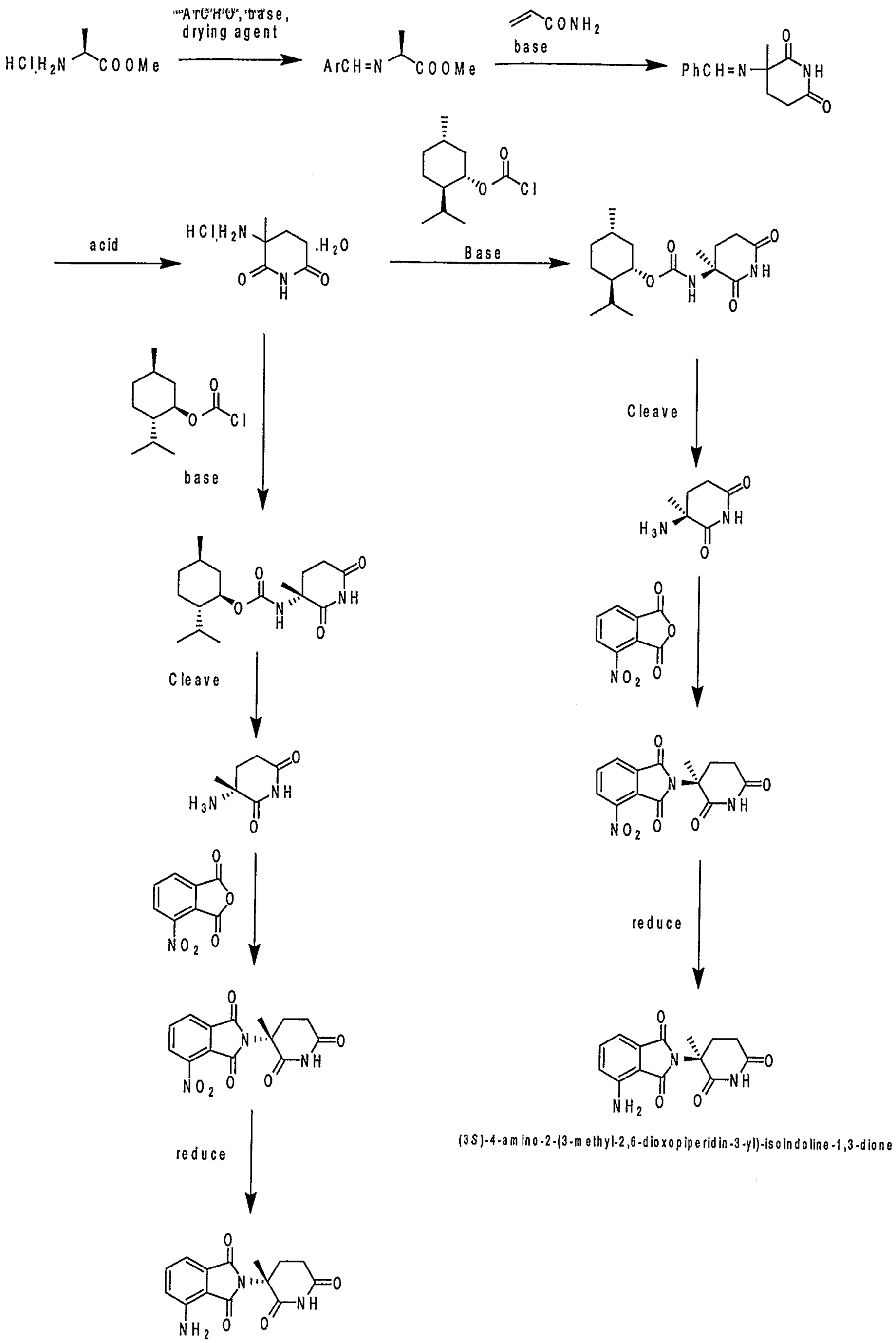


,

or a pharmaceutically acceptable salt, solvate, or prodrug thereof.

4-Amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione and its stereoisomers can be prepared according to the methods described herein, as well as other standard synthetic organic chemistry techniques. Compound of this invention include 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione that is racemic, stereomerically enriched, or stereomerically pure, and pharmaceutically acceptable salts, solvates, stereoisomers, clathrates, and prodrugs thereof.

For example, stereoisomers of 4-Amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione can be prepared according to the following general procedures:

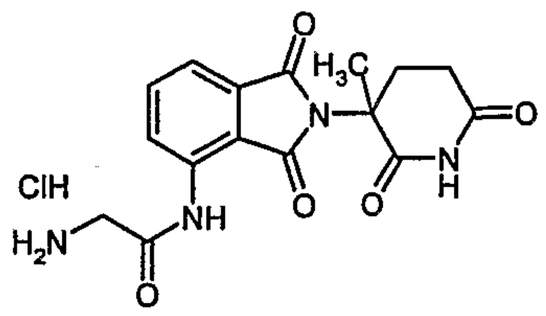


(3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindoline-1,3-dione

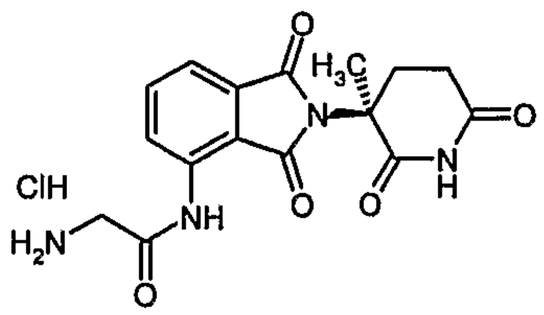
(3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindoline-1,3-dione

In another embodiment, this invention is directed to a prodrug of racemic or stereomerically pure 4-amino-2-(3-methyl-2,6-dioxo-piperidine-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof. In a specific embodiment, the

prodrug is 2-Amino-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-tl]-acetamide, which has the following structure:



In another embodiment, the prodrug is (3S)-2-Amino-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide:



The prodrugs of the invention can be prepared according to the methods described herein, as well as other standard synthetic organic chemistry techniques.

As used herein, and unless otherwise specified, the term "pharmaceutically acceptable salt" refers to salts prepared from pharmaceutically acceptable non-toxic acids, including inorganic acids and organic acids. Suitable non-toxic acids include inorganic and organic acids such as, but not limited to, acetic, alginic, anthranilic, benzenesulfonic, benzoic, camphorsulfonic, citric, ethenesulfonic, formic, fumaric, furoic, gluconic, glutamic, glucorenic, galacturonic, glycidic, hydrobromic, hydrochloric, isethionic, lactic, maleic, malic, mandelic, methanesulfonic, mucic, nitric, pamoic, pantothenic, phenylacetic, propionic, phosphoric, salicylic, stearic, succinic, sulfanilic, sulfuric, tartaric acid, p-toluenesulfonic and the like. Suitable are hydrochloric, hydrobromic, phosphoric, and sulfuric acids.

As used herein, and unless otherwise specified, the term "solvate" means a compound of the present invention or a salt thereof, that further includes a stoichiometric or non-stoichiometric amount of solvent bound by non-covalent intermolecular forces. Where the solvent is water, the solvate is a hydrate.

As used herein, and unless otherwise specified, 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, compounds 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 compounds that comprise -NO, -NO_2, -

ONO, or -ONO_2 moieties. Prodrugs can typically be prepared using well-known methods, such as those described in *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 specified, the terms "biohydrolyzable carbamate," "biohydrolyzable carbonate," "biohydrolyzable ureide" and "biohydrolyzable phosphate " mean a carbamate, carbonate, ureide and 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 carbamates include, but are not limited to, lower alkylamines, substituted ethylenediamines, aminoacids, hydroxyalkylamines, heterocyclic and heteroaromatic amines, and polyether amines.

As used herein, and unless otherwise specified, the term "stereoisomer" encompasses all enantiomerically/stereomerically pure and enantiomerically/stereomerically enriched compounds of this invention.

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 55% by weight of one stereoisomer of a compound, 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 "enantiomerically enriched" means a stereomerically enriched composition of a compound having one chiral center.

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.

4.2 METHODS OF TREATMENT, PREVENTION AND MANAGEMENT

This invention encompasses methods of treating, preventing, and/or managing various diseases or disorders using 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof. As sued herein, the term "prodrug" of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione encompasses a prodrug of racemic, stereomerically pure, and stereomerically enriched 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione. Examples of diseases or disorders include, but are not limited to, cancer, disorders associated with angiogenesis, pain including Complex Regional Pain Syndrome ("CRPS"), Macular Degeneration ("MD") and related syndromes, skin diseases, pulmonary disorders, asbestos-related disorders, parasitic diseases, immunodeficiency disorders, CNS disorders, CNS injury, atherosclerosis and related disorders, dysfunctional sleep and related disorders, hemoglobinopathy and related disorders (*e.g.*, anemia), TNFα related disorders, and other various diseases and disorders.

As used herein, and unless otherwise specified, the terms "treat," "treating" and "treatment" refer to the eradication or amelioration of a disease or disorder, or of one or more symptoms associated with the disease or disorder. In certain embodiments, the terms refer to minimizing the spread or worsening of the disease or disorder resulting from the administration of one or more prophylactic or therapeutic agents to a subject with such a disease or disorder.

As used herein, and unless otherwise specified, the terms "prevent," "preventing" and "prevention" refer to the prevention of the onset, recurrence or spread of a disease or disorder, or of one or more symptoms thereof.

As used herein, and unless otherwise specified, the terms "manage," "managing" and "management" refer to preventing or slowing the progression, spread or worsening of a disease or disorder, or of one or more symptoms thereof. Often, the beneficial effects that a subject derives from a prophylactic or therapeutic agent do not result in a cure of the disease or disorder.

As used herein, and unless otherwise specified, a "therapeutically effective amount" of a compound is an amount sufficient to provide a therapeutic benefit in the treatment or management of a disease or disorder, or to delay or minimize one or more symptoms associated with the disease or disorder. A therapeutically effective amount of a compound means an amount of therapeutic agent, alone or in combination with other therapies, which provides a therapeutic benefit in the treatment or management of the disease or disorder. The term "therapeutically effective amount" can encompass an amount that improves overall therapy, reduces or avoids symptoms or causes of disease or disorder, or enhances the therapeutic efficacy of another therapeutic agent.

As used herein, and unless otherwise specified, a "prophylactically effective amount" of a compound is an amount sufficient to prevent a disease or disorder, or prevent its recurrence. A prophylactically effective amount of a compound means an amount of therapeutic agent, alone or in combination with other agents, which provides a prophylactic benefit in the prevention of the disease. The term "prophylactically effective amount" can encompass an amount that improves overall prophylaxis or enhances the prophylactic efficacy of another prophylactic agent.

Examples of cancer and precancerous conditions include, but are not limited to, those described in U.S. patent nos. 6,281,230 and 5,635,517 to Muller *et al.*, in various U.S. patent applications to Zeldis, including application nos. 10/411,649, filed April 11, 2003 (Treatment of Myelodysplastic Syndrome); 10/438,213 filed May 15, 2003 (Treatment of Various Types of Cancer); and 10/411,656, filed April 11, 2003 (Treatment of Myeloproliferative Diseases). Examples also include those described in PCT/US04/14004, filed May 5, 2004. All of these references are incorporated herein in their entireties by reference.

Specific examples of cancer include, but are not limited to, cancers of the skin, such as melanoma; lymph node; breast; cervix; uterus; gastrointestinal tract; lung; ovary; prostate; colon; rectum; mouth; brain; head and neck; throat; testes; kidney; pancreas; bone; spleen; liver; bladder; larynx; nasal passages; and AIDS-related cancers. The compounds are particularly useful for treating cancers of the blood and bone marrow, such as multiple myeloma and acute and chronic leukemias, for example, lymphoblastic, myelogenous,

lymphocytic, and myelocytic leukemias. The compounds of the invention can be used for treating, preventing or managing either primary or metastatic tumors.

Other specific cancers include, but are not limited to, advanced malignancy, amyloidosis, neuroblastoma, meningioma, hemangiopericytoma, multiple brain metastase, glioblastoma multiforms, glioblastoma, brain stem glioma, poor prognosis malignant brain tumor, malignant glioma, recurrent malignant glioma, anaplastic astrocytoma, anaplastic oligodendroglioma, neuroendocrine tumor, rectal adenocarcinoma, Dukes C & D colorectal cancer, unresectable colorectal carcinoma, metastatic hepatocellular carcinoma, Kaposi's sarcoma, karotype acute myeloblastic leukemia, Hodgkin's lymphoma, non-Hodgkin's lymphoma, cutaneous T-Cell lymphoma, cutaneous B-Cell lymphoma, diffuse large B-Cell lymphoma, low grade follicular lymphoma, metastatic melanoma (localized melanoma, including, but not limited to, ocular melanoma), malignant mesothelioma, malignant pleural effusion mesothelioma syndrome, peritoneal carcinoma, papillary serous carcinoma, gynecologic sarcoma, soft tissue sarcoma, scelroderma, cutaneous vasculitis, Langerhans cell histiocytosis, leiomyosarcoma, fibrodysplasia ossificans progressive, hormone refractory prostate cancer, resected high-risk soft tissue sarcoma, unrescectable hepatocellular carcinoma, Waldenstrom's macroglobulinemia, smoldering myeloma, indolent myeloma, fallopian tube cancer, androgen independent prostate cancer, androgen dependent stage IV non-metastatic prostate cancer, hormone-insensitive prostate cancer, chemotherapy-insensitive prostate cancer, papillary thyroid carcinoma, follicular thyroid carcinoma, medullary thyroid carcinoma, and leiomyoma. In a specific embodiment, the cancer is metastatic. In another embodiment, the cancer is refractory or resistance to chemotherapy or radiation.

Examples of diseases and disorders associated with, or characterized by, undesired angiogenesis include, but are not limited to, inflammatory diseases, autoimmune diseases, viral diseases, genetic diseases, allergic diseases, bacterial diseases, ocular neovascular diseases, choroidal neovascular diseases, retina neovascular diseases, and rubeosis (neovascularization of the angle). Specific examples of the diseases and disorders associated with, or characterized by, undesired angiogenesis include, but are not limited to, endometriosis, Crohn's disease, heart failure, advanced heart failure, renal impairment, endotoxemia, toxic shock syndrome, osteoarthritis, retrovirus replication, wasting, meningitis, silica-induced fibrosis, asbestos-induced fibrosis, veterinary disorder, malignancy-associated hypercalcemia, stroke, circulatory shock, periodontitis, gingivitis, macrocytic anemia, refractory anemia, and 5q- syndrome.

Examples of pain include, but are not limited to those described in U.S. patent application no. 10/693,794, filed October 23, 2003, which is incorporated herein by reference. Specific types of pain include, but are not limited to, nociceptive pain, neuropathic pain, mixed pain of nociceptive and neuropathic pain, visceral pain, migraine, headache and post-operative pain.

Examples of nociceptive pain include, but are not limited to, pain associated with chemical or thermal burns, cuts of the skin, contusions of the skin, osteoarthritis, rheumatoid arthritis, tendonitis, and myofascial pain.

Examples of neuropathic pain include, but are not limited to, CRPS type I, CRPS type II, reflex sympathetic dystrophy (RSD), reflex neurovascular dystrophy, reflex dystrophy, sympathetically maintained pain syndrome, causalgia, Sudeck atrophy of bone, algoneurodystrophy, shoulder hand syndrome, post-traumatic dystrophy, trigeminal neuralgia, post herpetic neuralgia, cancer related pain, phantom limb pain, fibromyalgia, chronic fatigue syndrome, spinal cord injury pain, central post-stroke pain, radiculopathy, diabetic neuropathy, post-stroke pain, luetic neuropathy, and other painful neuropathic conditions such as those induced by drugs such as vincristine and velcade.

As used herein, the terms "complex regional pain syndrome," "CRPS" and "CRPS and related syndromes" mean a chronic pain disorder characterized by one or more of the following: pain, whether spontaneous or evoked, including allodynia (painful response to a stimulus that is not usually painful) and hyperalgesia (exaggerated response to a stimulus that is usually only mildly painful); pain that is disproportionate to the inciting event (*e.g.*, years of severe pain after an ankle sprain); regional pain that is not limited to a single peripheral nerve distribution; and autonomic dysregulation (*e.g.* , edema, alteration in blood flow and hyperhidrosis) associated with trophic skin changes (hair and nail growth abnormalities and cutaneous ulceration).

Examples of MD and related syndromes include, but are not limited to, those described in U.S. patent application no. 10/699,154, filed October 30, 2003, which is incorporated herein by reference. Specific examples include, but are not limited to, atrophic (dry) MD, exudative (wet) MD, age-related maculopathy (ARM), choroidal neovascularisation (CNVM), retinal pigment epithelium detachment (PED), and atrophy of retinal pigment epithelium (RPE).

Examples of skin diseases include, but are not limited to, those described in U.S. provisional application no. 60/554,923, filed March 22, 2004, which is incorporated herein by reference. Specific examples include, but are not limited to, keratoses and related

symptoms, skin diseases or disorders characterized with overgrowths of the epidermis, acne, and wrinkles.

As used herein, the term "keratosis" refers to any lesion on the epidermis marked by the presence of circumscribed overgrowths of the horny layer, including but not limited to actinic keratosis, seborrheic keratosis, keratoacanthoma, keratosis follicularis (Darier disease), inverted follicular keratosis, palmoplantar keratoderma (PPK, keratosis palmaris et plantaris), keratosis pilaris, and stucco keratosis. The term "actinic keratosis" also refers to senile keratosis, keratosis senilis, verruca senilis, plana senilis, solar keratosis, keratoderma or keratoma. The term "seborrheic keratosis" also refers to seborrheic wart, senile wart, or basal cell papilloma. Keratosis is characterized by one or more of the following symptoms: rough appearing, scaly, erythematous papules, plaques, spicules or nodules on exposed surfaces (*e.g.*, face, hands, ears, neck , legs and thorax), excrescences of keratin referred to as cutaneous horns, hyperkeratosis, telangiectasias, elastosis, pigmented lentigines, acanthosis, parakeratosis, dyskeratoses, papillomatosis, hyperpigmentation of the basal cells, cellular atypia, mitotic figures, abnormal cell-cell adhesion, dense inflammatory infiltrates and small prevalence of squamous cell carcinomas.

Examples of skin diseases or disorders characterized with overgrowths of the epidermis include, but are not limited to, any conditions, diseases or disorders marked by the presence of overgrowths of the epidermis, including but not limited to, infections associated with papilloma virus, arsenical keratoses, sign of Leser-Trélat, warty dyskeratoma (WD), trichostasis spinulosa (TS), erythrokeratodermia variabilis (EKV), ichthyosis fetalis (harlequin ichthyosis), knuckle pads, cutaneous melanoacanthoma, porokeratosis, squamous cell carcinoma, confluent and reticulated papillomatosis (CRP), acrochordons, cutaneous horn, cowden disease (multiple hamartoma syndrome), dermatosis papulosa nigra (DPN), epidermal nevus syndrome (ENS), ichthyosis vulgaris, molluscum contagiosum, prurigo nodularis, and acanthosis nigricans (AN).

Examples of pulmonary disorders include, but are not limited to, those described in U.S. provisional application no. 60/565,172, filed April 23, 2004, which is incorporated herein by reference. Specific examples include pulmonary hypertension and related disorders. Examples of pulmonary hypertension and related disorders include, but are not limited to: primary pulmonary hypertension (PPH); secondary pulmonary hypertension (SPH); familial PPH; sporadic PPH; precapillary pulmonary hypertension; pulmonary arterial hypertension (PAH); pulmonary artery hypertension; idiopathic pulmonary hypertension; thrombotic pulmonary arteriopathy (TPA); plexogenic pulmonary arteriopathy; functional classes I to IV pulmonary hypertension; and pulmonary

hypertension associated with, related to, or secondary to, left ventricular dysfunction, mitral valvular disease, constrictive pericarditis, aortic stenosis, cardiomyopathy, mediastinal fibrosis, anomalous pulmonary venous drainage, pulmonary venoocclusive disease, collagen vasular disease, congenital heart disease, HIV virus infection, drugs and toxins such as fenfluramines, congenital heart disease, pulmonary venous hypertension, chronic obstructive pulmonary disease, interstitial lung disease, sleep-disordered breathing, alveolar hypoventilation disorder, chronic exposure to high altitude, neonatal lung disease, alveolar-capillary dysplasia, sickle cell disease, other coagulation disorder, chronic thromboemboli, connective tissue disease, lupus, schistosomiasis, sarcoidosis or pulmonary capillary hemangiomatosis.

Examples of asbestos-related disorders include, but not limited to, those described in U.S. application no. 10/981,189, filed November 3, 2004, which is incorporated herein by reference. Specific examples include, but are not limited to, mesothelioma, asbestosis, malignant pleural effusion, benign exudative effusion, pleural plaques, pleural calcification, diffuse pleural thickening, rounded atelectasis, fibrotic masses, and lung cancer.

Examples of parasitic diseases include, but are not limited to, those described in U.S. provisional application no. 60/626,975, filed November 12, 2004, which is incorporated herein by reference. Parasitic diseases include diseases and disorders caused by human intracellular parasites such as, but not limited to, *P. falcifarium*, *P. ovale*, *P. vivax*, *P. malariae*, *L. donovari*, *L. infantum*, *L. aethiopica*, *L. major*, *L. tropica*, *L. mexicana*, *L. braziliensis*, *T. Gondii*, *B. microti*, *B. divergens*, *B. coli*, *C. parvum*, *C. cayetanensis*, *E. histolytica*, *I. belli*, *S. mansonii*, *S. haematobium*, *Trypanosoma ssp.*, *Toxoplasma ssp.*, and *O. volvulus*. Other diseases and disorders caused by non-human intracellular parasites such as, but not limited to, *Babesia bovis*, *Babesia canis*, *Banesia Gibsoni*, *Besnoitia darlingi*, *Cytauxzoon felis*, *Eimeria ssp.*, *Hammondia ssp.*, and *Theileria ssp.*, are also encompassed. Specific examples include, but are not limited to, malaria, babesiosis, trypanosomiasis, leishmaniasis, toxoplasmosis, meningoencephalitis, keratitis, amebiasis, giardiasis, cryptosporidiosis, isosporiasis, cyclosporiasis, microsporidiosis, ascariasis, trichuriasis, ancylostomiasis, strongyloidiasis, toxocariasis, trichinosis, lymphatic filariasis, onchocerciasis, filariasis, schistosomiasis, and dermatitis caused by animal schistosomes.

Examples of immunodeficiency disorders include, but are not limited to, those described in U.S. provisional application no. 60/631,870, filed December 1, 2004. Specific examples include, but not limited to, adenosine deaminase deficiency, antibody deficiency with normal or elevated Igs, ataxia-tenlangiectasia, bare lymphocyte syndrome, common

variable immunodeficiency, Ig deficiency with hyper-IgM, Ig heavy chain deletions, IgA deficiency, immunodeficiency with thymoma, reticular dysgenesis, Nezelof syndrome, selective IgG subclass deficiency, transient hypogammaglobulinemia of infancy, Wistcott-Aldrich syndrome, X-linked agammaglobulinemia, X-linked severe combined immunodeficiency.

Examples of CNS disorders include, but are not limited to, those described in U.S. provisional application no. 60/533,862, filed December 30, 2003, and the co-pending U.S. nonprovisional application which claims priority to 60/533,862, both of which are incorporated herein by reference. Specific examples include, but are not limited to, include, but are not limited to, Amyotrophic Lateral Sclerosis, Alzheimer Disease, Parkinson Disease, Huntington's Disease, Multiple Sclerosis other neuroimmunological disorders such as Tourette Syndrome, delerium, or disturbances in consciousness that occur over a short period of time, and amnestic disorder, or discreet memory impairments that occur in the absence of other central nervous system impairments.

Examples of CNS injuries and related syndromes include, but are not limited to, those described in U.S. provisional application no. 60/630,599, filed November 23, 2004, which is incorporated herein by reference. Specific examples include, but are not limited to, CNS injury/damage and related syndromes, include, but are not limited to, primary brain injury, secondary brain injury, traumatic brain injury, focal brain injury, diffuse axonal injury, head injury, concussion, post-concussion syndrome, cerebral contusion and laceration, subdural hematoma, epidermal hematoma, post-traumatic epilepsy, chronic vegetative state, complete SCI, incomplete SCI, acute SCI, subacute SCI, chronic SCI, central cord syndrome, Brown-Sequard syndrome, anterior cord syndrome, conus medullaris syndrome, cauda equina syndrome, neurogenic shock, spinal shock, altered level of consciousness, headache, nausea, emesis, memory loss, dizziness, diplopia, blurred vision, emotional lability, sleep disturbances, irritability, inability to concentrate, nervousness, behavioral impairment, cognitive deficit, and seizure.

Other disease or disorders include, but not limited to, viral, genetic, allergic, and autoimmune diseases. Specific examples include, but not limited to, HIV, hepatitis, adult respiratory distress syndrome, bone resorption diseases, chronic pulmonary inflammatory diseases, dermatitis, cystic fibrosis, septic shock, sepsis, endotoxic shock, hemodynamic shock, sepsis syndrome, post ischemic reperfusion injury, meningitis, psoriasis, fibrotic disease, cachexia, graft versus host disease, graft rejection, auto-immune disease, rheumatoid spondylitis, Crohn's disease, ulcerative colitis, inflammatory-bowel disease,

multiple sclerosis, systemic lupus erythrematosus, ENL in leprosy, radiation damage, cancer, asthma, or hyperoxic alveolar injury.

Examples of atherosclerosis and related conditions include, but are not limited to, those disclosed in U.S. application no. 09/734,460, filed December 11, 2000, which is incorporated herein by reference. Specific examples include, but are not limited to, all forms of conditions involving atherosclerosis, including restenosis after vascular intervention such as angioplasty, stenting, atherectomy and grafting. All forms of vascular intervention are contemplated by the invention including diseases of the cardiovascular and renal system, such as, but not limited to, renal angioplasty, percutaneous coronary intervention (PCI), percutaneous transluminal coronary angioplasty (PTCA), carotid percutaneous transluminal angioplasty (PTA), coronary by-pass grafting, angioplasty with stent implantation, peripheral percutaneous transluminal intervention of the iliac, femoral or popliteal arteries, and surgical intervention using impregnated artificial grafts. The following chart provides a listing of the major systemic arteries that may be in need of treatment, all of which are contemplated by the invention:

Artery	Body Areas Supplied
Axillary	Shoulder and axilla
Brachial	Upper arm
Brachiocephalic	Head, neck, and arm
Celiac	Divides into left gastric, splenic, and hepatic arteries
Common carotid	Neck
Common iliac	Divides into external and internal iliac arteries
Coronary	Heart
Deep femoral	Thigh
Digital	Fingers
Dorsalis pedis	Foot
External carotid	Neck and external head regions
External iliac	Femoral artery
Femoral	Thigh
Gastric	Stomach
Hepatic	Liver, gallbladder, pancreas, and duodenum
Inferior mesenteric	Descending colon, rectum, and pelvic wall
Internal carotid	Neck and internal head regions
Internal iliac	Rectum, urinary bladder, external genitalia, buttocks muscles, uterus and vagina
Left gastric	Esophagus and stomach
Middle sacral	Sacrum
Ovarian	Ovaries
Palmar arch	Hand
Peroneal	Calf
Popliteal	Knee
Posterior tibial	Calf
Pulmonary	Lungs
Radial	Forearm
Renal	Kidney
Splenic	Stomach, pancreas, and spleen
Subclavian	Shoulder
Superior mesenteric	Pancreas, small intestine, ascending and transverse colon
Testicular	Testes
Ulnar	Forearm

Examples of dysfunctional sleep and related syndromes include, but are not limited to, those disclosed in U.S. provisional application no. 60/559,261, filed April 1, 2004, which is incorporated herein by reference. Specific examples include, but are not limited to, snoring, sleep apnea, insomnia, narcolepsy, restless leg syndrome, sleep terrors, sleep walking sleep eating, and dysfunctional sleep associated with chronic neurological or inflammatory conditions. Chronic neurological or inflammatory conditions, include, but are not limited to, Complex Regional Pain Syndrome, chronic low back pain, musculoskeletal pain, arthritis, radiculopathy, pain associated with cancer, fibromyalgia, chronic fatigue syndrome, visceral pain, bladder pain, chronic pancreatitis, neuropathies (diabetic, post-herpetic, traumatic or inflammatory), and neurodegenerative disorders such as Parkinson's Disease, Alzheimer's Disease, amyotrophic lateral sclerosis, multiple sclerosis,

Huntington's Disease, bradykinesia; muscle rigidity; parkinsonian tremor; parkinsonian gait; motion freezing; depression; defective long-term memory, Rubinstein-Taybi syndrome (RTS); dementia; postural instability; hypokinetic disorders; synuclein disorders; multiple system atrophies; striatonigral degeneration; olivopontocerebellar atrophy; Shy-Drager syndrome; motor neuron disease with parkinsonian features; Lewy body dementia; Tau pathology disorders; progressive supranuclear palsy; corticobasal degeneration; frontotemporal dementia; amyloid pathology disorders; mild cognitive impairment; Alzheimer disease with parkinsonism; Wilson disease; Hallervorden-Spatz disease; Chediak-Hagashi disease; SCA-3 spinocerebellar ataxia; X-linked dystonia parkinsonism; prion disease; hyperkinetic disorders; chorea; ballismus; dystonia tremors; Amyotrophic Lateral Sclerosis (ALS); CNS trauma and myoclonus.

Examples of hemoglobinopathy and related disorders include, but are not limited to, those described in U.S. application no. 11/004,736, filed December 2, 2004, which is incorporated herein by reference. Specific examples include, but are not limited to, hemoglobinopathy, sickle cell anemia, and any other disorders related to the differentiation of $CD34^+$ cells.

Examples of TNFα related disorders include, but are not limited to, those described in WO 98/03502 and WO 98/54170, both of which are incorporated herein in their entireties by reference. Specific examples include, but are not limited to: endotoxemia or toxic shock syndrome; cachexia; adult respiratory distress syndrome; bone resorption diseases such as arthritis; hypercalcemia; Graft versus Host Reaction; cerebral malaria; inflammation; tumor growth; chronic pulmonary inflammatory diseases; reperfusion injury; myocardial infarction; stroke; circulatory shock; rheumatoid arthritis; Crohn's disease; HIV infection and AIDS; NFκB related disorders such as rheumatoid arthritis, rheumatoid spondylitis, osteoarthritis and other arthritic conditions, septic shock, septis, endotoxic shock, graft versus host disease, wasting, Crohn's disease, ulcerative colitis, multiple sclerosis, systemic lupus erythromatosis, ENL in leprosy, HIV, AIDS, and opportunistic infections in AIDS; cAMP related disorders such as septic shock, sepsis, endotoxic shock, hemodynamic shock and sepsis syndrome, post ischemic reperfusion injury, malaria, mycobacterial infection, meningitis, psoriasis, congestive heart failure, fibrotic disease, cachexia, graft rejection, oncogenic or cancerous conditions, asthma, autoimmune disease, radiation damages, and hyperoxic alveolar injury; viral infections, such as those caused by the herpes viruses; viral conjunctivitis; or atopic dermatitis.

Doses of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof, vary depending

on factors such as: specific indication to be treated, prevented, or managed; age and condition of a patient; and amount of second active agent used, if any. Generally, 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof, may be used in an amount of from about 0.1 mg to about 500 mg per day, and can be adjusted in a conventional fashion (*e.g.*, the same amount administered each day of the treatment, prevention or management period), in cycles (*e.g.*, one week on, one week off), or in an amount that increases or decreases over the course of treatment, prevention, or management. In other embodiments, the dose can be from about 1 mg to about 300 mg, from about 0.1 mg to about 150 mg, from about 1 mg to about 200 mg, from about 10 mg to about 100 mg, from about 0.1 mg to about 50 mg, from about 1 mg to about 50 mg, from about 10 mg to about 50 mg, from about 20 mg to about 30 mg, or from about 1 mg to about 20 mg.

4.3 SECOND ACTIVE AGENTS

4-Amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof, can be combined with other pharmacologically active compounds ("second active agents") in methods and compositions of the invention. It is believed that certain combinations may work synergistically in the treatment of particular types diseases or disorders, and conditions and symptoms associated with such diseases or disorders. 4-Amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof, can also work to alleviate adverse effects associated with certain second active agents, and vice versa.

One or more second active ingredients or agents can be used in the methods and compositions 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. Specific examples of the active agents are anti-CD40 monoclonal antibodies (such as, for example, SGN-40); histone deacetlyase inhibitors (such as, for example, SAHA and LAQ 824); heat-shock protein-90 inhibitors (such as, for example, 17-AAG); insulin-like growth factor-1 receptor kinase inhibitors; vascular endothelial growth factor receptor kinase inhibitors (such as, for example, PTK787); insulin growth factor receptor inhibitors; lysophosphatidic acid acyltransrerase inhibitors; IkB kinase inhibitors; p38MAPK inhibitors; EGFR inhibitors (such as, for example, gefitinib and erlotinib HCL); HER-2 antibodies (such as, for example, trastuzumab (Herceptin®) and pertuzumab (Omnitarg™));

VEGFR antibodies (such as, for example, bevacizumab (Avastin™)); VEGFR inhibitors (such as, for example, flk-1 specific kinase inhibitors, SU5416 and ptk787/zk222584); P13K inhibitors (such as, for example, wortmannin); C-Met inhibitors (such as, for example, PHA-665752); monoclonal antibodies (such as, for example, rituximab (Rituxan®), tositumomab (Bexxar®), edrecolomab (Panorex®) and G250); and anti-TNF-α antibodies.

Specific second active compounds that can be combined with compounds of this invention vary depending on the specific indication to be treated, prevented or managed.

For instance, for the treatment, prevention or management of cancer, second active agents include, but are not limited to: semaxanib; cyclosporin; etanercept; doxycycline; bortezomib; 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; brequinar sodium; bropirimine; busulfan; cactinomycin; calusterone; caracemide; carbetimer; carboplatin; carmustine; carubicin hydrochloride; carzelesin; cedefingol; celecoxib; 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; pegaspargase; 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 second agents 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; chlorlns; 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 (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, 2-methoxyestradiol, telomestatin, inducers of apoptosis in mutiple myeloma cells (such as, for example, TRAIL), statins, semaxanib, cyclosporin, etanercept, doxycycline, 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.

Similarly, examples of specific second agents according to the indications to be treated, prevented, or managed can be found in the following references, all of which are incorporated herein in their entireties: U.S. patent nos. 6,281,230 and 5,635,517; U.S. application nos. 10/411,649, 10/483,213, 10/411,656, 10/693,794, 10/699,154, and 10/981,189; and U.S. provisional application nos. 60/554,923, 60/565,172, 60/626,975, 60/630,599, 60/631,870, and 60/533,862.

Examples of second active agents that may be used for the treatment, prevention and/or management of pain include, but are not limited to, conventional therapeutics used to treat or prevent pain such as antidepressants, anticonvulsants, antihypertensives, anxiolytics, calcium channel blockers, muscle relaxants, non-narcotic analgesics, opioid analgesics, anti-inflammatories, cox-2 inhibitors, immunomodulatory agents, alpha-adrenergic receptor agonists or antagonists, immunosuppressive agents, corticosteroids, hyperbaric oxygen, ketamine, other anesthetic agents, NMDA antagonists, and other therapeutics found, for example, in the *Physician's Desk Reference* 2003. Specific examples include, but are not limited to, salicylic acid acetate (Aspirin®), celecoxib (Celebrex®), Enbrel®, ketamine, gabapentin (Neurontin ®), phenytoin (Dilantin®), carbamazepine (Tegretol®), oxcarbazepine (Trileptal®), valproic acid (Depakene®), morphine sulfate, hydromorphone, prednisone, griseofulvin, penthonium, alendronate, dyphenhydramide, guanethidine, ketorolac (Acular®), thyrocalcitonin, dimethylsulfoxide (DMSO), clonidine (Catapress®), bretylium, ketanserin, reserpine, droperidol, atropine, phentolamine, bupivacaine, lidocaine, acetaminophen, nortriptyline (Pamelor®), amitriptyline (Elavil®), imipramine (Tofranil®), doxepin (Sinequan®), clomipramine (Anafranil®), fluoxetine (Prozac®), sertraline (Zoloft®), nefazodone (Serzone®), venlafaxine (Effexor®), trazodone (Desyrel®), bupropion (Wellbutrin®), mexiletine, nifedipine, propranolol, tramadol, lamotrigine, ziconotide, ketamine, dextromethorphan, benzodiazepines, baclofen, tizanidine and phenoxybenzamine.

Examples of second active agents that may be used for the treatment, prevention and/or management of MD and related syndromes include, but are not limited to, a steroid, a light sensitizer, an integrin, an antioxidant, an interferon, a xanthine derivative, a growth hormone, a neutrotrophic factor, a regulator of neovascularization, an anti-VEGF antibody, a prostaglandin, an antibiotic, a phytoestrogen, an anti-inflammatory compound or an antiangiogenesis compound, or a combination thereof. Specific examples include, but are not limited to, verteporfin, purlytin, an angiostatic steroid, rhuFab, interferon-2α, pentoxifylline, tin etiopurpurin, motexafin lutetium, 9-fluoro-11,21-dihydroxy- 16,

17-1-methylethylidinebis(oxy)pregna-1,4-diene-3,20-dione, latanoprost (*see* U.S. Patent No. 6,225,348), tetracycline and its derivatives, rifamycin and its derivatives, macrolides, metronidazole (U.S. Patent Nos. 6,218,369 and 6,015,803), genistein, genistin, 6'- O-Mal genistin, 6'- O-Ac genistin, daidzein, daidzin, 6'- O-Mal daidzin, 6'- O-Ac daidzin, glycitein, glycitin, 6'- O-Mal glycitin, biochanin A, formononetin (U.S. Patent No. 6,001,368), triamcinolone acetomide, dexamethasone (U.S. Patent No. 5,770,589), thalidomide, glutathione (U.S. Patent No. 5,632,984), basic fibroblast growth factor (bFGF), transforming growth factor b (TGF-b), brain-derived neurotrophic factor (BDNF), plasminogen activator factor type 2 (PAI-2), EYE101 (Eyetech Pharmaceuticals), LY333531 (Eli Lilly), Miravant, and RETISERT implant (Bausch & Lomb). All of the references cited above are incorporated herein in their entireties by reference.

Examples of second active agents that may be used for the treatment, prevention and/or management of skin diseases include, but are not limited to, keratolytics, retinoids, α-hydroxy acids, antibiotics, collagen, botulinum toxin, interferon, and immunomodulatory agents. Specific examples include, but are not limited to, 5-fluorouracil, masoprocol, trichloroacetic acid, salicylic acid, lactic acid, ammonium lactate, urea, tretinoin, isotretinoin, antibiotics, collagen, botulinum toxin, interferon, corticosteroid, transretinoic acid and collagens such as human placental collagen, animal placental collagen, Dermalogen, AlloDerm, Fascia, Cymetra, Autologen, Zyderm, Zyplast, Resoplast, and Isolagen.

Examples of second active agents that may be used for the treatment, prevention and/or management of pulmonary hepertension and related disorders include, but are not limited to, anticoagulants, diuretics, cardiac glycosides, calcium channel blockers, vasodilators, prostacyclin analogues, endothelin antagonists, phosphodiesterase inhibitors (*e.g.*, PDE V inhibitors), endopeptidase inhibitors, lipid lowering agents, thromboxane inhibitors, and other therapeutics known to reduce pulmonary artery pressure. Specific examples include, but are not limited to, warfarin (Coumadin®), a diuretic, a cardiac glycoside, digoxin-oxygen, diltiazem, nifedipine, a vasodilator such as prostacyclin (*e.g.*, prostaglandin I_2 (PGI_2), epoprostenol (EPO, Floran®), treprostinil (Remodulin®), nitric oxide (NO), bosentan (Tracleer®), amlodipine, epoprostenol (Floran®), treprostinil (Remodulin®), prostacyclin, tadalafil (Cialis®), simvastatin (Zocor®), omapatrilat (Vanlev®), irbesartan (Avapro®), pravastatin (Pravachol®), digoxin, L-arginine, iloprost, betaprost, and sildenafil (Viagra®).

Examples of second active agents that may be used for the treatment, prevention and/or management of asbestos-related disorders include, but are not limited to,

anthracycline, platinum, alkylating agent, oblimersen (Genasense®), cisplatinum, cyclophosphamide, temodar, carboplatin, procarbazine, gliadel, tamoxifen, topotecan, methotrexate, taxotere, irinotecan, 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, bleomycin, hyaluronidase, mitomycin C, mepacrine, thiotepa, tetracycline and gemcitabine.

Examples of second active agents that may be used for the treatment, prevention and/or management of parasitic diseases include, but are not limited to, chloroquine, quinine, quinidine, pyrimethamine, sulfadiazine, doxycycline, clindamycin, mefloquine, halofantrine, primaquine, hydroxychloroquine, proguanil, atovaquone, azithromycin, suramin, pentamidine, melarsoprol, nifurtimox, benznidazole, amphotericin B, pentavalent antimony compounds (*e.g.*, sodium stiboglucuronate), interfereon gamma, itraconazole, a combination of dead promastigotes and BCG, leucovorin, corticosteroids, sulfonamide, spiramycin, IgG (serology), trimethoprim, and sulfamethoxazole.

Examples of second active agents that may be used for the treatment, prevention and/or management of immunodeficiency disorders include, but are not limited to: antibiotics (therapeutic or prophylactic) such as, but not limited to, ampicillin, tetracycline, penicillin, cephalosporins, streptomycin, kanamycin, and erythromycin; antivirals such as, but not limited to, amantadine, rimantadine, acyclovir, and ribavirin; immunoglobulin; plasma; immunologic enhancing drugs such as, but not limited to, levami sole and isoprinosine; biologics such as, but not limited to, gammaglobulin, transfer factor, interleukins, and interferons; hormones such as, but not limited to, thymic; and other immunologic agents such as, but not limited to, B cell stimulators (*e.g.*, BAFF/BlyS), cytokines (*e.g.*, IL-2, IL-4, and IL-5), growth factors (e.g., TGF-α), antibodies (e.g., anti-CD40 and IgM), oligonucleotides containing unmethylated CpG motifs (*e.g.*, TCGTCGTTTT*GTCGTT*TTGTCGTT), and vaccines (*e.g.*, viral and tumor peptide vaccines).

Examples of second active agents that may be used for the treatment, prevention and/or management of CNS disorders include, but are not limited to: a dopamine agonist or antagonist, such as, but not limited to, Levodopa, L-DOPA, cocaine, α-methyl-tyrosine, reserpine, tetrabenazine, benzotropine, pargyline, fenodolpam mesylate, cabergoline, pramipexole dihydrochloride, ropinorole, amantadine hydrochloride, selegiline hydrochloride, carbidopa, pergolide mesylate, Sinemet CR, and Symmetrel; a MAO

inhibitor, such as, but not limited to, iproniazid, clorgyline, phenelzine and isocarboxazid; a COMT inhibitor, such as, but not limited to, tolcapone and entacapone; a cholinesterase inhibitor, such as, but not limited to, physostigmine saliclate, physostigmine sulfate, physostigmine bromide, meostigmine bromide, neostigmine methylsulfate, ambenonim chloride, edrophonium chloride, tacrine, pralidoxime chloride, obidoxime chloride, trimedoxime bromide, diacetyl monoxim, endrophonium, pyridostigmine, and demecarium; an anti-inflammatory agent, such as, but not limited to, naproxen sodium, diclofenac sodium, diclofenac potassium, celecoxib, sulindac, oxaprozin, diflunisal, etodolac, meloxicam, ibuprofen, ketoprofen, nabumetone, refecoxib, methotrexate, leflunomide, sulfasalazine, gold salts, Rho-D Immune Globulin, mycophenylate mofetil, cyclosporine, azathioprine, tacrolimus, basiliximab, daclizumab, salicylic acid, acetylsalicylic acid, methyl salicylate, diflunisal, salsalate, olsalazine, sulfasalazine, acetaminophen, indomethacin, sulindac, mefenamic acid, meclofenamate sodium, tolmetin, ketorolac, dichlofenac, flurbinprofen, oxaprozin, piroxicam, meloxicam, ampiroxicam, droxicam, pivoxicam, tenoxicam, phenylbutazone, oxyphenbutazone, antipyrine, aminopyrine, apazone, zileuton, aurothioglucose, gold sodium thiomalate, auranofin, methotrexate, colchicine, allopurinol, probenecid, sulfinpyrazone and benzbromarone or betamethasone and other glucocorticoids; and an antiemetic agent, such as, but not limited to, metoclopromide, domperidone, prochlorperazine, promethazine, chlorpromazine, trimethobenzamide, ondansetron, granisetron, hydroxyzine, acetylleucine monoethanolamine, alizapride, azasetron, benzquinamide, bietanautine, bromopride, buclizine, clebopride, cyclizine, dimenhydrinate, diphenidol, dolasetron, meclizine, methallatal, metopimazine, nabilone, oxyperndyl, pipamazine, scopolamine, sulpiride, tetrahydrocannabinol, thiethylperazine, thioproperazine, tropisetron, and a mixture thereof.

Examples of second active agents that may be used for the treatment, prevention and/or management of CNS injuries and related syndromes include, but are not limited to, immunomodulatory agents, immunosuppressive agents, antihypertensives, anticonvulsants, fibrinolytic agents, antiplatelet agents, antipsychotics, antidepressants, benzodiazepines, buspirone, amantadine, and other known or conventional agents used in patients with CNS injury/damage and related syndromes. Specific examples include, but are not limited to: steroids (*e.g.*, glucocorticoids, such as, but not limited to, methylprednisolone, dexamethasone and betamethasone); an anti-inflammatory agent, including, but not limited to, naproxen sodium, diclofenac sodium, diclofenac potassium, celecoxib, sulindac, oxaprozin, diflunisal, etodolac, meloxicam, ibuprofen, ketoprofen, nabumetone, refecoxib, methotrexate, leflunomide, sulfasalazine, gold salts, RH_o-D Immune Globulin,

mycophenylate mofetil, cyclosporine, azathioprine, tacrolimus, basiliximab, daclizumab, salicylic acid, acetylsalicylic acid, methyl salicylate, diflunisal, salsalate, olsalazine, sulfasalazine, acetaminophen, indomethacin, sulindac, mefenamic acid, meclofenamate sodium, tolmetin, ketorolac, dichlofenac, flurbinprofen, oxaprozin, piroxicam, meloxicam, ampiroxicam, droxicam, pivoxicam, tenoxicam, phenylbutazone, oxyphenbutazone, antipyrine, aminopyrine, apazone, zileuton, aurothioglucose, gold sodium thiomalate, auranofin, methotrexate, colchicine, allopurinol, probenecid, sulfinpyrazone and benzbromarone; a cAMP analog including, but not limited to, db-cAMP; an agent comprising a methylphenidate drug, which comprises l-threo-methylphenidate, d-threo-methylphenidate, dl-threo-methylphenidate, l-erythro-methylphenidate, d-erythro-methylphenidate, dl-erythro-methylphenidate, and a mixture thereof; and a diuretic agent such as, but not limited to, mannitol, furosemide, glycerol, and urea.

Examples of second active agent that may be used for the treatment, prevention and/or management of dysfunctional sleep and related syndromes include, but are not limited to, a tricyclic antidepressant agent, a selective serotonin reuptake inhibitor, an antiepileptic agent (gabapentin, pregabalin, carbamazepine, oxcarbazepine, levitiracetam, topiramate), an antiaryhthmic agent, a sodium channel blocking agent, a selective inflammatory mediator inhibitor, an opioid agent, a second immunomodulatory compound, a combination agent, and other known or conventional agents used in sleep therapy. Specific examples include, but are not limited to, Neurontin, oxycontin, morphine, topiramate, amitryptiline, nortryptiline, carbamazepine, Levodopa, L-DOPA, cocaine, α-methyl-tyrosine, reserpine, tetrabenazine, benzotropine, pargyline, fenodolpam mesylate, cabergoline, pramipexole dihydrochloride, ropinorole, amantadine hydrochloride, selegiline hydrochloride, carbidopa, pergolide mesylate, Sinemet CR, Symmetrel, iproniazid, clorgyline, phenelzine, isocarboxazid, tolcapone, entacapone, physostigmine saliclate, physostigmine sulfate, physostigmine bromide, meostigmine bromide, neostigmine methylsulfate, ambenonim chloride, edrophonium chloride, tacrine, pralidoxime chloride, obidoxime chloride, trimedoxime bromide, diacetyl monoxim, endrophonium, pyridostigmine, demecarium, naproxen sodium, diclofenac sodium, diclofenac potassium, celecoxib, sulindac, oxaprozin, diflunisal, etodolac, meloxicam, ibuprofen, ketoprofen, nabumetone, refecoxib, methotrexate, leflunomide, sulfasalazine, gold salts, RH_O-D Immune Globulin, mycophenylate mofetil, cyclosporine, azathioprine, tacrolimus, basiliximab, daclizumab, salicylic acid, acetylsalicylic acid, methyl salicylate, diflunisal, salsalate, olsalazine, sulfasalazine, acetaminophen, indomethacin, sulindac, mefenamic acid, meclofenamate sodium, tolmetin, ketorolac, dichlofenac, flurbinprofen, oxaprozin,

piroxicam, meloxicam, ampiroxicam, droxicam, pivoxicam, tenoxicam, phenylbutazone, oxyphenbutazone, antipyrine, aminopyrine, apazone, zileuton, aurothioglucose, gold sodium thiomalate, auranofin, methotrexate, colchicine, allopurinol, probenecid, sulfinpyrazone, benzbromarone, betamethasone and other glucocorticoids, metoclopromide, domperidone, prochlorperazine, promethazine, chlorpromazine, trimethobenzamide, ondansetron, granisetron, hydroxyzine, acetylleucine monoethanolamine, alizapride, azasetron, benzquinamide, bietanautine, bromopride, buclizine, clebopride, cyclizine, dimenhydrinate, diphenidol, dolasetron, meclizine, methallatal, metopimazine, nabilone, oxyperndyl, pipamazine, scopolamine, sulpiride, tetrahydrocannabinol, thiethylperazine, thioproperazine, tropisetron, and a mixture thereof.

Examples of second active agents that may be used for the treatment, prevention and/or management of hemoglobinopathy and related disorders 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; and G-CSF; hydroxyurea; butyrates or butyrate derivatives; nitrous oxide; HEMOXIN™ (NIPRISAN™; *see* United States Patent No. 5,800,819); Gardos channel antagonists such as clotrimazole and triaryl methane derivatives; Deferoxamine; protein C; and transfusions of blood, or of a blood substitute such as Hemospan™ or Hemospan™ PS (Sangart).

Administration of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, stereoisomer or prodrug thereof, 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 compounds of this invention is oral. 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*, 1755-1760 (56th ed., 2002).

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 1000 mg, from about 5 to about 500 mg, from about 10 to about 350 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 compounds of the invention and any optional additional active agents concurrently administered to the patient.

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. Compounds of the invention and other active ingredients can be administered to a patient prior to, during, or after the occurrence of the adverse effect associated with conventional therapy.

4.4 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, a 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 a compound of the invention for more cycles than are typical when it is administered alone. In yet another specific embodiment of the invention, a 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, a compound of the invention is administered daily and continuously for three or four weeks at a dose of from about 0.1 mg to about 500 mg per day, followed by a break of one or two weeks. In other embodiments, the dose can be from about 1 mg to about 300 mg, from about 0.1 mg to about 150 mg, from about 1 mg to about 200 mg, from about 10 mg to about 100 mg, from about 0.1 mg to about 50 mg, from about 1 mg to about 50 mg, from about 10 mg to about 50 mg, from about 20 mg to about 30 mg, or from about 1 mg to about 20 mg, followed by a break.

In one embodiment of the invention, a compound of the invention and a second active ingredient are administered orally, with administration of the compound of the invention occurring 30 to 60 minutes prior to the second active ingredient, during a cycle of four to six weeks. In another embodiment of the invention, the combination of a compound

of the invention and a second active ingredient is administered by intravenous infusion over about 90 minutes every cycle.

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.

4.5 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 a compound of the invention, or a pharmaceutically acceptable salt, solvate, stereoisomer, 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. Examples of optional second, or additional, active ingredients are disclosed in Section 4.3, above.

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 di-saccharides. 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, NY, 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 a compound of the invention in an amount of from about 0.10 to about 500 mg. Typical dosage forms comprise a compound of the invention in an amount of about 0.1, 1, 2, 5, 7.5, 10, 12.5, 15, 17.5, 20, 25, 50, 100, 150, 200, 250, 300, 350, 400, 450, or 500 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 second active agent will depend on the specific agent used, the type of cancer being treated or managed, and the amount(s) of a compound of the invention and any optional additional active agents concurrently administered to the patient.

4.5.1 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).

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, TX), CAB-O-SIL (a pyrogenic silicon dioxide product sold by Cabot Co. of Boston, MA), 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 a compound of the invention, anhydrous lactose, microcrystalline cellulose, polyvinylpyrrolidone, stearic acid, colloidal anhydrous silica, and gelatin.

4.5.2 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. Patent 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.

4.5.3 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. Patent No. 5,134,127, which is incorporated herein by reference.

4.5.4 TOPICAL AND MUCOSAL DOSAGE FORMS

Topical and mucosal dosage forms of the invention include, but are not limited to, sprays, aerosols, solutions, emulsions, suspensions, eye drops or other ophthalmic preparations, or other forms known to one of skill in the art. *See, e.g., Remington's Pharmaceutical Sciences*, 16th and 18th eds., Mack Publishing, Easton PA (1980 & 1990); and *Introduction to Pharmaceutical Dosage Forms*, 4th ed., Lea & Febiger, Philadelphia (1985). Dosage forms suitable for treating mucosal tissues within the oral cavity can be formulated as mouthwashes or as oral gels.

Suitable excipients (*e.g.*, carriers and diluents) and other materials that can be used to provide topical and mucosal dosage forms encompassed by this invention are well known to those skilled in the pharmaceutical arts, and depend on the particular tissue to which a given pharmaceutical composition or dosage form will be applied. With that fact in mind, typical excipients include, but are not limited to, water, acetone, ethanol, ethylene glycol, propylene glycol, butane-1,3-diol, isopropyl myristate, isopropyl palmitate, mineral oil, and mixtures thereof to form solutions, emulsions or gels, which are non-toxic and pharmaceutically acceptable. Moisturizers or humectants can also be added to pharmaceutical compositions and dosage forms if desired. Examples of such additional ingredients are well known in the art. *See, e.g.*, *Remington's Pharmaceutical Sciences*, 16th and 18th eds., Mack Publishing, Easton PA (1980 & 1990).

The pH of a pharmaceutical composition or dosage form may also be adjusted to improve delivery of one or more active ingredients. Similarly, the polarity of a solvent carrier, its ionic strength, or tonicity can be adjusted to improve delivery. Compounds such as stearates can also be added to pharmaceutical compositions or dosage forms to advantageously alter the hydrophilicity or lipophilicity of one or more active ingredients so as to improve delivery. In this regard, stearates can serve as a lipid vehicle for the formulation, as an emulsifying agent or surfactant, and as a delivery-enhancing or penetration-enhancing agent. Different salts, hydrates or solvates of the active ingredients can be used to further adjust the properties of the resulting composition.

4.5.5 KITS

Typically, active ingredients of the invention are preferably not administered to a patient at the same time or by the same route of administration. This invention therefore encompasses kits which, when used by the medical practitioner, can simplify the administration of appropriate amounts of active ingredients to a patient.

A typical kit of the invention comprises a dosage form of a compound of the invention. Kits encompassed by this invention can further comprise additional active ingredients such as oblimersen (Genasense®), melphalan, G-CSF, GM-CSF, EPO, topotecan, dacarbazine, irinotecan, taxotere, IFN, COX-2 inhibitor, pentoxifylline, ciprofloxacin, dexamethasone, IL2, IL8, IL18, Ara-C, vinorelbine, isotretinoin, 13 cis-retinoic acid, or a pharmacologically active mutant or derivative thereof, or a combination thereof. Examples of the additional active ingredients include, but are not limited to, those disclosed herein (*see, e.g.*, section 4.3).

Kits of the invention can further comprise devices that are used to administer the active ingredients. Examples of such devices include, but are not limited to, syringes, drip bags, patches, and inhalers.

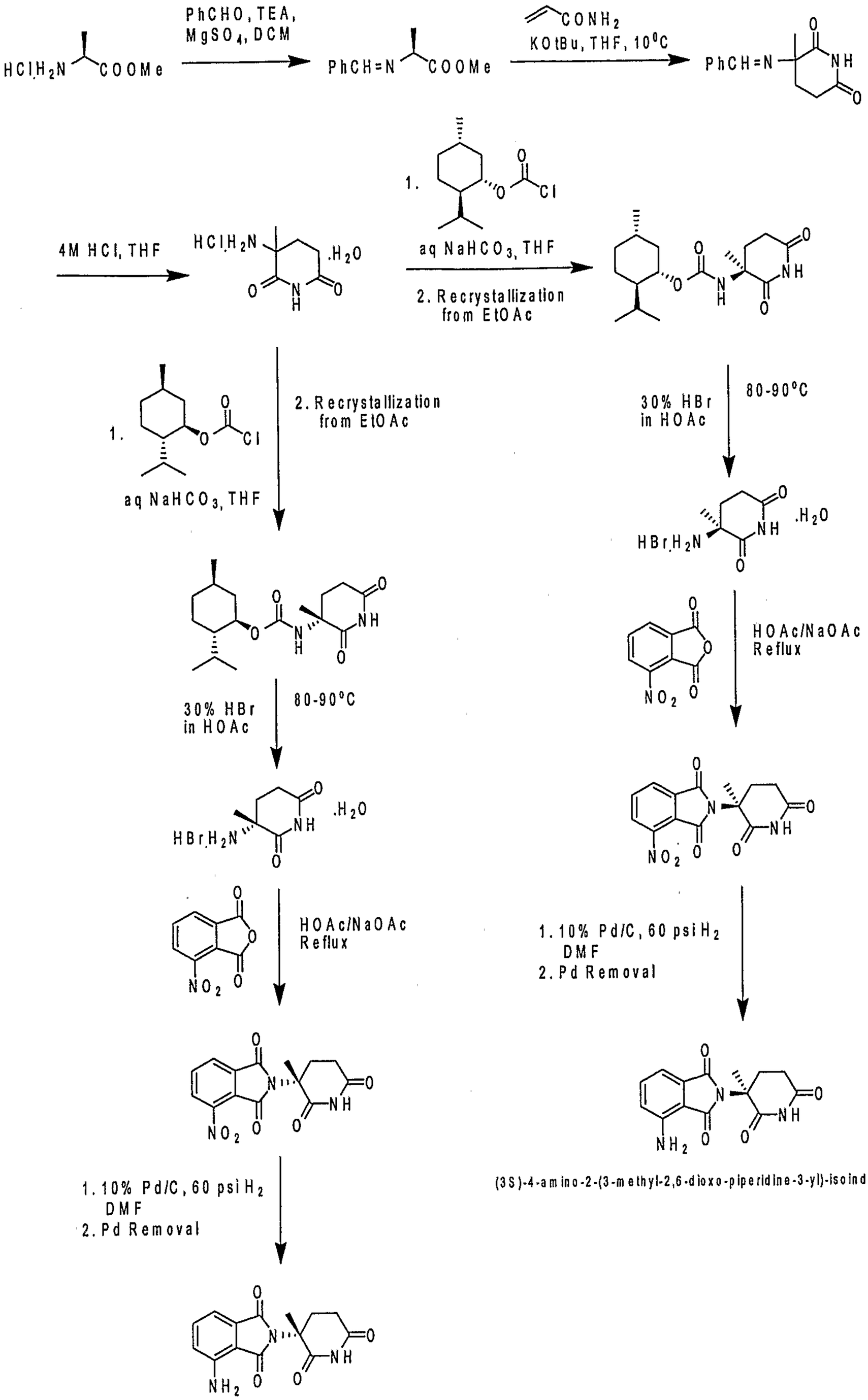
Kits of the invention can further comprise cells or blood for transplantation as well as pharmaceutically acceptable vehicles that can be used to administer one or more active ingredients. For example, if an active ingredient is provided in a solid form that must be reconstituted for parenteral administration, the kit can comprise a sealed container of a suitable vehicle in which the active ingredient can be dissolved to form a particulate-free sterile solution that is suitable for parenteral administration. Examples of pharmaceutically acceptable vehicles 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.

5. EXAMPLES

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

5.1 SYNTHESIS OF STEREOISOMERS OF 4-AMINO-2-(3-METHYL-2,6-DIOXOPIPERIDIN-3-YL)-ISOINDOLE-1,3-DIONE

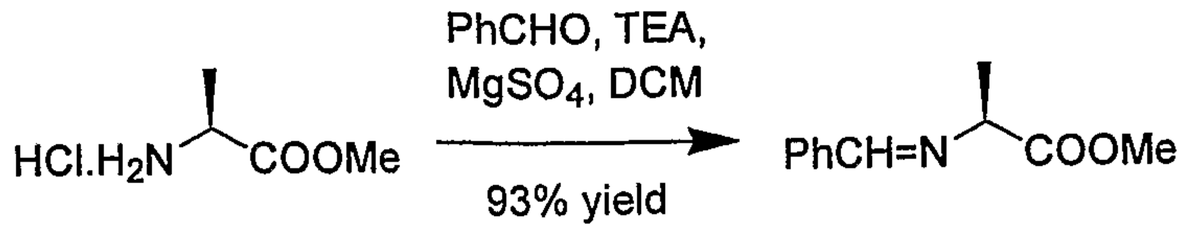
Stereoisomers of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione can be prepared according to the following scheme:



(3S)-4-amino-2-(3-methyl-2,6-dioxo-piperidine-3-yl)-isoindoline-1,3-dione

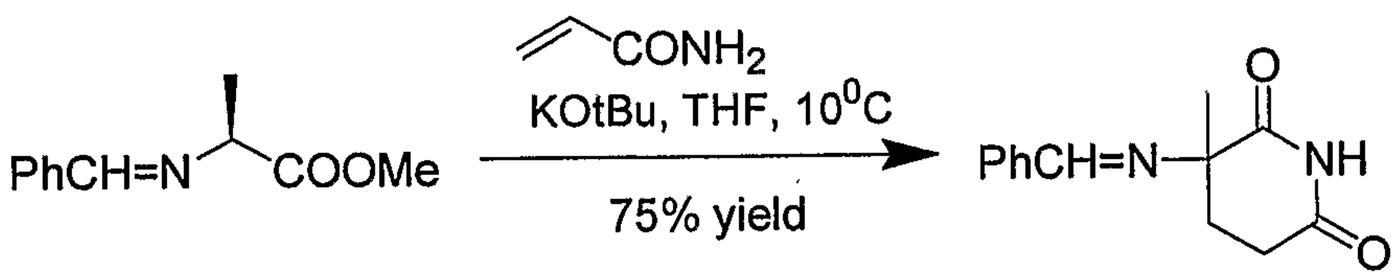
(3R)-4-amino-2-(3-methyl-2,6-dioxo-piperidine-3-yl)-isoindoline-1,3-dione

5.1.1 2-(Benzylideneamino)-Propionic Acid Methyl Ester



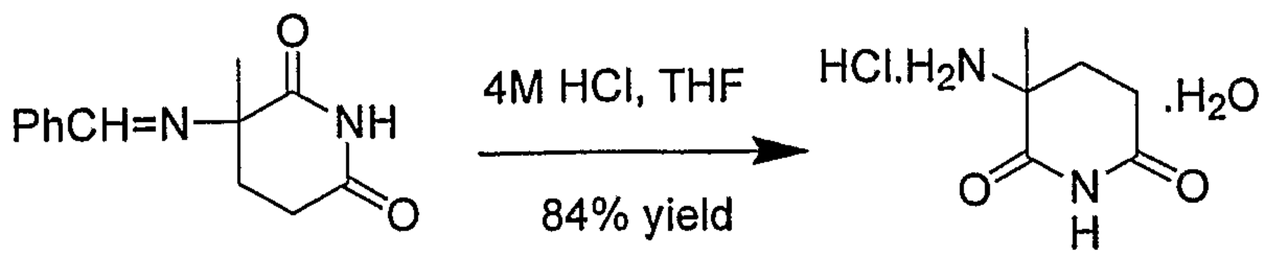
To a slurry of L-alanine methyl ester hydrochloride (125.0 g, 895 mmol) and magnesium sulfate (75.0 g) in dichloromethane (DCM, 1,250 mL), was added TEA (150 mL, 1,076 mmol) over a period of 10 minutes, followed by an addition of benzaldehyde (91.0 mL, 895 mmol) over a period of 10 minutes. The reaction was stirred at room temperature overnight and filtered, and the solid was washed with DCM (250 mL). The DCM solution was washed with water (3 x 500 mL), and concentrated to give 159.9 g (93% crude yield) of the product as a brown oil: ^{1}H NMR ($CDCl_3$): 8.32 (s, 1H), 7.76-7.80 (m, 2H), 7.37-7.44 (m, 3H), 4.12-4.21 (q, 1H), 3.75 (s, 3H), 1.53 (d, 3H).

5.1.2 3-(Benzylideneamino)-3-Methylpiperidine-2,6-Dione



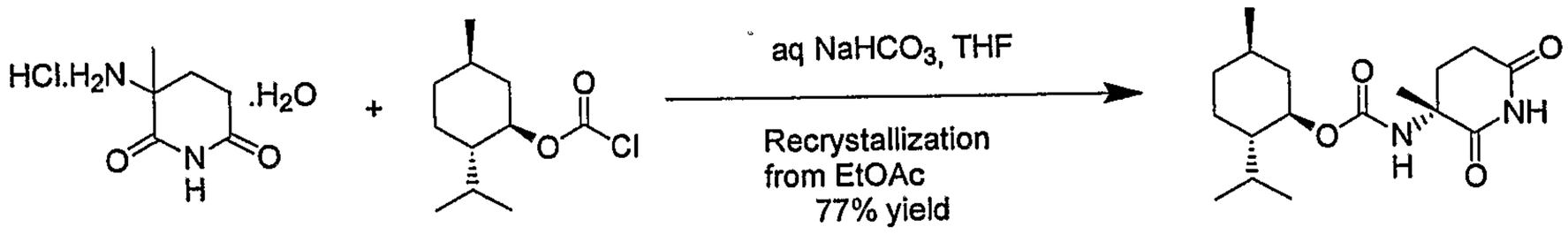
To a solution of 2-(benzylideneamino)-propionic acid methyl ester (62.1 g, 325 mmol) and acrylamide (34.7 g, 488 mmol) in THF (1,250 mL), was added KOtBu (40.2 g, 95% purity, 341 mmol) in portions over a period of 25 minutes, while keeping the reaction temperature below 5 °C. The reaction mixture was stirred at 0 °C for another 15 minutes after the addition of KOtBu. Solid NH_4Cl (20.0 g, 341 mmol) was then added in portions, and the mixture was stirred at 0 °C for additional 5 minutes. The resulting mixture was quenched with ice-cold water (1,250 mL) and concentrated to remove ~1.3 L of distillate. The reaction mixture was filtered, and the solid was washed with water (3 x 310 mL). The product was dried *in vacuo* at 45 °C overnight, giving 55.8 g (75% yield) of the product as a white solid. ^{1}H NMR (DMSO-d_6): 10.86 (s, 1H), 8.38 (s, 1H), 7.34-7.84 (m, 5H), 2.03-2.77 (m, 4H), 1.43 (s, 3H).

5.1.3 3-Amino-3-Methylpiperidine-2,6-Dione Hydrochloride Monohydarate



To a solution of 3-(benzylideneamino)-3-methylpiperidine-2,6-dione (52.0 g, 226 mmol) in THF (520 mL), was added drop-wise 4M aqueous HCl (68.0 mL, 272 mmol), while maintaining the reaction temperature at 3-10 °C. The mixture was allowed to warm to room temperature and stirred at room temperature for another 3 hours. The solid was collected by vacuum filtration and washed with THF (2x100 mL). The product was dried *in vacuo* at 50 °C overnight, providing 38.2 g (84% yield) of the product as an off-white solid. m.p. 292-294 °C. ^{1}H NMR (DMSO-d_6): 11.27 (s, 1H), 8.87 (s, 3H), 2.58-2.87 (m, 2H), 2.08-2.33 (m, 2H), 1.54 (s, 3H). Calcd. for $C_6H_{11}ClN_2O_2 \cdot 0.95H_2O$: C, 36.82; H, 6.64; N, 14.31. Found: C, 37.25; H, 6.52; N, 13.82.

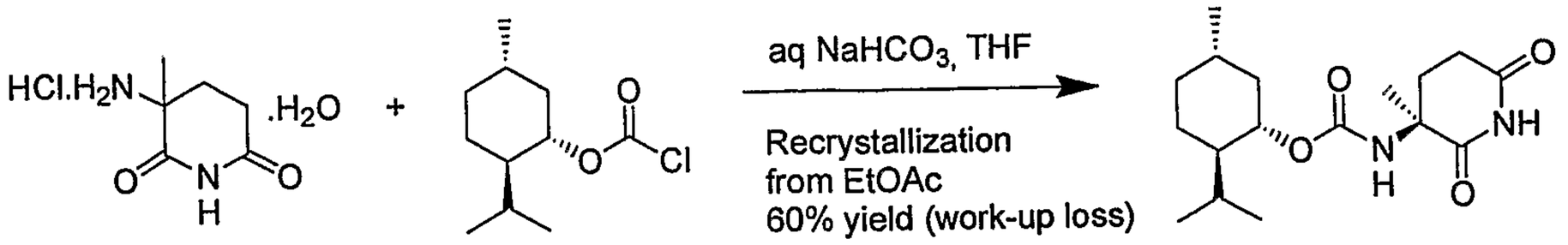
5.1.4 (3*R*)-(3-Methyl-2,6-Dioxopiperidin-3-yl)-Carbamic Acid 2-Isopropyl-5-Methylcyclohexyl Ester



To a slurry of 3-amino-3-methylpiperidine-2,6-dione hydrochloride monohydrate (5.68 g, 28.9 mmol) in a mixture of water (30 mL) and THF (30 mL), was added (-)-menthyl chloroformate (6.4 mL, 29.8 mmol) at 0 °C. To the resulting reaction mixture, was added portion-wise solid $NaHCO_3$ (10.1 g, 120.0 mmol) over 5 minutes while keeping the reaction temperature at 0-5 °C. After the addition of $NaHCO_3$, the mixture was stirred for 1 hour at 0 °C and for another 5 hours at room temperature before additional (-)-menthyl chloroformate (2.0 mL, 9.3 mmol) was added. The slurry was stirred at room temperature overnight, quenched with water (30 mL), and concentrated to remove ~30 mL of a distillate. The mixture was then filtered, and the solid was washed with water (3 x 15 mL) and hexane (3 x 15 mL). The crude product was air-dried and then refluxed with EtOAc (20 mL) for 30 minutes. The mixture was then cooled to 0 °C and stirred at 0 °C for 30 minutes. Solid was collected by filtration and quickly rinsed with cold EtOAc (20 mL). The product was dried *in vacuo* at 40 °C overnight, affording 3.60 g (77% yield based on single isomer conversion) of a white crystalline material. m.p. 175-177 °C. HPLC (Waters Nova-Pak C18 column, 3.9x150 mm, 4 μm, 40/60 CH_3CN/0.1% aq H_3PO_4, 1.0 mL/min, 210 nm): 11.95 min (>99.0%). Chiral HPLC (Daicel ChiralPak AD column, 4.6 x 250 mm, 15/85 IPA/hexanes, 1.0 mL/min, 210 nm): 9.53 min (>99.0% ee). ^{1}H NMR (DMSO-d_6): 10.67 (s, 1H), 7.50 (s, 1H), 4.31-4.41 (m, 1H), 2.42-2.75 (m, 2H), 1.84-1.98 (m, 2H), 1.60-1.75 (m, 3H), 1.40-1.50 (m, 5H), 0.70-1.09 (m, 13H). ^{13}C NMR (DMSO-d_6): 174.39, 172.37, 154.79, 73.03, 54.46, 46.81, 41.17, 33.77, 30.91, 29.22, 29.08, 25.44, 22.91, 22.13, 21.91,

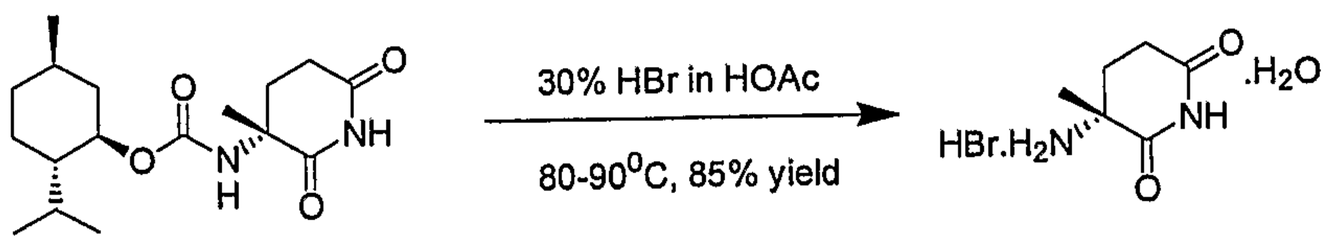
20.60, 16.14. Calcd. for $C_{17}H_{28}N_2O_4$: C, 62.94; H, 8.70; N, 8.64. Found: C, 62.84; H, 8.69; N, 8.52.

5.1.5 (3*S*)-(3-Methyl-2,6-Dioxopiperidin-3-yl)-Carbamic Acid 2-Isopropyl-5-Methylcyclohexyl Ester



(3*S*)-(3-methyl-2,6-dioxo-piperidin-3-yl)-carbamic acid 2-isopropyl-5-methylcyclohexyl ester was synthesized using procedures substantially the same as those used for the synthesis of (3*R*)-(3-methyl-2,6-dioxo-piperidin-3-yl)-carbamic acid 2-isopropyl-5-methylcyclohexyl ester. The product was a white crystalline solid. m.p. 170-172 °C. HPLC (Waters Nova-Pak C18 column, 3.9 x 150 mm, 4 µm, 40/60 CH_3CN/0.1% aqueous H_3PO_4, 1.0 mL/min, 210 nm): 12.09 min (>99.0%). Chiral HPLC (Daicel ChiralPak AD column, 4.6 x 250 mm, 15/85 IPA/hexanes, 1.0 mL/min, 210 nm): 7.88 min (>99.0% ee). ^{1}H NMR (DMSO-d_6): 10.66 (s, 1H), 7.49 (s, 1H), 4.32-4.41 (m, 1H), 2.42-2.75 (m, 2H), 1.84-1.98 (m, 2H), 1.50-1.75 (m, 3H), 1.40-1.50 (m, 5H), 0.70-1.07 (m, 13H). ^{13}C NMR (DMSO-d_6): 174.39, 172.36, 154.80, 73.03, 54.46, 46.81, 41.17, 33.77, 30.91, 29.22, 29.09, 25.44, 22.91, 22.13, 21.91, 20.60, 16.13. Calcd. for $C_{17}H_{28}N_2O_4$: C, 62.94; H, 8.70; N, 8.64. Found: C, 62.69; H, 8.70; N, 8.54.

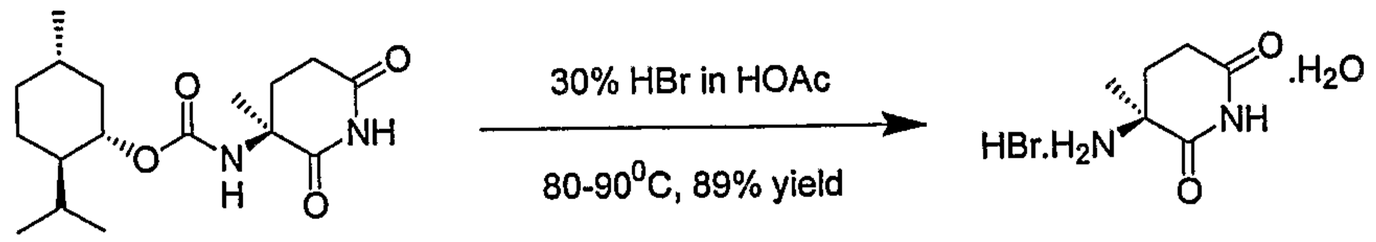
5.1.6 (3*R*)-3-Amino-3-Methylpiperidine-2,6-Dione Hydrobromide Monohydrate



A 50-mL 3N RBF was charged with (3*R*)-(3-methyl-2,6-dioxo-piperidin-3-yl)-carbamic acid 2-isopropyl-5-methylcyclohexyl ester (3.13 g, 9.6 mmol) and 30% HBr in HOAc (31 .0 mL). The mixture was slowly heated to 90-100 °C, then stirred within the same temperature range for 6 hours. The mixture was allowed to cool to room temperature and stirred at room temperature for 30 minutes. Solid was collected by vacuum filtration and washed with HOAc (3 x 10 mL) and EtOAc (3 x 10 mL). The product was dried *in vacuo* at 45 °C overnight, generating 2.0 g (85% yield) of the product as a white crystalline solid. m.p. 305-307 °C. Chiral HPLC (Regis ChiroSil CH SCA column, 4.6 x 150 mm, 70/30 EtOH/0.02% aqueous H_3PO_4, 1.0 mL/min, 210 nm): 3.71 min (>99.5% ee). ^{1}H

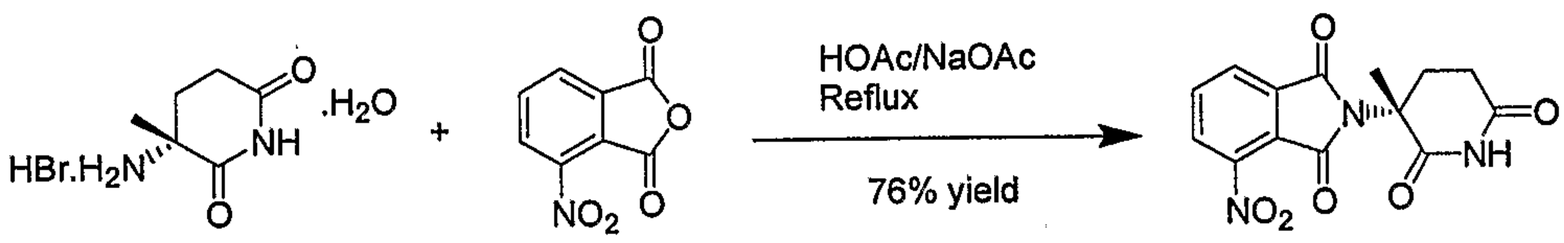
NMR (DMSO-d_6): 11.30 (s, 1H), 8.63 (s, 3H), 2.51-2.89 (m, 2H), 2.04-2.30 (m, 2H), 1.54 (s, 3H). ^{13}C NMR (DMSO-d_6): 172.58, 171.67, 54.72, 28.31, 27.60, 20.66. Calcd. for $C_6H_{11}BrN_2O_2.H_2O$: C, 29.89; H, 5.44; N, 11.62. Found: C, 30.01; H, 5.20; N, 11.49.

5.1.7 (3*S*)-3-Amino-3-Methylpiperidine-2,6-Dione Hydrobromide Monohydrate



(3*S*)-3-Amino-3-methylpiperidine-2,6-dione hydrobromide monohydrate was synthesized using procedures substantially the same as those used for the synthesis of (3*R*)-3-amino-3-methylpiperidine-2,6-dione hydrobromide monohydrate. The product was a white crystalline solid. m.p. 305-307 °C. Chiral HPLC (Regis ChiroSil CH SCA column, 4.6 x 150 mm, 70/30 EtOH/0.02% aqueous H_3PO_4, 1.0 mL/min, 210 nm): 4.71 min (>99.5% ee). ^{1}H NMR (DMSO-d_6): 11.31 (s, 1H), 8.62 (s, 3H), 2.51-2.89 (m, 2H), 2.04-2.29 (m, 2H), 1.54 (s, 3H). ^{13}C NMR (DMSO-d_6): 172.58, 171.67, 54.71, 28.31, 27.60, 20.66. Calcd. for $C_6H_{11}BrN_2O_2.H_2O$: C, 29.89; H, 5.44; N, 11.62. Found: C, 30.04; H, 5.28; N, 11.57.

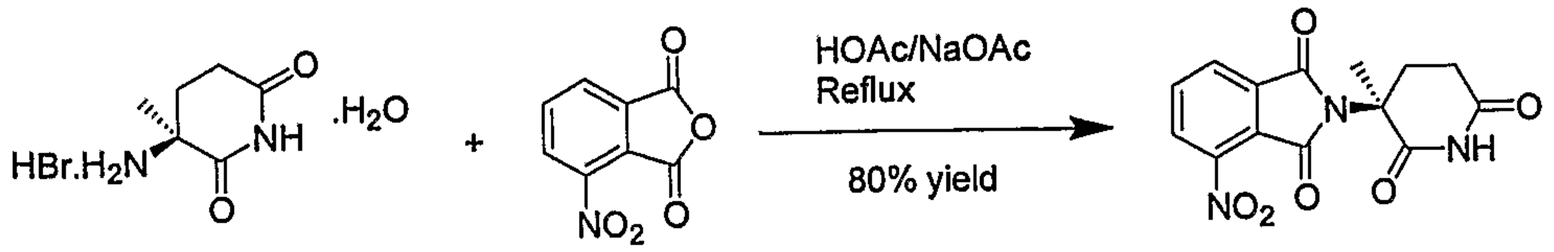
5.1.8 (3*R*)-2-(3-Methyl-2,6-Dioxopiperidin-3-yl)-4-Nitro-Isoindole-1,3-Dione



A mixture of 3-nitrophthalic anhydride (1.49 g, 7.7 mmol), (3*R*)-3-amino-3-methylpiperidine-2,6-dione hydrobromide monohydrate (1.56 g, 6.2 mmol), and NaOAc (0.66 g, 8.0 mmol) in HOAc (31 mL) was refluxed for 24 hours. Without stirring, the solution was allowed to cool to room temperature and left at room temperature for another 30 minutes. Solid was collected by vacuum filtration, washed with HOAc (15 mL), water (2 x 15 mL), and MTBE (2 x 15 mL), and dried *in vacuo* at 45 °C overnight, giving 1.24 g of the product as an off-white solid. The filtrate and HOAc wash were combined and concentrated to almost dryness. Water (30 mL) and MTBE (30 mL) were added, and the mixture was vigorously stirred at room temperature for 2 hours. Solid was collected by filtration, washed with water (2 x 15 mL) and MTBE (2 x 15 mL), and dried *in vacuo* at 45 °C overnight, affording 0.25 g of additional product as an off-white material. The total yield for this experiment was 76%. HPLC (Waters Nova-Pak C18 column, 3.9 x 150 mm, 4

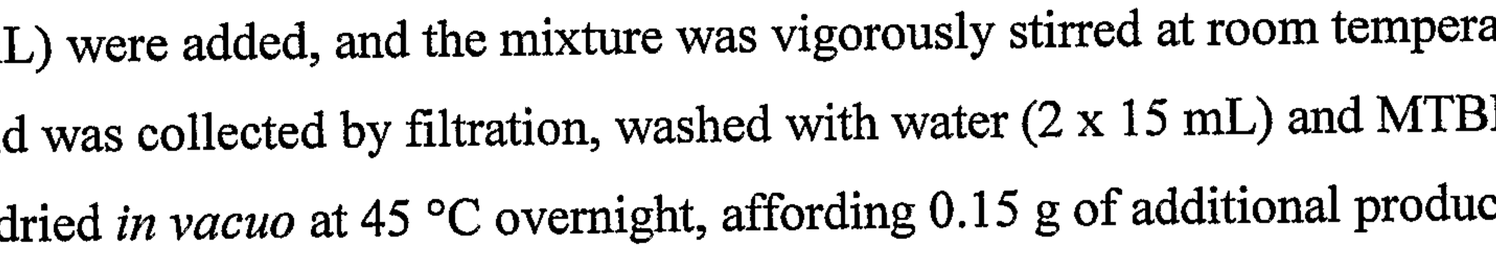
μm, 35/65 CH_3CN/0.1% aqueous H_3PO_4, 1.0 mL/min, 210 nm): 2.85 min (>99.5%). ^1H NMR (DMSO-d_6): 11.07 (s, 1H), 8.04-8.31 (m, 3H), 2.52-2.64 (m, 3H), 1.99-2.09 (m, 1H), 1.89 (s, 3H). ^{13}C NMR (DMSO-d_6): 172.23, 171.73, 165.90, 163.32, 144.19, 136.44, 133.05, 128.50, 126.78, 122.26, 59.22, 28.87, 28.50, 21.05.

5.1.9 (3*S*)-2-(3-Methyl-2,6-Dioxopiperidin-3-yl)-4-Nitro-Isoindole-1,3-Dione



A mixture of 3-nitrophthalic anhydride (1.49 g, 7.7 mmol), (3*S*)-3-amino-3-methylpiperidine-2,6-dione hydrobromide monohydrate (1.56 g, 6.2 mmol), and NaOAc (0.66 g, 8.0 mmol) in HOAc (31 mL) was refluxed for 24 hours. The mixture was then allowed to cool to room temperature with vigorous stirring, and the stirring was continued at room temperature for another 30 minutes. Solid was collected by vacuum filtration, washed with HOAc (15 mL), water (2 x 15 mL), and MTBE (2 x 15 mL), and dried *in vacuo* at 45 °C overnight, giving 1.43 g of the product as an off-white solid. The filtrate and HOAc wash were combined and concentrated to almost dryness. Water (30 mL) and MTBE (30 mL) were added, and the mixture was vigorously stirred at room temperature for 2 hours. Solid was collected by filtration, washed with water (2 x 15 mL) and MTBE (2 x 10 mL), and dried *in vacuo* at 45 °C overnight, affording 0.15 g of additional product as an off-white material. The total yield for this experiment was 80%. HPLC (Waters Nova-Pak C18 column, 3.9 x 150 mm, 4 μm, 35/65 CH_3CN/0.1% aqueous H_3PO_4, 1.0 mL/min, 210 nm): 2.85 min (96.5%). ^1H NMR (DMSO-d_6): 11.07 (s, 1H), 8.04-8.31 (m, 3H), 2.51-2.64 (m, 3H), 1.88-2.08 (m, 4H).

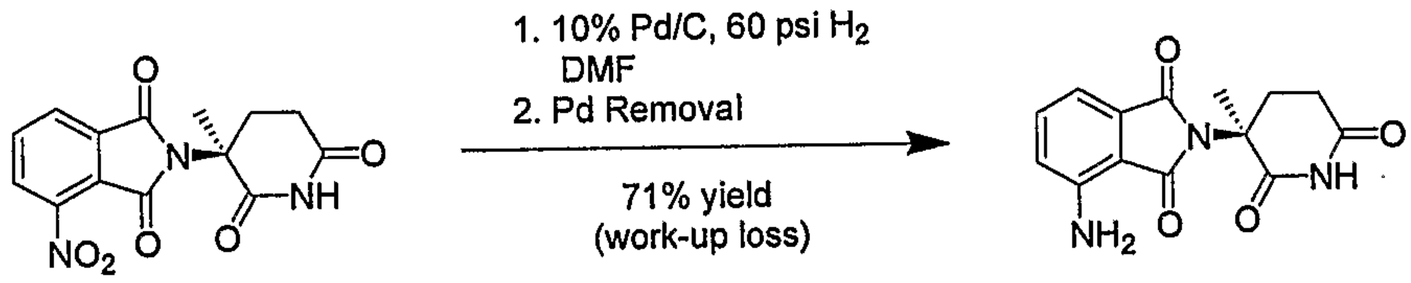
5.1.10 (3*R*)-4-Amino-2-(3-Methyl-2,6-Dioxopiperidin-3-yl)-Isoindole-1,3-Dione



A slurry of (3*R*)-2-(3-methyl-2,6-dioxo-piperidin-3-yl)-4-nitro-isoindole-1,3-dione (1.12 g, 3.5 mmol) and 10% Pd/C (140 mg) in DMF (22 mL) was hydrogenated with 60 psi H_2 at room temperature for 19 hours. The mixture was filtered through a celite bed, and the celite bed was washed with DMF (2 x 6 mL). The filtrate was stirred with charcoal (560 mg) at room temperature for 2 hours, filtered through a 0.2 μm Millipore nylon membrane

filter, and treated with 3-mercaptopropyl-functionalized silica gel (1.12 g) at room temperature for 2 hours. The resulting mixture was filtered and the filtrate was concentrate to almost dryness. The residue was reslurried in water (22 mL) over the weekend. The slurry was filtered, washed with water (4 x 11 mL), rinsed with THF (6 mL) and DCM (2x11 mL), respectively. It should be noted that the product may have good solubility in THF and DCM. The solid was dried *in vacuo* at 45 °C overnight, affording 0.57 g (57% yield) of the product as a bright yellow solid. m.p. 236-238°C. HPLC (Waters Nova-Pak C18 column, 3.9 x 150 mm, 4 μm, 20/80 CH_3CN/0.1% aqueous H_3PO_4, 1.0 mL/min, 240 nm): 6.92 min (>99.0%). Chiral HPLC (Daicel ChiralPak AD column, 4.6 x 250 mm, 70/30 IPA/hexanes, 0.75 mL/min, 240 nm): 13.30 min (>99.0% ee). ^{1}H NMR (DMSO-d_6): 10.99 (s, 1H), 7.42-7.47 (m, 1H), 6.92-7.00 (m, 2H), 6.52 (s, 2H), 2.55-2.71 (m, 3H), 1.88-2.05 (m, 4H). ^{13}C NMR (DMSO-d_6): 172.44, 172.13, 169.48, 168.02, 146.53, 135.34, 131.78, 121.48, 110.52, 108.28, 58.26, 29.23, 28.60, 20.98. Calcd. for $C_{14}H_{13}N_3O_4$.0.4 H_2O (or 2.4% H_2O): C, 57.10; H, 4.72; N, 14.27. Found: C, 57.28; H, 4.53; N, 14.14. Water content by QTI: 2.3%.

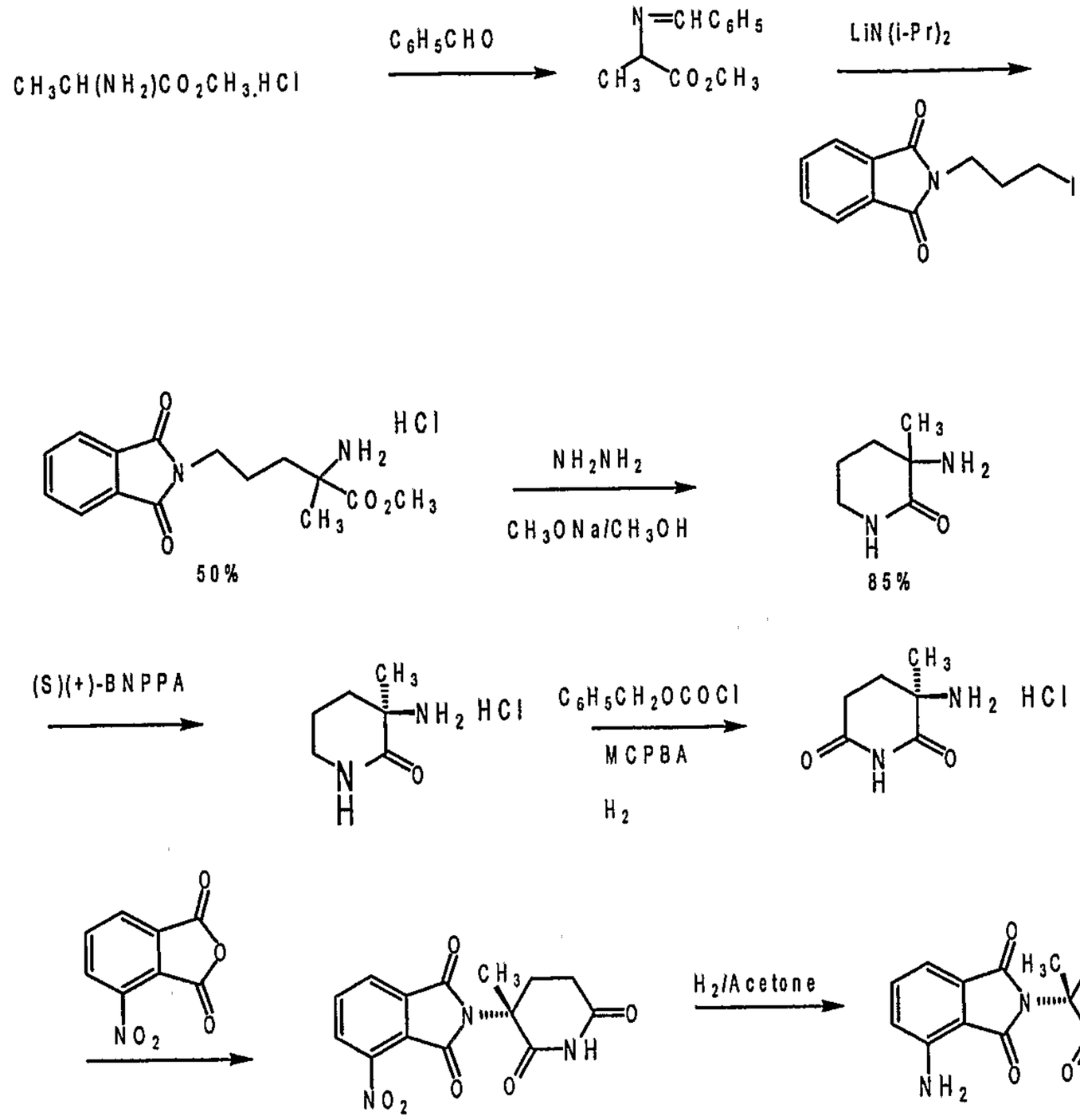
5.1.11 (3*S*)-4-Amino-2-(3-Methyl-2,6-Dioxopiperidin-3-yl)-Isoindole-1,3-Dione



(3*S*)-4-Amino-2-(3-methyl-2,6-dioxo-piperidin-3-yl)-isoindole-1,3-dione was synthesized using procedures substantially the same as those used for the synthesis of (3*R*)-4-amino-2-(3-methyl-2,6-dioxo-piperidin-3-yl)-isoindole-1,3-dione. The product (0.88 g, 71% yield) was a bright yellow solid. m.p. 235-237 °C. HPLC (Waters Nova-Pak C18 column, 3.9 x 150 mm, 4 μm, 20/80 CH_3CN/0.1% aqueous H_3PO_4, 1.0 mL/min, 240 nm): 6.92 min (>99.0%). Chiral HPLC (Daicel ChiralPak AD column, 4.6 x 250 mm, 70/30 IPA/hexanes, 0.75 mL/min, 240 nm): 26.35 min (>99.0% ee). ^{1}H NMR (DMSO-d_6): 10.99 (s, 1H), 7.44(t, 1H), 6.91-7.00 (m, 2H), 6.52 (s, 2H), 2.51-2.78 (m, 3H), 1.88-2.04 (m, 4H). ^{13}C NMR (DMSO-d_6): 172.45, 172.14, 169.49, 168.03, 146.54, 135.35, 131.79, 121.49, 110.53, 108.29, 58.27, 29.23, 28.61, 20.99. Calcd. for $C_{14}H_{13}N_3O_4$.0.4 H_2O (or 2.4% H_2O): C, 57.10; H, 4.72; N, 14.27. Found: C, 57.25; H, 4.46; N, 14.07. Water content by QTI: 2.1%.

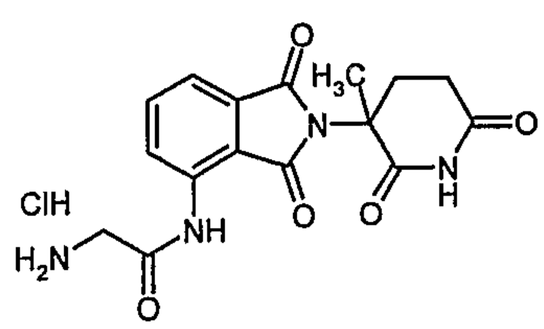
5.2 Alternative Synthesis of (3*R*)-4-Amino-2-(3-Methyl-2,6-Dioxopiperidin-3-yl)-Isoindoline-1,3-Dione

(3*R*)-4-Amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)isoindoline-1,3-dione was synthesized using the following alternative synthetic method:



(3*S*)-4-Amino-2-(3-methyl-2,6-dioxo-piperidin-3-yl)isoindoline-1,3-dione can also be synthesized using the same procedures, but by replacing (S)-(+)-BNPPA with (R)-(+)-BNPPA.

5.3 2-Amino-N-[2-(3-Methyl-2,6-Dioxo-Piperidin-3-yl)-1,3-Dioxo-2,3-Dihydro-1H-Isoindol-4-yl]-Acetamide Hydrochloride



5.3.1 2-Chloro-N-[2-(3-Methyl-2,6-Dioxo-Piperidin-3-yl)-1,3-Dioxo-2,3-Dihydro-1H-Isoindol-4-yl]-Acetamide

Chloroacetyl chloride (0.6 mL, 7.8 mmol) was added to a stirred suspension of 4-amino-2-(3-methyl-2,6-dioxo-piperidin-3-yl)-isoindole-1,3-dione (1.5 g, 5.2 mmol) in THF (20 mL). The mixture was heated to reflux for 30 minutes. The mixture was cooled to room temperature and filtered to afford 2-chloro-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-

1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide (1.6 g, 84%) as an off white solid: ^{1}H NMR (DMSO-d_6) δ 11.05 (s, 1H), 10.26 (s, 1H), 8.51 (d, J=8.4 Hz, 1H), 7.84 (t, J=7.7 Hz, 1H), 7.60 (d, J=7.3 Hz, 1H), 4.53 (s, 2H), 2.70-2.50 (m, 3H), 2.08-2.03 (m, 1H), 1.89 (s, 3H); ^{13}C NMR (DMSO-d_6) δ 172.16, 171.98, 168.74, 167.31, 165.69, 136.16, 135.39, 131.30, 125.27, 118.54, 116.95, 58.89, 43.14, 29.04, 28.53, 20.98.

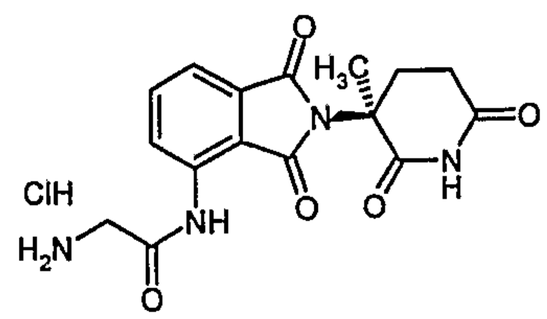
5.3.2 3-Azido-N-[2-(3-Methyl-2,6-Dioxo-Piperidin-3-yl)-1,3-Dioxo-2,3-Dihydro-1H-Isoindol-4-yl]-Acetamide

A mixture of 2-chloro-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide (1.5 g, 4.1 mmol), sodium azide (0.4 g, 6.2 mmol) and sodium iodide (20 mg) in acetone (50 mL) was heated to refluxed for 17 hours. The mixture was cooled to room temperature and concentrated. Residue was stirred with water (30 mL) and filtered to give 1.5 g of crude product. The crude product was stirred with ethanol (15 mL) to afford 3-azido-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide (1.4 g, 91%): ^{1}H NMR (CMSO-d_6) δ 11.05 (s, 1H), 10.0 (s, 1H), 8.50 (d, J=8.4 Hz, 1H), 7.86 (dd, J=7.4 and 8.3 Hz, 1H), 7.59 (d, J=7.2 Hz, 1H), 4.34 (s, 2H), 2.70-2.48 (m, 3H), 2.10-2.03 (m, 1H), 1.90 (s, 3H).

5.3.3 2-Amino-N-[2-(3-Methyl-2,6-Dioxo-Piperidin-3-yl)-1,3-Dioxo-2,3-Dihydro-1H-Isoindol-4-yl]-Acetamide Hydrochloride

A mixture of 2-azido-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide (1.4 g, 3.8 mmol) and 10% Pd/C (0.15 g) in 4N HCl (20 mL) and methanol (100 mL) was hydrogenated at 50 psi for 5 hours. The mixture was filtered through celite, and the filtrate was concentrated to give 0.5 g of crude product. The filtered catalyst was reslurried with water (15 mL) and filtered, and the filtrate was concentrated to give another 0.6 g of crude product. The combined crude product was slurried with hot methanol (30 mL) to afford 2-amino-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide hydrochloride (0.5 g, 35%) as yellow solid: mp 111-113°C; ^{1}H NMR (DMSO-d_6) δ 11.05 (s, 1H), 10.30 (b, 1H), 8.40 (s, 3H), 8.32 (d, J=8.2 Hz, 1H), 7.86 (t, J=7.7 Hz, 1H), 7.64 (d, J=7.2 Hz, 1H), 3.97 (s, 2H), 2.72-2.50 (m, 3H), 2.09-2.04 (m, 1H), 1.90 (s, 3H); ^{13}C NMR (DMSO-d_6) δ 172.18, 172.04, 167.75, 167.22, 166.18, 135.99, 134.74, 131.76, 127.13, 118.92, 117.98, 58.83, 41.11, 29.10, 28.55, 21.05; Anal. Calcd for $C_{16}H_{17}N_4O_5Cl$: C, 50.47, H, 4.50, N, 14.71, Cl, 9.31. Found: C, 50.35, H, 4.40, N, 14.54, Cl, 9.01.

5.4 (3*S*)-2-Amino-N-[2-(3-Methyl-2,6-Dioxo-Piperidin-3-Yl)-1,3-Dioxo-2,3-Dihydro-1H-Isoindol-4-Yl]-Acetamide Hydrochloride



5.4.1 (3*S*)-2-Chloro-N-[2-(3-Methyl-2,6-Dioxo-Piperidin-3-yl)-1,3-Dioxo-2,3-Dihydro-1H-Isoindol-4-yl]-Acetamide

Chloroacetyl chloride (0.6 mL, 7.8 mmol) was added to a stirred suspension of (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione (1.5 g, 5.2 mmol) in THF (40 mL). The mixture was heated to reflux for 30 minutes, and then cooled to room temperature. The mixture was concentrated to half volume and ether (20 mL) was added. The mixture was stirred for 30 minutes, then filtered to give (3*S*)-2-chloro-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide (1.9 g, 100%) as an off white solid: ^{1}H NMR (DMSO-d_6) δ 11.05 (s, 1H), 10.26 (s, 1H), 8.51 (d, J=8.3 Hz, 1H), 7.84 (t, J=7.8 Hz, 1H), 7.60 (d, J=7.3 Hz, 1H), 4.53 (s, 2H), 2.68-2.49 (m, 3H), 2.10-2.03 (m, 1H), 1.89 (s, 3H).

5.4.2 (3*S*)-2-Azido-N-[2-(3-Methyl-2,6-Dioxo-Piperidin-3-yl)-1,3-Dioxo-2,3-Dihydro-1H-Isoindol-4-yl]-Acetamide

A mixture of (3*S*)-2-chloro-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide (1.9 g, 4.1 mmol), sodium azide (0.5 g, 7.8 mmol), and sodium iodide (40 mg) in acetone (70 mL) was heated to reflux for 17 hours. The mixture was cooled to room temperature and concentrated. The residue was stirred with water (30 mL) for 30 minutes, then filtered. The solid was slurried in ethanol (20 mL) to give (3*S*)-2-azido-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide (1.8 g, 94%): ^{1}H NMR (DMSO-d_6) δ 11.05 (s, 1H), 10.05 (s, 1H), 8.50 (d, J=8.4 Hz, 1H), 7.83 (t, J=7.6 Hz, 1H), 7.59 (d, J=7.2 Hz, 1H), 4.34 (s, 2H), 2.71-2.49 (m, 3H), 2.10-2.03 (m, 1H), 1.90 (s, 3H).

5.4.3 (3*S*)-2-Amino-N-[2-(3-Methyl-2,6-Dioxo-Piperidin-3-yl)-1,3-Dioxo-2,3-Dihydro-1H-Isoindol-4-yl]-Acetamide Hydrochloride

A mixture of (3*S*)-2-azido-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide (1.8 g, 4.9 mmol) and 10% Pd/C (0.3 g) in 4N HCl (40 mL) and methanol (400 mL) was hydrogenated at 50 psi for 3 hours. The mixture was filtered through celite, and the filtrate was concentrated. The residue was stirred with ethanol (20 mL) to give 2 g of solid. The solid was slurried with hot methanol (30 mL) to

give 1.4 g of crude product. The crude product was recrystallized from methanol (150 mL) to afford (3*S*)-2-amino-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide hydrochloride (0.9 g, 46%) as yellow solid: mp >260°C; ^{1}H NMR (DMSO-d_6) δ 11.05 (s, 1H), 10.30 (b, 1H), 8.40 (b, 3H), 8.32 (d, J=8.4 Hz, 1H), 7.86 (t, J=7.5 Hz, 1H), 7.64 (d, J=7.2 Hz, 1H), 3.97 (s, 2H), 2.72-2.51 (m, 3H), 2.09-2.04 (m, 1H), 1.90 (s, 3H); ^{13}C NMR (DMSO-d_6) δ 172.20, 172.06, 167.76, 167.24, 166.19, 136.00, 134.74, 131.77, 127.14, 118.94, 117.99, 58.83, 41.11, 29.11, 28.57, 21.06; Anal. Calcd for $C_{16}H_{17}N_4O_5Cl$ +0.46H_2O: C, 49.39: H, 4.64; N, 14.40; Cl, 9.11. Found: C, 49.18; H, 4.48; N, 14.20; Cl, 9.08.

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.

All of the patents, patent applications and publications referred to herein are incorporated herein in their entireties. Moreover, citation or identification of any reference in this application is not an admission that such reference is available as prior art to this invention. The full scope of the invention is better understood with reference to the appended claims.

CLAIMS

What is claimed is:

1. A method of treating, managing or preventing a disease or disorder which comprises administering to a patient in need of such treatment, management or prevention a therapeutically or prophylactically effective amount of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, or stereoisomer thereof, wherein the disease or disorder is cancer, a disorder associated with angiogenesis, pain, macular degeneration or a related syndrome, a skin disease, a pulmonary disorder, an asbestos-related disorder, a parasitic disease, an immunodeficiency disorder, a CNS disorder, CNS injury, atherosclerosis or a related disorder, dysfunctional sleep or a related disorder, hemoglobinopathy or a related disorder, or a TNFα related disorder.

2. A method of treating, managing or preventing a disease or disorder, which comprises administering to a patient in need of such treatment, management or prevention a therapeutically or prophylactically effective amount of (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, wherein the disease or disorder is cancer, a disorder associated with angiogenesis, pain, macular degeneration or a related syndrome, a skin disease, a pulmonary disorder, an asbestos-related disorder, a parasitic disease, an immunodeficiency disorder, a CNS disorder, CNS injury, atherosclerosis or a related disorder, dysfunctional sleep or a related disorder, hemoglobinopathy or a related disorder, or a TNFα related disorder.

3. A method of treating, managing or preventing a disease associated with undesired angiogenesis, which comprises administering to a patient in need of such treatment, management or prevention a therapeutically or prophylactically effective amount of (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, wherein the disease or disorder is cancer, a disorder associated with angiogenesis, pain, macular degeneration or a related syndrome, a skin disease, a pulmonary disorder, an asbestos-related disorder, a parasitic disease, an immunodeficiency disorder, a CNS disorder, CNS injury, atherosclerosis or a related disorder, dysfunctional sleep or a related disorder, hemoglobinopathy or a related disorder, or a TNFα related disorder.

4. The method of claim 1, 2, or 3, which further comprises administration of one or more additional active agents.

5. The method of claim 1, wherein 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, or stereoisomer thereof, is administered orally or parenterally.

6. The method of claim 5, wherein 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, or stereoisomer thereof, is administered orally.

7. The method of claim 2, wherein (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, is administered orally or parenterally.

8. The method of claim 7, wherein (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, is administered orally.

9. The method of claim 3, wherein (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, is administered orally or parenterally.

10. The method of claim 9, wherein (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, is administered orally.

11. A pharmaceutical composition comprising 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, or stereoisomer thereof.

12. A pharmaceutical composition comprising (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof.

13. A pharmaceutical composition comprising (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof.

14. The pharmaceutical composition of claim 11, 12, or 13, which further comprises one of more additional active agents.

15. A single unit dosage form comprising 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt, solvate, or stereoisomer thereof.

16. A single unit dosage form comprising (3*R*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof.

17. A single unit dosage form comprising (3*S*)-4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof.

18. The single unit dosage form of claim 15, 16, or 17, which further comprises one or more additional active agents.

19. The single unit dosage form of claim 15, 16, or 17, which is suitable for oral or parenteral administration.

20. The single unit dosage form of claim 19, which is suitable for oral administration.

21. The single unit dosage form of claim 20, which is a tablet or a capsule.

22. A method of treating, managing or preventing a disease or disorder which comprises administering to a patient in need of such treatment, management or prevention a therapeutically or prophylactically effective amount of a prodrug of 4-amino-2-(3-methyl-2,6-dioxopiperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, wherein the disease or disorder is cancer, a disorder associated with angiogenesis, pain, macular degeneration or a related syndrome, a skin disease, a pulmonary disorder, an asbestos-related disorder, a parasitic disease, an immunodeficiency disorder, a CNS disorder, CNS injury, atherosclerosis or a related disorder, dysfunctional sleep or a related disorder, hemoglobinopathy or a related disorder, or a TNFα related disorder.

23. The method of claim 22, wherein the prodrug is 2-amino-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide.

24. A method of treating, managing or preventing a disease or disorder which comprises administering to a patient in need of such treatment, management or

prevention a therapeutically or prophylactically effective amount of a prodrug of (3*R*)-4-amino-2-(3-methyl-2,6-dioxo-piperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, wherein the disease or disorder is cancer, a disorder associated with angiogenesis, pain, macular degeneration or a related syndrome, a skin disease, a pulmonary disorder, an asbestos-related disorder, a parasitic disease, an immunodeficiency disorder, a CNS disorder, CNS injury, atherosclerosis or a related disorder, dysfunctional sleep or a related disorder, hemoglobinopathy or a related disorder, or a TNFα related disorder.

25. The method of claim 24, wherein the prodrug is (3*R*)-2-amino-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide.

26. A method of treating, managing or preventing a disease or disorder which comprises administering to a patient in need of such treatment, management or prevention a therapeutically or prophylactically effective amount of a prodrug of (3*S*)-4-amino-2-(3-methyl-2,6-dioxo-piperidin-3-yl)-isoindole-1,3-dione, or a pharmaceutically acceptable salt or solvate thereof, wherein the disease or disorder is cancer, a disorder associated with angiogenesis, pain, macular degeneration or a related syndrome, a skin disease, a pulmonary disorder, an asbestos-related disorder, a parasitic disease, an immunodeficiency disorder, a CNS disorder, CNS injury, atherosclerosis or a related disorder, dysfunctional sleep or a related disorder, hemoglobinopathy or a related disorder, or a TNFα related disorder.

27. The method of claim 26, wherein the prodrug is (3*S*)-2-amino-N-[2-(3-methyl-2,6-dioxo-piperidin-3-yl)-1,3-dioxo-2,3-dihydro-1H-isoindol-4-yl]-acetamide.