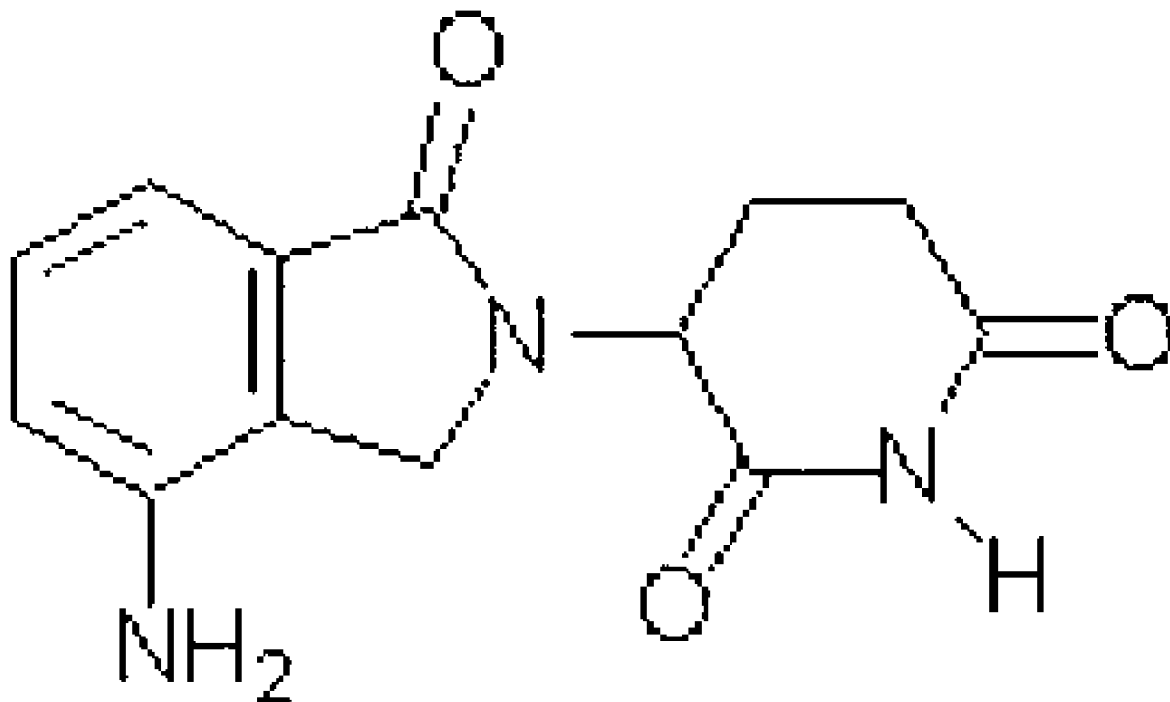




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(54) Titre : 2-(2,6- DIOXOPIPERIDINE-3-YL)-PHTHALIMIDES ET -1-OXO-ISO-INDOLINES SUBSTITUEES ET METHODES  
POUR REDUIRE LES TAUX DE TNF-ALPHA  
(54) Title: SUBSTITUTED 2(2,6-DIOXOPIPERIDIN-3-YL)PHTHALIMIDES AND -1-OXOISOINDOLINES AND METHOD  
OF REDUCING TNF-ALPHA LEVELS

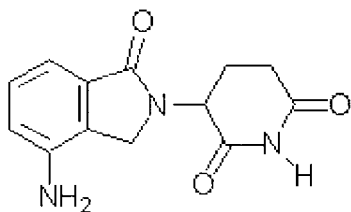


(57) Abrégé/Abstract:

Substituted 2-(2,6-dioxopiperidin-3-yl)phthalimides and 1-oxo-2-(2,6-dioxopiperidin-3-yl)isoindolines reduce the levels of TNF-alpha in a mammal. A typical embodiment is 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having the following formula: (see above formula)

## Abstract

Substituted 2-(2,6-dioxopiperidin-3-yl)phthalimides and 1-oxo-2-(2,6-dioxopiperidin-3-yl)isoindolines reduce the levels of TNF-alpha in a mammal. A typical embodiment is 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having the following formula:



**SUBSTITUTED 2-(2,6-DIOXOPIPERIDIN-3-YL)-  
PHTHALIMIDES AND -1-OXOISOINDOLINES AND  
METHOD OF REDUCING TNF $\alpha$  LEVELS**

The present invention relates to substituted 2-(2,6-dioxopiperidin-3-yl)phthalimides and substituted 2-(2,6-dioxopiperidin-3-yl)-1-oxoisoindolines, the method of reducing levels of tumor necrosis factor  $\alpha$  in a mammal through the administration thereof, and pharmaceutical compositions of such derivatives.

*Background of the Invention*

Tumor necrosis factor  $\alpha$ , or TNF $\alpha$ , is a cytokine which is released primarily by mononuclear phagocytes in response to a number immunostimulators. When administered to animals or humans, it causes inflammation, fever, cardiovascular effects, hemorrhage, coagulation, and acute phase responses similar to those seen during acute infections and shock states. Excessive or unregulated TNF $\alpha$  production thus has been implicated in a number of disease conditions. These include endotoxemia and/or toxic shock syndrome {Tracey *et al.*, *Nature* **330**, 662-664 (1987) and Hinshaw *et al.*, *Circ. Shock* **30**, 279-292 (1990)}; cachexia {Dezube *et al.*, *Lancet*, **335** (8690), 662 (1990)} and Adult Respiratory Distress Syndrome where TNF $\alpha$  concentration in excess of 12,000 pg/mL have been detected in pulmonary aspirates from ARDS patients {Millar *et al.*, *Lancet* **2**(8665), 712-714 (1989)}. Systemic infusion of recombinant TNF $\alpha$  also resulted in changes typically seen in ARDS {Ferrai-Baliviera *et al.*, *Arch. Surg.* **124**(12), 1400-1405 (1989)}.

TNF $\alpha$  appears to be involved in bone resorption diseases, including arthritis. When activated, leukocytes will produce bone-resorption, an activity to which the data suggest TNF $\alpha$  contributes. {Bertolini *et al.*, *Nature* **319**, 516-518 (1986) and Johnson *et al.*, *Endocrinology* **124**(3), 1424-1427 (1989).} TNF $\alpha$  also has been shown to stimulate bone resorption and inhibit bone formation *in vitro* and *in vivo* through stimulation of osteoclast formation and activation combined with inhibition of osteoblast function. Although TNF $\alpha$  may be involved in many bone resorption diseases, including arthritis, the most compelling link with disease is the association between production of TNF $\alpha$  by tumor or host tissues and malignancy associated

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hypercalcemia {*Calci. Tissue Int. (US)* **46**(Suppl.), S3-10 (1990)}. In Graft versus Host Reaction, increased serum TNF $\alpha$  levels have been associated with major complication following acute allogenic bone marrow transplants {Holler *et al.*, *Blood*, **75**(4), 1011-1016 (1990)}.

5 Cerebral malaria is a lethal hyperacute neurological syndrome associated with high blood levels of TNF $\alpha$  and the most severe complication occurring in malaria patients. Levels of serum TNF $\alpha$  correlated directly with the severity of disease and the prognosis in patients with acute malaria attacks {Grau *et al.*, *N. Engl. J. Med.* **320**(24), 1586-1591 (1989)}.

10 Macrophage-induced angiogenesis TNF $\alpha$  is known to be mediated by TNF $\alpha$ . Leibovich *et al.* {*Nature*, **329**, 630-632 (1987)} showed TNF $\alpha$  induces *in vivo* capillary blood vessel formation in the rat cornea and the developing chick chorioallantoic membranes at very low doses and suggest TNF $\alpha$  is a candidate for inducing angiogenesis in inflammation, wound repair, and tumor growth. TNF $\alpha$   
15 production also has been associated with cancerous conditions, particularly induced tumors {Ching *et al.*, *Brit. J. Cancer*, (1955) **72**, 339-343, and Koch, *Progress in Medicinal Chemistry*, **22**, 166-242 (1985)}.

TNF $\alpha$  also plays a role in the area of chronic pulmonary inflammatory diseases. The deposition of silica particles leads to silicosis, a disease of progressive respiratory  
20 failure caused by a fibrotic reaction. Antibody to TNF $\alpha$  completely blocked the silica-induced lung fibrosis in mice {Pignet *et al.*, *Nature*, **344**:245-247 (1990)}. High levels of TNF $\alpha$  production (in the serum and in isolated macrophages) have been demonstrated in animal models of silica and asbestos induced fibrosis {Bissonnette *et al.*, *Inflammation* **13**(3), 329-339 (1989)}. Alveolar macrophages  
25 from pulmonary sarcoidosis patients have also been found to spontaneously release massive quantities of TNF $\alpha$  as compared with macrophages from normal donors {Baughman *et al.*, *J. Lab. Clin. Med.* **115**(1), 36-42 (1990)}.

TNF $\alpha$  is also implicated in the inflammatory response which follows reperfusion, called reperfusion injury, and is a major cause of tissue damage after loss of blood  
30 flow {Vedder *et al.*, *PNAS* **87**, 2643-2646 (1990)}. TNF $\alpha$  also alters the properties of endothelial cells and has various pro-coagulant activities, such as producing an

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increase in tissue factor pro-coagulant activity and suppression of the anticoagulant protein C pathway as well as down-regulating the expression of thrombomodulin {Sherry *et al.*, *J. Cell Biol.* **107**, 1269-1277 (1988)}. TNF $\alpha$  has pro-inflammatory activities which together with its early production (during the initial stage of an inflammatory event) make it a likely mediator of tissue injury in several important disorders including but not limited to, myocardial infarction, stroke and circulatory shock. Of specific importance may be TNF $\alpha$ -induced expression of adhesion molecules, such as intercellular adhesion molecule (ICAM) or endothelial leukocyte adhesion molecule (ELAM) on endothelial cells {Munro *et al.*, *Am. J. Path.* **135**(1), 121-132 (1989)}.

TNF $\alpha$  blockage with monoclonal anti-TNF $\alpha$  antibodies has been shown to be beneficial in rheumatoid arthritis {Elliot *et al.*, *Int. J. Pharmac.* 1995 **17**(2), 141-145} and Crohn's disease {von Dullemen *et al.*, *Gastroenterology*, 1995 **109**(1), 129-135}

Moreover, it now is known that TNF $\alpha$  is a potent activator of retrovirus replication including activation of HIV-1. {Duh *et al.*, *Proc. Nat. Acad. Sci.* **86**, 5974-5978 (1989); Poll *et al.*, *Proc. Nat. Acad. Sci.* **87**, 782-785 (1990); Monto *et al.*, *Blood* **79**, 2670 (1990); Clouse *et al.*, *J. Immunol.* **142**, 431-438 (1989); Poll *et al.*, *AIDS Res. Hum. Retrovirus*, 191-197 (1992)}. AIDS results from the infection of T lymphocytes with Human Immunodeficiency Virus (HIV). At least three types or strains of HIV have been identified, *i.e.*, HIV-1, HIV-2 and HIV-3. As a consequence of HIV infection, T-cell mediated immunity is impaired and infected individuals manifest severe opportunistic infections and/or unusual neoplasms. HIV entry into the T lymphocyte requires T lymphocyte activation. Other viruses, such as HIV-1, HIV-2 infect T lymphocytes after T cell activation and such virus protein expression and/or replication is mediated or maintained by such T cell activation. Once an activated T lymphocyte is infected with HIV, the T lymphocyte must continue to be maintained in an activated state to permit HIV gene expression and/or HIV replication. Cytokines, specifically TNF $\alpha$ , are implicated in activated T-cell mediated HIV protein expression and/or virus replication by playing a role in maintaining T lymphocyte activation. Therefore, interference with cytokine activity such as by prevention or inhibition of cytokine production, notably TNF $\alpha$ , in an HIV-infected individual assists in limiting the maintenance of T lymphocyte caused by HIV infection.

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Monocytes, macrophages, and related cells, such as kupffer and glial cells, also have been implicated in maintenance of the HIV infection. These cells, like T cells, are targets for viral replication and the level of viral replication is dependent upon the activation state of the cells. {Rosenberg *et al.*, *The Immunopathogenesis of HIV Infection*, Advances in Immunology, **57** (1989)}. Cytokines, such as TNF $\alpha$ , have been shown to activate HIV replication in monocytes and/or macrophages {Poli *et al.*, *Proc. Natl. Acad. Sci.*, **87**, 782-784 (1990)}, therefore, prevention or inhibition of cytokine production or activity aids in limiting HIV progression for T cells. Additional studies have identified TNF $\alpha$  as a common factor in the activation of HIV *in vitro* and has provided a clear mechanism of action via a nuclear regulatory protein found in the cytoplasm of cells (Osborn, *et al.*, *PNAS* **86** 2336-2340). This evidence suggests that a reduction of TNF $\alpha$  synthesis may have an antiviral effect in HIV infections, by reducing the transcription and thus virus production.

AIDS viral replication of latent HIV in T cell and macrophage lines can be induced by TNF $\alpha$  {Folks *et al.*, *PNAS* **86**, 2365-2368 (1989)}. A molecular mechanism for the virus inducing activity is suggested by TNF $\alpha$ 's ability to activate a gene regulatory protein (NF $\kappa$ B) found in the cytoplasm of cells, which promotes HIV replication through binding to a viral regulatory gene sequence (LTR) {Osborn *et al.*, *PNAS* **86**, 2336-2340 (1989)}. TNF $\alpha$  in AIDS associated cachexia is suggested by elevated serum TNF $\alpha$  and high levels of spontaneous TNF $\alpha$  production in peripheral blood monocytes from patients {Wright *et al.*, *J. Immunol.* **141**(1), 99-104 (1988)}. TNF $\alpha$  has been implicated in various roles with other viral infections, such as the cytomegalia virus (CMV), influenza virus, adenovirus, and the herpes family of viruses for similar reasons as those noted.

The nuclear factor  $\kappa$ B (NF $\kappa$ B) is a pleiotropic transcriptional activator (Lenardo, *et al.*, *Cell* 1989, 58, 227-29). NF $\kappa$ B has been implicated as a transcriptional activator in a variety of disease and inflammatory states and is thought to regulate cytokine levels including but not limited to TNF $\alpha$  and also to be an activator of HIV transcription (Dbaibo, *et al.*, *J. Biol. Chem.* 1993, 17762-66; Duh *et al.*, *Proc. Natl. Acad. Sci.* 1989, 86, 5974-78; Bachelier *et al.*, *Nature* 1991, 350, 709-12; Boswas *et al.*, *J. Acquired Immune Deficiency Syndrome* 1993, 6, 778-786; Suzuki *et al.*, *Biochem. And Biophys. Res. Comm.* 1993, 193, 277-83; Suzuki *et al.*, *Biochem. And Biophys. Res Comm.* 1992, 189, 1709-15; Suzuki *et al.*, *Biochem. Mol. Bio. Int.* 1993, 31(4), 693-

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700; Shakhov *et al.*, *Proc. Natl. Acad. Sci. USA* 1990, 171, 35-47; and Staal *et al.*, *Proc. Natl. Acad. Sci. USA* 1990, 87, 9943-47). Thus, inhibition of NF $\kappa$ B binding can regulate transcription of cytokine gene(s) and through this modulation and other mechanisms be useful in the inhibition of a multitude of disease states. The compounds described herein can inhibit the action of NF $\kappa$ B in the nucleus and thus are useful in the treatment of a variety of diseases including but not limited to rheumatoid arthritis, rheumatoid spondylitis, osteoarthritis, other arthritic conditions, septic shock, sepsis, endotoxic shock, graft versus host disease, wasting, Crohn's disease, ulcerative colitis, multiple sclerosis, systemic lupus erythematosus, ENL in leprosy, HIV, AIDS, and opportunistic infections in AIDS. TNF $\alpha$  and NF $\kappa$ B levels are influenced by a reciprocal feedback loop. As noted above, the compounds of the present invention affect the levels of both TNF $\alpha$  and NF $\kappa$ B.

Many cellular functions are mediated by levels of adenosine 3',5'-cyclic monophosphate (cAMP). Such cellular functions can contribute to inflammatory conditions and diseases including asthma, inflammation, and other conditions (Lowe and Cheng, *Drugs of the Future*, 17(9), 799-807, 1992). It has been shown that the elevation of cAMP in inflammatory leukocytes inhibits their activation and the subsequent release of inflammatory mediators, including TNF $\alpha$  and NF $\kappa$ B. Increased levels of cAMP also leads to the relaxation of airway smooth muscle.

Decreasing TNF $\alpha$  levels and/or increasing cAMP levels thus constitutes a valuable therapeutic strategy for the treatment of many inflammatory, infectious, immunological, and malignant diseases. These include but are not restricted to 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, opportunistic infections in AIDS, rheumatoid arthritis, rheumatoid spondylitis, osteoarthritis, other arthritic conditions, Crohn's disease, ulcerative colitis, multiple sclerosis, systemic lupus erythematosus, ENL in leprosy, radiation damage, oncogenic conditions, and hyperoxic alveolar injury. Prior efforts directed to the suppression of the effects of TNF $\alpha$  have ranged from the utilization of steroids such as dexamethasone and prednisolone to the use of both polyclonal and monoclonal antibodies {Beutler *et al.*, *Science* 234, 470-474 (1985); WO 92/11383}.

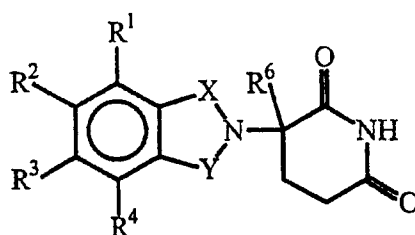
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*Detailed Description*

The present invention is based on the discovery that certain classes of non-polypeptide compounds more fully described herein decrease the levels of TNF $\alpha$ .

In particular, the invention pertains to (i) compounds of the formula:



I.

in which:

one of X and Y is C=O and the other of X and Y is C=O or CH<sub>2</sub>;

(i) each of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup>, independently of the others, is halo, alkyl of 1 to 4 carbon atoms, or alkoxy of 1 to 4 carbon atoms or (ii) one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NHR<sup>5</sup> and the remaining of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> are hydrogen;

R<sup>5</sup> is hydrogen or alkyl of 1 to 8 carbon atoms;

R<sup>6</sup> is hydrogen, alkyl of 1 to 8 carbon atoms, benzyl, or halo;

provided that R<sup>6</sup> is other than hydrogen if X and Y are C=O and (i) each of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is fluoro or (ii) one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, or R<sup>4</sup> is amino; and

(b) the acid addition salts of said compounds which contain a nitrogen atom capable of being protonated.

A preferred group of compounds are those of Formula I in which each of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup>, independently of the others, is halo, alkyl of 1 to 4 carbon atoms, or alkoxy of 1 to 4 carbon atoms, and R<sup>6</sup> is hydrogen, methyl, ethyl, or propyl. A second preferred group of compounds are those of Formula I in which one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NH<sub>2</sub>, the remaining of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> are hydrogen, and R<sup>6</sup> is hydrogen, methyl, ethyl, or propyl.



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Unless otherwise defined, the term alkyl denotes a univalent saturated branched or straight hydrocarbon chain containing from 1 to 8 carbon atoms. Representative of such alkyl groups are methyl, ethyl, propyl, isopropyl, butyl, isobutyl, sec-butyl, and tert-butyl. Alkoxy refers to an alkyl group bound to the remainder of the molecule through an ethereal oxygen atom. Representative of such alkoxy groups are methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy, sec-butoxy, and tert-butoxy. Preferably  $R^1$ ,  $R^2$ ,  $R^3$ , and  $R^4$  are chloro, fluoro, methyl or methoxy.

The compounds of Formula I are used, under the supervision of qualified professionals, to inhibit the undesirable effects of  $TNF\alpha$ . The compounds can be administered orally, rectally, or parenterally, alone or in combination with other therapeutic agents including antibiotics, steroids, etc., to a mammal in need of treatment.

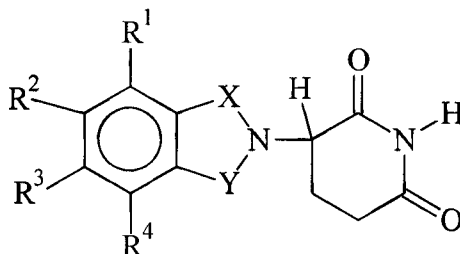
The compounds of the present invention also can be used topically in the treatment or prophylaxis of topical disease states mediated or exacerbated by excessive  $TNF\alpha$  production, respectively, such as viral infections, such as those caused by the herpes viruses, or viral conjunctivitis, psoriasis, atopic dermatitis, etc.

The compounds also can be used in the veterinary treatment of mammals other than humans in need of prevention or inhibition of  $TNF\alpha$  production.  $TNF\alpha$  mediated diseases for treatment, therapeutically or prophylactically, in animals include disease states such as those noted above, but in particular viral infections. Examples include feline immunodeficiency virus, equine infectious anaemia virus, caprine arthritis virus, visna virus, and maedi virus, as well as other lentiviruses.

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Thus, in one aspect, the invention provides a compound of the following formula:



or a pharmaceutically acceptable salt thereof, in which:

one of X and Y is C=O and the other of X and Y is CH<sub>2</sub>;

one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NHR<sup>5</sup> and the remaining of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> are hydrogen; and

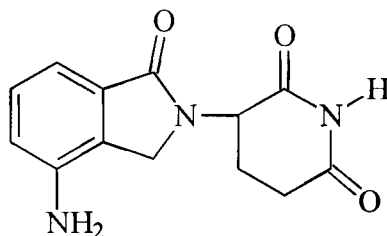
R<sup>5</sup> is hydrogen or alkyl of 1 to 8 carbon atoms. In related aspects, the invention provides: a pharmaceutical composition comprising a compound of this formula or a pharmaceutically acceptable salt thereof, and a pharmaceutically carrier, diluent or excipient; use of a compound of this formula for reducing levels of TNF $\alpha$ , inhibiting angiogenesis, treating an inflammatory disease, treating an autoimmune disease, or treating a cancerous condition in a mammal, and in the preparation of medicaments therefor; a compound of this formula for use for reducing levels of TNF $\alpha$ , inhibiting angiogenesis, treating an inflammatory disease, treating an autoimmune disease, or treating a cancerous condition in a mammal; and a commercial package comprising a compound of this formula, together with instructions for use for reducing levels of TNF $\alpha$ , inhibiting angiogenesis, treating an inflammatory disease, treating an autoimmune disease, or treating a cancerous condition in a mammal.

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In another aspect, the invention provides use of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having the following structure:

5



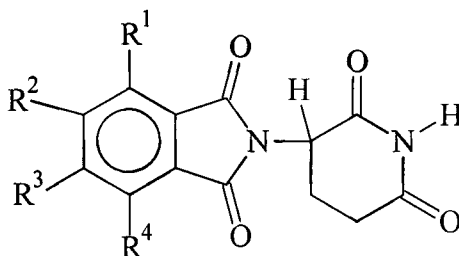
for treating a cancerous condition in a human, and in the preparation of a medicament therefor.

10

In another aspect, the invention provides a pharmaceutical composition comprising:

a compound of the following formula:

15



or a pharmaceutically acceptable salt thereof, in which:

one of  $R^1$ ,  $R^2$ ,  $R^3$ , and  $R^4$  is  $-NHR^5$  and the remaining of  $R^1$ ,  $R^2$ ,  $R^3$  and  $R^4$  are hydrogen; and

20

$R^5$  is hydrogen or alkyl of 1 to 8 carbon atoms; and

a pharmaceutically acceptable carrier, diluent or excipient, wherein said composition is formulated for inhibiting angiogenesis in a mammal.

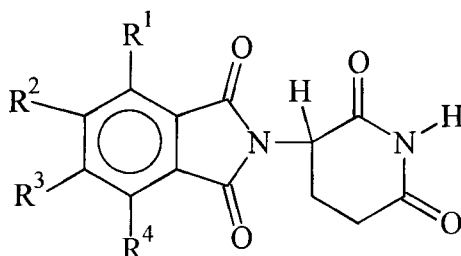
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In another aspect, the invention provides a pharmaceutical composition comprising:

a compound of the following formula:

5



or a pharmaceutically acceptable salt thereof, in which:

one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NHR<sup>5</sup> and the remaining  
 10 of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> are hydrogen; and

R<sup>5</sup> is hydrogen or alkyl of 1 to 8 carbon atoms; and

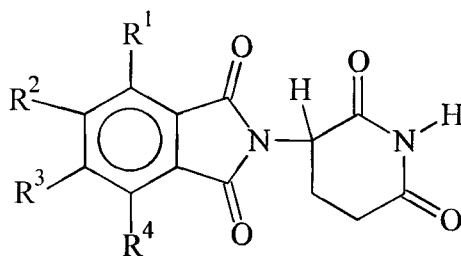
a pharmaceutically acceptable carrier, diluent or excipient,  
 wherein said composition is formulated for treating an  
 inflammatory condition in a mammal.

15

In another aspect, the invention provides a pharmaceutical composition comprising:

a compound of the following formula:

20



or a pharmaceutically acceptable salt thereof, in which:

one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NHR<sup>5</sup> and the remaining  
 of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> are hydrogen; and

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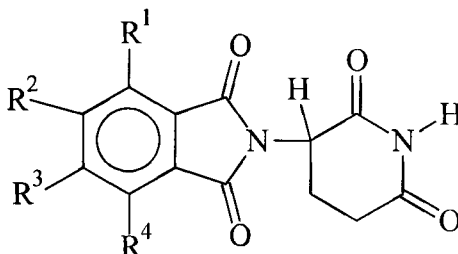
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$R^5$  is hydrogen or alkyl of 1 to 8 carbon atoms; and  
 a pharmaceutically acceptable carrier, diluent or excipient,  
 wherein said composition is formulated for treating a  
 cancerous condition in a mammal.

5 In another aspect, the invention provides a  
 pharmaceutical composition comprising:

a compound of the following formula:

10



or a pharmaceutically acceptable salt thereof, in which:

one of  $R^1$ ,  $R^2$ ,  $R^3$ , and  $R^4$  is  $-NHR^5$  and the remaining  
 of  $R^1$ ,  $R^2$ ,  $R^3$  and  $R^4$  are hydrogen; and

15  $R^5$  is hydrogen or alkyl of 1 to 8 carbon atoms; and

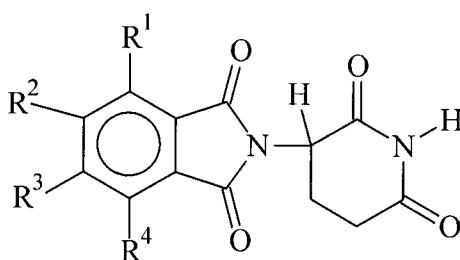
a pharmaceutically acceptable carrier, diluent or excipient,  
 wherein said composition is formulated for reducing levels  
 of  $TNF\alpha$  in a mammal that has a condition or disease  
 associated with elevated  $TNF\alpha$  levels, wherein said condition  
 20 or disease is adult respiratory distress syndrome, asthma,  
 cachexia, a chronic pulmonary inflammatory disease,  
 congestive heart failure, Crohn's disease, endotoxic shock,  
 ENL in leprosy, fibrotic disease, hemodynamic shock,  
 hyperoxic alveolar injury, inflammation, malaria,  
 25 meningitis, multiple sclerosis, mycobacterial infection, an  
 oncogenic or cancerous condition, opportunistic infection in  
 AIDS, osteoarthritis, post ischemic reperfusion injury,

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psoriasis, radiation damage, rheumatoid arthritis, rheumatoid spondylitis, septic shock, sepsis, sepsis syndrome, systemic lupus erythrematosis, or ulcerative colitis.

5 In another aspect, the invention provides use of a compound of the following formula:



10

or a pharmaceutically acceptable salt thereof, in which:

one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NHR<sup>5</sup> and the remaining of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> are hydrogen; and

R<sup>5</sup> is hydrogen or alkyl of 1 to 8 carbon atoms;

15 for inhibiting angiogenesis, treating an inflammatory condition, or treating a cancerous condition, and in the preparation of medicaments therefor. The invention further provide the use of such compounds for reducing levels of TNF $\alpha$  in a mammal that has a condition or disease associated  
 20 with elevated TNF $\alpha$  levels, wherein said condition or disease is adult respiratory distress syndrome, asthma, cachexia, a chronic pulmonary inflammatory disease, congestive heart failure, Crohn's disease, endotoxic shock, ENL in leprosy, fibrotic disease, hemodynamic shock, hyperoxic alveolar  
 25 injury, inflammation, malaria, meningitis, multiple sclerosis, mycobacterial infection, an oncogenic or cancerous condition, opportunistic infection in AIDS, osteoarthritis, post ischemic reperfusion injury, psoriasis, radiation damage, rheumatoid arthritis, rheumatoid

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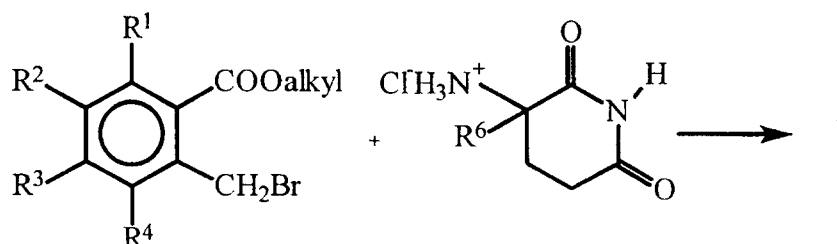
spondylitis, septic shock, sepsis, sepsis syndrome, systemic lupus erythrematosis, or ulcerative colitis, and in the preparation of medicaments therefor.

5           Compounds in which one of  $R^1$ ,  $R^2$ ,  $R^3$ ,  $R^4$  is amino and  $R^5$  and  $R^6$ , as well as the remainder of  $R^1$ ,  $R^2$ ,  $R^3$ ,  $R^4$ , are hydrogen, as for example, 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline or 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline are known. See, e.g., Jönsson, *Acta Pharma. Succica*, **9**, 521-542 (1972).

10           The compounds can be prepared using methods which are known in general. In particular, the compounds can be prepared through the reaction of 2,6-dioxopiperidin-3-ammonium chloride, and a lower alkyl ester of 2-bromomethylben-

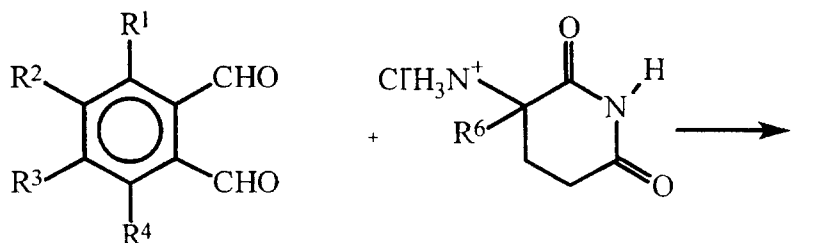
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zoic acid in the presence of an acid acceptor such as dimethylaminopyridine or triethylamine.



The substituted benzoate intermediates are known or can be obtained through conventional processes. For example, a lower alkyl ester of an *ortho*-toluic acid is brominated with N-bromosuccinimide under the influence of light to yield the lower alkyl 2-bromomethylbenzoate.

Alternatively, a dialdehyde is allowed to react with 2,6-dioxopiperidin-3-ammonium chloride:

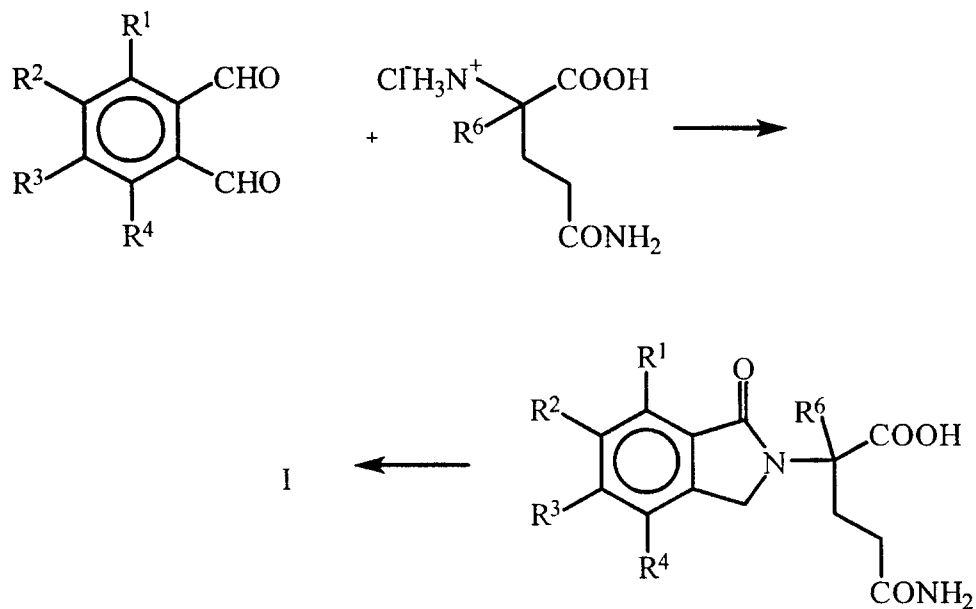


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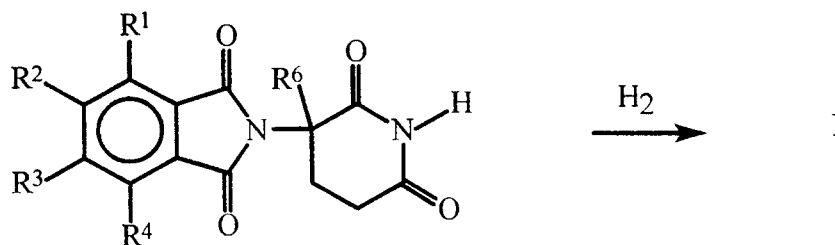
In a further method, a dialdehyde is allowed to react with glutamine and the resulting 2-(1-oxoisindolin-2-yl)glutaric acid then cyclized to yield a 1-oxo-2-(2,6-dioxopiperidin-3-yl)-isindoline of Formula I:



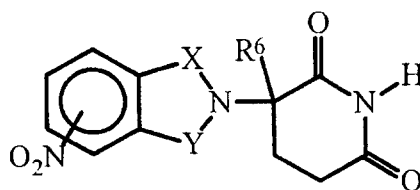
- 9 -



Finally, an appropriately substituted phthalidimide intermediate is selectively reduced:



- 5 Amino compounds can be prepared through catalytic hydrogenation of the corresponding nitro compound:



IA

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The nitro intermediates of Formula IA are known or can be obtained through conventional processes. For example, a nitrophthalic anhydride is allowed to react with  $\alpha$ -aminoglutarimide hydrochloride {alternatively named as 2,6-dioxopiperidin-3-ylammonium chloride} in the presence of sodium acetate and glacial acetic acid to  
5 yield an intermediate of Formula IA in which X and Y are both C=O.

In a second route, a lower alkyl ester of nitro-*ortho*-toluic acid is brominated with N-bromosuccinimide under the influence of light to yield a lower alkyl 2-(bromomethyl)nitrobenzoate. This is allowed to react with 2,6-dioxopiperidin-3-ylammonium chloride in, for example, dimethylformamide in the presence of triethylamine to yield an intermediate of Formula II in which one of X is C=O and the other is CH<sub>2</sub>.  
10

Alternatively, if one of R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, and R<sub>4</sub> is protected amino, the protecting group can be cleaved to yield the corresponding compound in which one of R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, and R<sub>4</sub> is amino. Protecting groups utilized herein denote groups which generally  
15 are not found in the final therapeutic compounds but which are intentionally introduced at some stage of the synthesis in order to protect groups which otherwise might be altered in the course of chemical manipulations. Such protecting groups are removed at a later stage of the synthesis and compounds bearing such protecting groups thus are of importance primarily as chemical intermediates (although some  
20 derivatives also exhibit biological activity). Accordingly the precise structure of the protecting group is not critical. Numerous reactions for the formation and removal of such protecting groups are described in a number of standard works including, for example, "Protective Groups in Organic Chemistry", Plenum Press, London and New York, 1973; Greene, Th. W. "Protective Groups in Organic Synthesis", Wiley, New  
25 York, 1981; "The Peptides", Vol. I, Schröder and Lubke, Academic Press, London and New York, 1965; "Methoden der organischen Chemie", Houben-Weyl, 4th Edition, Vol.15/I, Georg Thieme Verlag, Stuttgart 1974.

An amino group can be protected as an amide utilizing an acyl group which is selectively removable under mild conditions, especially benzyloxycarbonyl, formyl, or a lower alkanoyl group which is branched in 1-  
30 or  $\alpha$  position to the carbonyl group, particularly tertiary alkanoyl such as pivaloyl, a lower alkanoyl group which is substituted in the position  $\alpha$  to the carbonyl group, as for example trifluoroacetyl.

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The compounds of the present invention possess a center of chirality and can exist as optical isomers. Both the racemates of these isomers and the individual isomers themselves, as well as diastereomers when there are two chiral centers, are within the scope of the present invention. The racemates can be used as such or can be separated  
5 into their individual isomers mechanically as by chromatography using a chiral adsorbent. Alternatively, the individual isomers can be prepared in chiral form or separated chemically from a mixture by forming salts with a chiral acid, such as the individual enantiomers of 10-camphorsulfonic acid, camphoric acid,  $\alpha$ -bromocamphoric acid, methoxyacetic acid, tartaric acid, diacetyltartaric acid, malic acid,  
10 pyrrolidone-5-carboxylic acid, and the like, and then freeing one or both of the resolved bases, optionally repeating the process, so as obtain either or both substantially free of the other; *i.e.*, in a form having an optical purity of >95%.

The present invention also pertains to the physiologically acceptable non-toxic acid addition salts of the compounds of Formula I. Such salts include those derived from  
15 organic and inorganic acids such as, without limitation, hydrochloric acid, hydrobromic acid, phosphoric acid, sulfuric acid, methanesulphonic acid, acetic acid, tartaric acid, lactic acid, succinic acid, citric acid, malic acid, maleic acid, sorbic acid, aconitic acid, salicylic acid, phthalic acid, embonic acid, enanthic acid, and the like.

Oral dosage forms include tablets, capsules, dragees, and similar shaped, compressed pharmaceutical forms containing from 1 to 100 mg of drug per unit dosage.  
20 Isotonic saline solutions containing from 20 to 100 mg/mL can be used for parenteral administration which includes intramuscular, intrathecal, intravenous and intra-arterial routes of administration. Rectal administration can be effected through the use of suppositories formulated from conventional carriers such as cocoa butter.

Pharmaceutical compositions thus comprise one or more compounds of the present invention associated with at least one pharmaceutically acceptable carrier, diluent or excipient. In preparing such compositions, the active ingredients are usually mixed with or diluted by an excipient or enclosed within such a carrier which can be in the form of a capsule or sachet. When the excipient serves as a diluent, it may be a solid,  
25 semi-solid, or liquid material which acts as a vehicle, carrier, or medium for the active ingredient. Thus, the compositions can be in the form of tablets, pills, powders, elixirs, suspensions, emulsions, solutions, syrups, soft and hard gelatin capsules,  
30

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suppositories, sterile injectable solutions and sterile packaged powders. Examples of suitable excipients include lactose, dextrose, sucrose, sorbitol, mannitol, starch, gum acacia, calcium silicate, microcrystalline cellulose, polyvinylpyrrolidone, cellulose, water, syrup, and methyl cellulose, the formulations can additionally include lubricating agents such as talc, magnesium stearate and mineral oil, wetting agents, emulsifying and suspending agents, preserving agents such as methyl- and propylhydroxybenzoates, sweetening agents or flavoring agents.

The compositions preferably are formulated in unit dosage form, meaning physically discrete units suitable as a unitary dosage, or a predetermined fraction of a unitary dose to be administered in a single or multiple dosage regimen to human subjects and other mammals, each unit containing a predetermined quantity of active material calculated to produce the desired therapeutic effect in association with a suitable pharmaceutical excipient. The compositions can be formulated so as to provide an immediate, sustained or delayed release of active ingredient after administration to the patient by employing procedures well known in the art.

Oral dosage forms include tablets, capsules, dragees, and similar shaped, compressed pharmaceutical forms containing from 1 to 100 mg of drug per unit dosage. Isotonic saline solutions containing from 20 to 100 mg/mL can be used for parenteral administration which includes intramuscular, intrathecal, intravenous and intra-arterial routes of administration. Rectal administration can be effected through the use of suppositories formulated from conventional carriers such as cocoa butter.

Pharmaceutical compositions thus comprise one or more compounds of the present invention associated with at least one pharmaceutically acceptable carrier, diluent or excipient. In preparing such compositions, the active ingredients are usually mixed with or diluted by an excipient or enclosed within such a carrier which can be in the form of a capsule or sachet. When the excipient serves as a diluent, it may be a solid, semi-solid, or liquid material which acts as a vehicle, carrier, or medium for the active ingredient. Thus, the compositions can be in the form of tablets, pills, powders, elixirs, suspensions, emulsions, solutions, syrups, soft and hard gelatin capsules, suppositories, sterile injectable solutions and sterile packaged powders. Examples of suitable excipients include lactose, dextrose, sucrose, sorbitol, mannitol, starch, gum acacia, calcium silicate, microcrystalline cellulose, polyvinylpyrrolidone, cellulose,

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water, syrup, and methyl cellulose, the formulations can additionally include lubricating agents such as talc, magnesium stearate and mineral oil, wetting agents, emulsifying and suspending agents, preserving agents such as methyl- and propylhydroxybenzoates, sweetening agents or flavoring agents.

5       The compositions preferably are formulated in unit dosage form, meaning physically discrete units suitable as a unitary dosage, or a predetermined fraction of a unitary dose to be administered in a single or multiple dosage regimen to human subjects and other mammals, each unit containing a predetermined quantity of active material calculated to produce the desired therapeutic effect in association with a  
10       suitable pharmaceutical excipient.

The compositions can be formulated so as to provide an immediate, sustained or delayed release of active ingredient after administration to the patient by employing procedures well known in the art.

15       The following examples will serve to further typify the nature of this invention but should not be construed as a limitation in the scope thereof, which scope is defined solely by the appended claims.

### EXAMPLE 1

#### 1,3-Dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline

A mixture of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-nitroisoindoline {alternatively named as N-(2,6-dioxopiperidin-3-yl)-4-nitrophthalimide} (1 g, 3.3 mmol) and  
20       10% Pd/C (0.13 g) in 1,4-dioxane (200 mL) was hydrogenated at 50 psi for 6.5 hours. The catalyst was filtered through Celite™ and the filtrate concentrated *in vacuo*. The residue was crystallized from ethyl acetate (20 mL) to give 0.62 g (69%) of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline {alternatively named as N-(2,6-dioxopiperidin-3-yl)-4-aminophthalimide} as an orange solid. Recrystallization from  
25       dioxane/ethyl acetate gave 0.32 g of yellow solid: mp 318.5-320.5°C; HPLC (nova Pak C18, 15/85 acetonitrile/0.1% H<sub>3</sub>PO<sub>4</sub>) 3.97 min (98.22%); <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 11.08(s, 1H), 7.53-7.50 (d, J=8.3 Hz, 1H), 6.94(s, 1H), 6.84-6.81(d, J=8.3 Hz, 1H), 6.55(s, 2H), 5.05-4.98(m, 1H), 2.87-1.99(m, 4H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ  
30       172.79, 170.16, 167.65, 167.14, 155.23, 134.21, 125.22, 116.92, 116.17, 107.05,

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48.58, 30.97, 22.22; Anal. Calcd for  $C_{13}H_{11}N_3O_4$ : C, 57.14; H, 4.06; N, 15.38. Found: C, 56.52; H, 4.17; N, 14.60.

In a similar fashion from 1-oxo-2-(2,6-dioxopiperidin-3-yl)-5-nitroisindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-nitroisindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-nitroisindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-7-nitroisindoline, and 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-4-nitroisindoline, there is respectively obtained 1-oxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisindoline, and 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisindoline, respectively, upon hydrogenation.

## EXAMPLE 2

### 1,3-Dioxo-2-(2,6-dioxopiperidin-3-yl)-5-nitroisindoline

A mixture of 4-nitrophthalic anhydride (1.7 g, 8.5 mmol),  $\alpha$ -aminoglutarimide hydrochloride (1.4 g, 8.5 mmol) and sodium acetate (0.7 g, 8.6 mmol) in glacial acetic acid (30 mL) was heated under reflux for 17 hours. The mixture was concentrated *in vacuo* and the residue was stirred with methylene chloride (40 mL) and water (30 mL). The aqueous layer was separated, extracted with methylene chloride (2x40 mL). The combined methylene chloride solutions were dried over magnesium sulfate and concentrated *in vacuo* to give 1.4 g (54%) of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-nitroisindoline as a light brown solid. An analytical sample was obtained by recrystallization from methanol: mp 228.5-229.5°C;  $^1H$  NMR (DMSO- $d_6$ )  $\delta$  11.18(s, 1H), 8.69-8.65(d,d J=1.9 and 8.0 Hz, 1H), 8.56(d, J=1.9 Hz, 1H), 8.21(d, H=8.2 Hz, 1H), 5.28(d,d J=5.3 and 12.8 Hz, 1H), 2.93-2.07(m, 4H);  $^{13}C$  NMR (DMSO- $d_6$ )  $\delta$  172.66, 169.47, 165.50, 165.23, 151.69, 135.70, 132.50, 130.05, 124.97, 118.34, 49.46, 30.85, 21.79; Anal. Calcd for  $C_{13}H_9N_3O_6$ : C, 51.49; H, 2.99; N, 13.86. Found: C, 51.59; H, 3.07; N, 13.73.

1-Oxo-2-(2,6-dioxopiperidin-3-yl)-5-nitroisindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-nitroisindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-nitroisindoline, and 1-oxo-2-(2,6-dioxopiperidin-3-yl)-7-nitroisindoline can be obtained by allowing 2,6-dioxopiperidin-3-ammonium chloride to react with methyl 2-bromomethyl-5-nitrobenzoate, methyl 2-bromomethyl-4-nitrobenzoate, methyl 2-bromomethyl-6-

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nitrobenzoate, and methyl 2-bromomethyl-7-nitrobenzoate, respectively, in dimethylformamide in the presence of triethylamine. The methyl 2-(bromomethyl)nitrobenzoates in turn are obtained from the corresponding methyl esters of nitro-*ortho*-toluic acids by conventional bromination with N-bromosuccinimide under the influence of light.

### EXAMPLE 3

#### 1-Oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline

A mixture of 16.25 g of 2,6-dioxopiperidin-3-ammonium chloride, and 30.1 g of methyl 2-bromomethyl-3,4,5,6-tetrafluorobenzoate, and 12.5 g of triethylamine in 100 mL of dimethylformamide is stirred at room temperature for 15 hours. The mixture is then concentrated *in vacuo* and the residue mixed with methylene chloride and water. The aqueous layer is separated and back-extracted with methylene chloride. The combined methylene chloride solutions are dried over magnesium sulfate and concentrated *in vacuo* to give 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline.

In a similar fashion 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetrachloroisoindoline, 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetramethylisoindoline, and 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetramethoxyisoindoline are obtained by substituting equivalent amounts of 2-bromomethyl-3,4,5,6-tetrachlorobenzoate, 2-bromomethyl-3,4,5,6-tetramethylbenzoate, and 2-bromomethyl-3,4,5,6-tetramethoxybenzoate, respectively, for 2-bromomethyl-3,4,5,6-tetrafluorobenzoate.

### EXAMPLE 4

#### N-Benzylloxycarbonyl- $\alpha$ -methyl-glutamic Acid

To a stirred solution of  $\alpha$ -methyl-D,L-glutamic acid (10 g, 62 mmol) in 2 N sodium hydroxide (62 mL) at 0-5°C was added benzyl chloroformate (12.7 g, 74.4 mmol) over 30 min. After the addition was complete the reaction mixture was stirred at room temperature for 3 hours. During this time the pH was maintained at 11 by addition of 2N sodium hydroxide (33 mL). The reaction mixture was then extracted with ether (60 mL). The aqueous layer was cooled in an ice bath and then acidified with 4N hydrochloric acid (34 mL) to pH=1. The resulting mixture was extracted

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with ethyl acetate (3 x 100 mL). The combined ethyl acetate extracts were washed with brine (60 mL) and dried (MgSO<sub>4</sub>). The solvent was removed in vacuo to give 15.2 g (83%) of N-benzyloxycarbonyl- $\alpha$ -methylglutamic acid as an oil: <sup>1</sup>H NMR (CDCl<sub>3</sub>)  $\delta$  8.73(m, 5H), 5.77(b, 1H), 5.09(s, 2H), 2.45-2.27(m, 4H), 2.0(s, 3H).

- 5 In a similar fashion from  $\alpha$ -ethyl-D,L-glutamic acid and  $\alpha$ -propyl-D,L-glutamic acid, there is obtained N-benzyloxycarbonyl- $\alpha$ -ethylglutamic acid and N-benzyloxycarbonyl- $\alpha$ -propylglutamic acid, respectively.

#### EXAMPLE 5

##### N-Benzyloxycarbonyl- $\alpha$ -methyl-glutamic Anhydride

- 10 A stirred mixture of N-benzyloxycarbonyl- $\alpha$ -methyl-glutamic acid (15 g, 51 mmol) and acetic anhydride (65 mL) was heated at reflux under nitrogen for 30 min. The reaction mixture was cooled to room temperature and then concentrated in vacuo to afford N-benzylcarbonyl- $\alpha$ -methylglutamic anhydride as an oil (15.7 g) which can be used in next reaction without further purification: <sup>1</sup>H NMR (CDCl<sub>3</sub>)  $\delta$  7.44-7.26  
15 (m, 5H), 5.32-5.30 (m, 2H), 5.11 (s, 1H), 2.69-2.61 (m, 2H), 2.40-2.30 (m, 2H), 1.68 (s, 3H).

In a similar fashion from N-benzyloxycarbonyl- $\alpha$ -ethylglutamic acid and N-benzyloxycarbonyl- $\alpha$ -propylglutamic acid, there is obtained N-benzylcarbonyl- $\alpha$ -ethylglutamic anhydride and N-benzylcarbonyl- $\alpha$ -propylglutamic anhydride, respectively.

20

#### EXAMPLE 6

##### N-Benzyloxycarbonyl- $\alpha$ -methyloisoglutamine

- A stirred solution of N-benzylcarbonyl- $\alpha$ -methylglutamic anhydride (14.2 g, 51.5 mmol) in methylene chloride (100 mL) was cooled in an ice bath. Gaseous ammonia was bubbled into the cooled solution for 2 hours. The reaction mixture was stirred at  
25 room temperature for 17 hours and then extracted with water (2 x 50 mL). The combined aqueous extracts were cooled in an ice bath and acidified with 4N hydrochloric acid (32 mL) to pH 1. The resulting mixture was extracted with ethyl acetate (3 x 80 mL). The combined ethyl acetate extracts were washed with brine (60 mL) and then dried (MgSO<sub>4</sub>). The solvent was removed in vacuo to give 11.5 g of N-  
30 benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -methyloisoglutamine: <sup>1</sup>H NMR (CDCl<sub>3</sub>/DMSO)  $\delta$  7.35 (m, 5H), 7.01 (s, 1H), 6.87 (s, 1H), 6.29 (s, 1H), 5.04 (s, 2H), 2.24-1.88 (m, 4H), 1.53 (s, 3H).



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In a similar fashion from N-benzylcarbonyl- $\alpha$ -ethylglutamic anhydride and N-benzylcarbonyl- $\alpha$ -propylglutamic anhydride there is obtained N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -ethylisoglutamine and N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -propylisoglutamine, respectively.

5

**EXAMPLE 7****N-Benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -methylglutarimide**

A stirred mixture of N-benzyloxycarbonyl- $\alpha$ -methylisoglutamine (4.60 g, 15.6 mmol), 1,1'-carbonyldiimidazole (2.80 g, 17.1 mmol), and 4-dimethylaminopyridine (0.05 g) in tetrahydrofuran (50 mL) was heated to reflux under nitrogen for 17 hours.

10 The reaction mixture was then concentrated in vacuo to an oil. The oil was slurried in water (50 mL) for 1 hour. The resulting suspension was filtered and the solid washed with water and air dried to afford 3.8 g of the crude product as a white solid. The crude product was purified by flash chromatography (methylene chloride:ethyl acetate 8:2) to afford 2.3 g (50%) of N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -methylglutarimide as a

15 white solid: mp 150.5-152.5°C;  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  8.21 (s, 1H), 7.34 (s, 5H), 5.59 (s, 1H), 5.08 (s, 2H), 2.74-2.57 (m, 3H), 2.28-2.25 (m, 1H), 1.54 (s, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  174.06, 171.56, 154.68, 135.88, 128.06, 127.69, 127.65, 66.15, 54.79, 29.14, 28.70, 21.98; HPLC : Waters Nova-Pak C18 column, 4 micron, 3.9x150 mm, 1mL/min, 240nm, 20/80  $\text{CH}_3\text{CN}/0.1\%$   $\text{H}_3\text{PO}_4(\text{aq})$ , 7.56 min (100%); Anal. Calcd For  $\text{C}_{14}\text{H}_{16}\text{N}_2\text{O}_4$ ; C, 60.86; H, 5.84; N, 10.14. Found: C, 60.88; H, 5.72; N, 10.07.

20

In a similar fashion from N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -ethylisoglutamine and N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -propylisoglutamine there is obtained N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -ethylglutarimide and N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -propylglutarimide, respectively.

25

**EXAMPLE 8** **$\alpha$ -Amino- $\alpha$ -methylglutarimide hydrochloride**

N-Benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -methylglutarimide (2.3 g, 8.3 mmol) was dissolved in ethanol (200 mL) with gentle heat and the resulting solution allowed to cool to room temperature. To this solution was added 4N hydrochloric acid (3 mL)

30 followed by 10% Pd/C (0.4 g). The mixture was hydrogenated in a Parr apparatus under 50 psi of hydrogen for 3 hours. To the mixture was added water (50 mL) to dissolve the product. This mixture was filtered through a Celite pad which was

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washed with water (50 mL). The filtrate was concentrated in vacuo to afford a solid residue. The solid was slurried in ethanol (20 mL) for 30 min. The slurry was filtered to afford 1.38 g (93%) of  $\alpha$ -amino- $\alpha$ -methylglutarimide hydrochloride as a white solid:  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  11.25 (s, 1H), 8.92 (s, 3H), 2.84-2.51 (m, 2H), 2.35-2.09 (m, 2H), 1.53 (s, 3H); HPLC, Waters Nova-Pak<sup>TM</sup> C<sub>18</sub> column, 4 micron, 1 mL/min, 240 nm, 20/80 CH<sub>3</sub>CN/ 0.1% H<sub>3</sub>PO<sub>4</sub>(aq), 1.03 min (94.6%).

In a similar fashion from N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -ethylglutarimide and N-benzyloxycarbonyl- $\alpha$ -amino- $\alpha$ -propylglutarimide there is obtained  $\alpha$ -amino- $\alpha$ -ethylglutarimide hydrochloride and  $\alpha$ -amino- $\alpha$ -propylglutarimide hydrochloride, respectively.

### EXAMPLE 9

#### 3-(3-Nitrophthalimido)-3-methylpiperidine-2,6-dione

A stirred mixture of  $\alpha$ -amino- $\alpha$ -methylglutarimide hydrochloride (1.2 g, 6.7 mmol), 3-nitrophthalic anhydride (1.3 g, 6.7 mmol), and sodium acetate (0.6 g, 7.4 mmol) in acetic acid (30 mL) was heated to reflux under nitrogen for 6 hours. The mixture then was cooled and concentrated in vacuo. The resulting solid was slurried in water (30 mL) and methylene chloride (30 mL) for 30 min. The suspension was filtered, the solid was washed with methylene chloride, and dried in vacuo (60°C, <1 mm) to afford 1.44 g (68%) of 3-(3-nitrophthalimido)-3-methylpiperidine-2,6-dione as a off-white solid : mp 265-266.5°C;  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  11.05 (s, 1H), 8.31 (dd,  $J=1.1$  and 7.9 Hz, 1H), 8.16-8.03 (m, 2H), 2.67-2.49 (m, 3H), 2.08-2.02 (m, 1H), 1.88 (s, 3H);  $^{13}\text{C}$  NMR (DMSO- $d_6$ )  $\delta$  172.20, 171.71, 165.89, 163.30, 144.19, 136.43, 133.04, 128.49, 126.77, 122.25, 59.22, 28.87, 28.49, 21.04; HPLC, Water Nova-Pak<sup>TM</sup> C<sub>18</sub> column, 4 micron, 1 mL/min, 240nm, 20/80 CH<sub>3</sub>CN/0.1% H<sub>3</sub>PO<sub>4</sub>(aq), 7.38 min(98%). Anal. Calcd For C<sub>14</sub>H<sub>11</sub>N<sub>3</sub>O<sub>6</sub> : C, 53.00; H, 3.49; N, 13.24. Found : C, 52.77; H, 3.29; N, 13.00.

In a similar fashion from  $\alpha$ -amino- $\alpha$ -ethylglutarimide hydrochloride and  $\alpha$ -amino- $\alpha$ -propylglutarimide hydrochloride there is obtained 3-(3-nitrophthalimido)-3-ethylpiperidine-2,6-dione and 3-(3-nitrophthalimido)-3-propylpiperidine-2,6-dione, respectively.

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**EXAMPLE 10****3-(3-Aminophthalimido)-3-methylpiperidine-2,6-dione**

3-(3-Nitrophthalimido)-3-methylpiperidine-2,6-dione (0.5 g, 1.57 mmol) was dissolved in acetone (250 mL) with gentle heat and then cooled to room temperature. To this solution was added 10% Pd/C (0.1 g) under nitrogen. The mixture was hydrogenated in a Parr apparatus at 50 psi of hydrogen for 4 hours. The mixture then was filtered through Celite and the pad washed with acetone (50 mL). The filtrate was concentrated in vacuo to yield a yellow solid. The solid was slurried in ethyl acetate (10 mL) for 30 minutes. The slurry then was filtered and dried (60°C, <1 mm) to afford 0.37 g (82%) of 3-(3-aminophthalimido)-3-methylpiperidine-2,6-dione as a yellow solid: mp 268-269°C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 10.98 (s, 1H), 7.44 (dd, J=7.1 and 7.3 Hz, 1H), 6.99 (d, J=8.4 Hz, 1H), 6.94 (d, J=6.9 Hz, 1H), 6.52 (s, 2H), 2.71-2.47 (m, 3H), 2.08-1.99 (m, 1H), 1.87 (s, 3H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 172.48, 172.18, 169.51, 168.06, 146.55, 135.38, 131.80, 121.51, 110.56, 108.30, 58.29, 29.25, 28.63, 21.00; HPLC, Water Nova-Pak/C<sub>18</sub> column, 4 micron, 1 mL/min, 240 nm, 20/80 CH<sub>3</sub>CN/0.1% H<sub>3</sub>PO<sub>4</sub>(aq), 5.62 min (99.18%). Anal. Calcd For C<sub>14</sub>H<sub>13</sub>N<sub>3</sub>O<sub>4</sub>: C, 58.53; H, 4.56; N, 14.63. Found: C, 58.60; H, 4.41; N, 14.36.

In a similar fashion from 3-(3-nitrophthalimido)-3-ethylpiperidine-2,6-dione and 3-(3-nitrophthalimido)-3-propylpiperidine-2,6-dione there is obtained 3-(3-aminophthalimido)-3-ethylpiperidine-2,6-dione and 3-(3-aminophthalimido)-3-propylpiperidine-2,6-dione, respectively.

**EXAMPLE 11****Methyl 2-bromomethyl-3-nitrobenzoate**

A stirred mixture of methyl 2-methyl-3-nitrobenzoate (17.6 g, 87.1 mmol) and N-bromosuccinimide (18.9 g, 105 mmol) in carbon tetrachloride (243 mL) was heated under gentle reflux with a 100 W light bulb situated 2 cm away shining on the reaction mixture overnight. After 18 hours, the reaction mixture was cooled to room temperature and filtered. The filtrate was washed with water (2 x 120 mL), brine (120 mL), and dried (MgSO<sub>4</sub>). The solvent was removed in vacuo to give a yellow solid. The product was purified by flash chromatography (hexane:ethyl acetate 8:2) to give 22 g (93%) of methyl 2-bromomethyl-3-nitrobenzoate as a yellow solid: mp 69-72 °C; <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 8.13-8.09 (dd, J=1.36 and 7.86 Hz, 1H), 7.98-7.93 (dd, J=1.32 and 8.13 Hz, 1H), 7.57-7.51 (t, J=7.97 Hz, 1H), 5.16 (s, 2H), 4.0 (s, 3H); <sup>13</sup>C NMR

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(CDCl<sub>3</sub>)  $\delta$  65.84, 150.56, 134.68, 132.64, 132.36, 129.09, 53.05, 22.70; HPLC : Waters Nova-Pak C<sub>18</sub> column, 4 micron, 1 mL/min, 240nm, 40/60 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq), 8.2 min 99 %. Anal. Calcd for C<sub>9</sub>H<sub>8</sub>NO<sub>4</sub>Br: C, 39.44; H, 2.94; N, 5.11, Br, 29.15. Found: C, 39.51; H, 2.79; N, 5.02; Br, 29.32.

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**EXAMPLE 12****3-(1-Oxo-4-nitroisindolin-1-yl)-3-methylpiperidine-2,6-dione**

To a stirred mixture of  $\alpha$ -amino- $\alpha$ -methylglutarimide hydrochloride (2.5g, 14.0 mmol) and methyl 2-bromomethyl-3-nitrobenzoate(3.87g, 14.0 mmol in dimethylformamide (40 mL) was added triethylamine (3.14g, 30.8 mmol). The resulting  
10 mixture was heated to reflux under nitrogen for 6 hours. The mixture was cooled and then concentrated in vacuo. The resulting solid was slurried in water (50 mL) and CH<sub>2</sub>Cl<sub>2</sub> for 30 min. The slurry was filtered, the solid washed with methylene chloride, and dried in vacuo (60°C, <1mm) to afford 2.68 g (63%) of 3-(1-oxo-4-nitroisindolin-1-yl)-3-methylpiperidine-2,6-dione as a off-white solid : mp 233-235 °C; <sup>1</sup>H NMR  
15 (DMSO-d<sub>6</sub>)  $\delta$  10.95 (s, 1H), 8.49-8.46 (d, J=8.15 Hz, 1H), 8.13-8.09 (d, J=7.43 Hz, 1H), 7.86-7.79 (t, J= 7.83 Hz, 1H), 5.22-5.0 (dd, J=19.35 and 34.6 Hz, 2H), 2.77-2.49 (m, 3H), 2.0-1.94 ( m, 1H), 1.74 (S, 3H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>)  $\delta$  173.07, 172.27, 164.95, 143.15, 137.36, 135.19, 130.11, 129.32, 126.93, 57.57, 48.69, 28.9, 27.66, 20.6; HPLC, Waters Nova-Pak C<sub>18</sub> column, 4 micron, 1 mL/min, 240nm, 20/80  
20 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq), 4.54 min 99.6%. Anal. Calcd for C<sub>14</sub>H<sub>13</sub>N<sub>3</sub>O<sub>5</sub>: C, 55.45; H, 4.32; N, 13.86. Found: C, 52.16; H, 4.59; N, 12.47.

By substituting equivalent amounts of  $\alpha$ -amino- $\alpha$ -ethylglutarimide hydrochloride and  $\alpha$ -amino- $\alpha$ -propylglutarimide hydrochloride for  $\alpha$ -amino- $\alpha$ -methylglutarimide hydrochloride, there is obtained respectively 3-(1-oxo-4-nitroisindolin-1-yl)-3-  
25 ethylpiperidine-2,6-dione and 3-(1-oxo-4-nitroisindolin-1-yl)-3-propylpiperidine-2,6-dione.

**EXAMPLE 13****3-(1-Oxo-4-aminoisindolin-1-yl)-3-methylpiperidine-2,6-dione**

3-(1-Oxo-4-nitroisindolin-1-yl)-3-methylpiperidine-2,6-dione (1.0 g, 3.3 mmol)  
30 was dissolved in methanol (500 mL) with gentle heat and allowed to cool to room temperature. To this solution was added 10% Pd/C (0.3 g) under nitrogen. The mixture was hydrogenated in a Parr apparatus at 50 psi of hydrogen for 4 hours. The

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mixture was filtered through Celite and the Celite washed with methanol (50 mL). The filtrate was concentrated in vacuo to an off white solid. The solid was slurried in methylene chloride (20 mL) for 30 min. The slurry was then filtered and the solid dried (60°C, <1 mm) to afford 0.54 g (60%) of 3-(1-oxo-4-aminoisindolin-1-yl)-3-methylpiperidine-2,6-dione as a white solid: mp 268-270 °C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 10.85 (s, 1H), 7.19-7.13 (t, J=7.63 Hz, 1H), 6.83-6.76 (m, 2H), 5.44 (s, 2H), 4.41(s, 2H), 2.71-2.49 (m, 3H), 1.9-1.8 (m, 1H), 1.67 (s, 3H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 173.7, 172.49, 168.0, 143.5, 132.88, 128.78, 125.62, 116.12, 109.92, 56.98, 46.22, 29.04, 27.77, 20.82; HPLC, Waters Nova-Pak/C18 column, 4 micron, 1 mL/min, 240 nm, 20/80 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq), 1.5 min (99.6%); Anal. Calcd for C<sub>14</sub>H<sub>15</sub>N<sub>3</sub>O<sub>3</sub> : C, 61.53; H, 5.53; N, 15.38. Found : C, 58.99; H, 5.48; N, 14.29.

From 3-(1-oxo-4-nitroisindolin-1-yl)-3-ethylpiperidine-2,6-dione and 3-(1-oxo-4-nitroisindolin-1-yl)-3-propylpiperidine-2,6-dione there is similarly obtained 3-(1-oxo-4-aminoisindolin-1-yl)-3-ethylpiperidine-2,6-dione and 3-(1-oxo-4-aminoisindolin-1-yl)-3-propylpiperidine-2,6-dione, respectively.

#### EXAMPLE 14

##### S-4-Amino-2-(2,6-dioxopiperid-3-yl)isoindoline-1,3-dione

###### A. 4-Nitro-N-ethoxycarbonylphthalimide

Ethyl chloroformate (1.89 g, 19.7 mmol) was added dropwise over 10 min to a stirred solution of 3-nitrophthalimide (3.0 g, 15.6 mmol) and triethylamine (1.78 g, 17.6 mmol) in dimethylformamide (20 mL) at 0-5°C under nitrogen. The reaction mixture was allowed to warm to room temperature and stirred for 4 hours. The mixture was then slowly added to an agitated mixture of ice and water (60 mL). The resulting slurry was filtered and the solid was crystallized from chloroform (15 mL) and pet ether (15 mL) to afford 3.1 g (75%) of the product as an off-white solid: mp 100-100.5°C; <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 8.25(d, J=7.5 Hz, 1H), 8.20(d, J=8.0 Hz, 1H), 8.03(t, J=7.9 Hz, 1H), 4.49(q, J=7.1 Hz, 2H), 1.44(t, J=7.2 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>) δ 161.45, 158.40, 147.52, 145.65, 136.60, 132.93, 129.65, 128.01, 122.54, 64.64, 13.92; HPLC, Waters Nova-Pak/C18, 3.9x150 mm, 4 micron, 1 mL/min, 240 nm, 30/70 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq), 5.17 min(98.11%); Anal. Calcd for C<sub>11</sub>H<sub>8</sub>N<sub>2</sub>O<sub>6</sub>: C, 50.00; H, 3.05; N, 10.60. Found : C, 50.13; H, 2.96; N, 10.54.

*B. t-Butyl N-(4-nitrophthaloyl)-L-glutamine*

A stirred mixture of 4-nitro-N-ethoxycarbonylphthalimide (1.0 g, 3.8 mmol), L-glutamine t-butyl ester hydrochloride (0.90 g, 3.8 mmol) and triethylamine (0.54 g, 5.3 mmol) in tetrahydrofuran (30 mL) was heated to reflux for 24 hours. The tetrahydrofuran was removed *in vacuo* and the residue was dissolved in methylene chloride (50 mL). The methylene chloride solution was washed with water (2x15 mL), brine (15 mL) and then dried (sodium sulfate). The solvent was removed in *vacuo* and the residue was purified by flash chromatograph (7:3 methylene chloride:ethyl acetate) to give 0.9 g (63%) of a glassy material: <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 8.15(d, J=7.9 Hz, 2H), 7.94(t, J=7.8 Hz, 1H), 5.57(b, 2H), 4.84(dd, J=5.1 and 9.7 Hz, 1H), 2.53-2.30(m, 4H), 1.43(s, 9H); HPLC, Wasters Nova-Pak<sup>TM</sup>C18, 3.9x150 mm, 4 micron, 1 mL/min, 240 nm, 30/70 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq), 6.48 min(99.68%); Chiral Analysis, Daicel Chiral Pak<sup>TM</sup>AD, 0.4x25 Cm, 1 mL/min, 240 nm, 5.32 min(99.39%); Anal. Calcd for C<sub>17</sub>H<sub>19</sub>N<sub>3</sub>O<sub>7</sub> : C, 54.11; H, 5.08; N, 11.14. Found : C, 54.21; H, 5.08; N, 10.85.

*C. N-(4-Nitrophthaloyl)-L-glutamine*

Hydrogen chloride gas was bubbled into a stirred 5°C solution of t-butyl N-(4-nitrophthaloyl)-L-glutamine (5.7 g, 15.1 mmol) in methylene chloride (100 mL) for 25 min. The mixture was then stirred at room temperature for 16 hours. Ether (50 mL) was added and the resulting mixture was stirred for 30 min. The resulting slurry was filtered to yield 4.5 g of crude product as a solid, which was used directly in the next reaction : <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 8.36(dd, J=0.8 and 8.0 Hz, 1H), 8.24(dd, J=0.8 and 7.5 Hz, 1H), 8.11(t, J=7.9 Hz, 1H), 7.19(b, 1H), 6.72(b, 1H), 4.80(dd, J=3.5 and 8.8 Hz, 1H), 2.30-2.10(m, 4H).

*D. (S)-2-(2,6-dioxo(3-piperidyl))-4-nitroisindoline-1,3-dione*

A stirred suspension of N-(4-nitrophthaloyl)-L-glutamine (4.3 g, 13.4 mmol) in anhydrous methylene chloride (170 mL) was cooled to -40°C (IPA/dry ice bath). Thionyl chloride (1.03 mL, 14.5 mmol) was added dropwise to the mixture followed by pyridine (1.17 mL, 14.5 mmol). After 30 minutes, triethylamine (2.06 mL, 14.8 mmol) was added and the mixture was stirred at -30 to -40°C for 3 hours. The mixture was allowed to warm to room temperature, filtered and washed with methylene chloride to afford 2.3 g (57%) of the crude product. Recrystallization from acetone (300 mL) afforded 2 g of the product as a white solid : mp 259.0-

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284.0°C(dec.); <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 11.19(s, 1H), 8.34(d, J=7.8 Hz, 1H), 8.23(d, J=7.1 Hz, 1H), 8.12(t, J=7.8 Hz, 1H), 5.25-5.17(dd, J=5.2 and 12.7 Hz, 1H), 2.97-2.82(m, 1H), 2.64-2.44(m, 2H), 2.08-2.05(m, 1H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 172.67, 169.46, 165.15, 162.50, 144.42, 136.78, 132.99, 128.84, 127.27, 122.53, 49.41, 30.84, 21.71; HPLC, Waters Nova-Pak/C18, 3.9x150 mm, 4 micron, 1mL/min, 240 nm, 10/90 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq) 4.27 min(99.63%); Anal. Calcd for C<sub>13</sub>H<sub>9</sub>N<sub>3</sub>O<sub>6</sub> : C, 51.49; H, 2.99; N, 13.86. Found : C, 51.67; H, 2.93; N, 13.57.

*E. S-4-Amino-2-(2,6-dioxopiperid-3-yl)isoindoline-1,3-dione.*

A mixture of (S)-3-(4'-nitrophthalimido)-piperidine-2,6-dione (0.76 g, 2.5 mmol) and 10%Pd/C (0.3 g) in acetone (200 mL) was hydrogenated in a Parr-Shaker apparatus at 50 psi of hydrogen for 24 hours. The mixture was filtered through celite and the filtrate was concentrated *in vacuo*. The solid residue was slurried in hot ethyl acetate for 30 min and filtered to yield 0.47 g (69%) of the product as a yellow solid : mp 309-310°C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 11.10 (s, 1H), 7.47(dd, J=7.2 and 8.3 Hz, 1H), 7.04-6.99(dd, J=6.9 and 8.3 Hz, 2H), 6.53(s, 2H), 5.09-5.02(dd, J=5.3 and 12.4 Hz, 1H), 2.96-2.82(m, 1H), 2.62-2.46(m, 2H), 2.09-1.99(m, 1H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 172.80, 170.10, 168.57, 167.36, 146.71, 135.44, 131.98, 121.69, 110.98, 108.54, 48.48, 30.97, 22.15; HPLC, Waters Nova-Pak/C18, 3.9x150 mm, 4 micron, 1 mL/min, 240 nm, 15/85 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq) 4.99 min(98.77%); Chiral analysis, Daicel Chiral Pak AD, 0.46x25 cm, 1 mL/min, 240 nm, 30/70 Hexane/IPA 9.55 min (1.32%), 12.55 min (97.66%); Anal. Calcd for C<sub>13</sub>H<sub>11</sub>N<sub>3</sub>O<sub>4</sub> : C, 57.14; H, 4.06; N, 15.38. Found : C, 57.15; H, 4.15; N, 14.99.

### EXAMPLE 15

#### R-4-Amino-2-(2,6-dioxopiperid-3-yl)isoindoline-1,3-dione

##### 25 A. *t*-Butyl N-(4-nitrophthaloyl)-D-glutamine

A stirred mixture of 4-nitro-N-ethoxycarbonyl-phthalimide (5.9 g, 22.3 mmol), D-glutamine *t*-butyl ester (4.5 g, 22.3 mmol) and triethylamine (0.9 g, 8.9 mmol) in tetrahydrofuran (100 mL) was refluxed for 24 hours. The mixture was diluted with methylene chloride (100 mL) and washed with water (2 x 50 mL), brine (50 mL) and then dried. The solvent was removed *in vacuo* and the residue was purified by flash chromatography (2% CH<sub>3</sub>OH in methylene chloride) to afford 6.26 g (75%) of the product as a glassy material : <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 8.12(d, J=7.5 Hz, 2H),

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7.94(dd, J=7.9 and 9.1 Hz, 1H), 5.50(b, 1H), 5.41(b, 1H), 4.85(dd, J=5.1 and 9.8 Hz, 1H), 2.61-2.50(m, 2H), 2.35-2.27(m, 2H), 1.44(s, 9H); <sup>13</sup>C NMR (CDCl<sub>3</sub>) δ 173.77, 167.06, 165.25, 162.51, 145.07, 135.56, 133.78, 128.72, 127.27, 123.45, 83.23, 53.18, 32.27, 27.79, 24.42; HPLC, Waters Nova-Pak/C18, 3.9x150 mm, 4 micron, 1 mL/min, 240 nm, 25/75 CH<sub>3</sub>CN/0.1% H<sub>3</sub>PO<sub>4</sub>(aq) 4.32 min(99.74%); Chiral analysis, Daicel Chiral Pak AD, 0.46x25 cm, 1 mL/min, 240 nm, 55/45 Hexane/IPA 5.88 min(99.68%); Anal. Calcd for C<sub>17</sub>H<sub>19</sub>N<sub>3</sub>O<sub>7</sub>: C, 54.11; H, 5.08; N, 11.14. Found: C, 54.25; H, 5.12; N, 10.85.

*B. N-(4-Nitrophthaloyl)-D-glutamine*

Hydrogen chloride gas was bubbled into a stirred 5°C solution of t-butyl N-(4-nitrophthaloyl)-D-glutamine (5.9 g, 15.6 mmol) in methylene chloride (100 mL) for 1 hour then stirred at room temperature for another hour. Ether (100 mL) was added and stirred for another 30 minutes. The mixture was filtered, the solid was washed with ether (60 mL) and dried (40°C, <1mm Hg) to afford 4.7 g (94%) of the product: <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 8.33(d, J=7.8 Hz, 1H), 8.22(d, J=7.2 Hz, 1H), 8.11(t, J=7.8 Hz, 1H), 7.19(b, 1H), 6.72(b, 1H), 4.81(dd, J=4.6 and 9.7 Hz, 1H), 2.39-2.12(m, 4H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 173.21, 169.99, 165.41, 162.73, 144.45, 136.68, 132.98, 128.80, 127.23, 122.52, 51.87, 31.31, 23.87.

*C. (R)-2-(2,6-dioxo(3-piperidyl))-4-nitroisindoline-1,3-dione.*

A stirred suspension of N-(4'-nitrophthaloyl)-D-glutamine (4.3 g, 13.4 mmol) in anhydrous methylene chloride (170 mL) was cooled to -40°C with isopropanol/dry ice bath. Thionyl chloride (1.7 g, 14.5 mmol) was added dropwise followed by pyridine (1.2 g, 14.5 mmol). After 30 min, triethylamine (1.5 g, 14.8 mmol) was added and the mixture was stirred at -30 to -40°C for 3 hours. The mixture was filtered, the solid washed with methylene chloride (50 mL) and dried (60°C, <1mm Hg) to give 2.93 g of the product. Another 0.6 g of the product was obtained from the methylene chloride filtrate. Both fractions were combined (3.53 g) and recrystallized from acetone (450 mL) to afford 2.89 g (71%) of the product as a white solid: mp 256.5-257.5°C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 11.18(s, 1H), 8.34(dd, J=0.8 and 7.9 Hz, 1H), 8.23(dd, J=0.8 and 7.5 Hz, 1H), 8.12(t, J=7.8 Hz, 1H), 5.22(dd, J=5.3 and 12.8 Hz, 1H), 2.97-2.82(m, 1H), 2.64-2.47(m, 2H), 2.13-2.04(m, 1H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 172.66, 169.44, 165.14, 162.48, 144.41, 136.76, 132.98, 128.83, 127.25, 122.52, 49.41, 30.83, 21.70; HPLC, Waters Nova-Pak/C18, 3.9x150 mm, 4



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micron, 1 mL/min, 240 nm, 10/90 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq) 3.35 min(100%); Anal. Calcd for C<sub>13</sub>H<sub>9</sub>N<sub>3</sub>O<sub>6</sub> : C, 51.49; H, 2.99; N, 13.86. Found : C, 51.55; H, 2.82; N, 13.48.

*D. (R)-4-Amino-2-(2,6-dioxopiperid-3-yl)isoindoline-1,3-dione*

5 A mixture of R-3-(4'-nitrophthalimido)-piperidine-2,6-dione (1.0 g, 3.3 mmol) and 10% Pd/C (0.2 g) in acetone (250 mL) was hydrogenated in a Parr-Shaker apparatus at 50 psi of hydrogen for 4 hours. The mixture was filtered through celite and the filtrate was concentrated *in vacuo*. The resulting yellow solid was slurried in hot ethyl acetate (20 mL) for 30 min to give after filtration and drying 0.53 g (59%) of  
10 the product as a yellow solid : mp 307.5-309.5°C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 11.06(s, 1H), 7.47(dd, J=7.0 and 8.4 Hz, 1H), 7.02(dd, J=4.6 and 8.4 Hz, 2H), 6.53(s, 2H), 5.07(dd, J=5.4 and 12.5 Hz, 1H), 2.95-2.84(m, 1H), 2.62-2.46(m, 2H), 2.09-1.99(m, 1H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 172.78, 170.08, 168.56, 167.35, 146.70, 135.43, 131.98, 121.68, 110.95, 108.53, 48.47, 30.96, 22.14; HPLC, Waters Nove-Pak/C18, 3.9x150  
15 mm, 4 micron, 1 mL/min, 240 nm, 10/90 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq) 3.67 min(99.68%); Chiral analysis, Daicel Chiral Pak AD, 0.46x25 cm, 1 mL/min, 240 nm, 30/70 Hexane/ IPA 7.88min (97.48%); Anal. Calcd for C<sub>13</sub>H<sub>11</sub>N<sub>3</sub>O<sub>4</sub> : C, 57.14; H, 4.06; N, 15.38. Found : C, 57.34; H, 3.91; N, 15.14.

**EXAMPLE 16**

20 **3-(4-Amino-1-oxoisoindolin-2-yl)piperidine-2,6-dione**

*A. Methyl 2-bromomethyl-3-nitrobenzoate*

A stirred mixture of methyl 2-methyl-3-nitrobenzoate (14.0 g, 71.7 mmol) and N-bromosuccinimide (15.3 g, 86.1 mmol) in carbon tetrachloride (200 mL) was heated under gentle reflux for 15 hours while a 100W bulb situated 2 cm away was  
25 shining on the flask. The mixture was filtered and the solid was washed with methylene chloride (50 mL). The filtrate was washed with water (2x100 mL), brine (100 mL) and dried. The solvent was removed *in vacuo* and the residue was purified by flash chromatography (hexane/ethyl acetate, 8/2) to afford 19 g (96%) of the  
30 product as a yellow solid : mp 70.0-71.5°C; <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 8.12-8.09(dd, J=1.3 and 7.8 Hz, 1H), 7.97-7.94(dd, J=1.3 and 8.2 Hz, 1H), 7.54(t, J=8.0 Hz, 1H), 5.15(s, 2H), 4.00(s, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>) δ 165.85, 150.58, 134.68, 132.38, 129.08, 127.80, 53.06, 22.69; HPLC, Water Nove-Pak/C18, 3.9x150 mm, 4 micron, 1

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mL/min, 240 nm, 40/60 CH<sub>3</sub>CN/0.1% H<sub>3</sub>PO<sub>4</sub>(aq) 7.27 min(98.92%); Anal. Calcd for C<sub>9</sub>H<sub>8</sub>NO<sub>4</sub>Br : C, 39.44; H, 2.94; N, 5.11; Br, 29.15. Found : C, 39.46; H, 3.00; N, 5.00; Br, 29.11.

*B. t-Butyl N-(1-oxo-4-nitroisindolin-2-yl)-L-glutamine*

5        Triethylamine (2.9 g, 28.6 mmol) was added dropwise to a stirred mixture of methyl 2-bromomethyl-3-nitrobenzoate (3.5 g, 13.0 mmol) and L-glutamine t-butyl ester hydrochloride (3.1 g, 13.0 mmol) in tetrahydrofuran (90 mL). The mixture was heated to reflux for 24 hours. To the cooled mixture was added methylene chloride (150 mL) and the mixture was washed with water (2 x 40 mL), brine (40 mL) and  
10        dried. The solvent was removed *in vacuo* and the residue was purified by flash chromatography (3% CH<sub>3</sub>OH in methylene chloride) to afford 2.84 g (60%) of crude product which was used directly in the next reaction: <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 8.40(d, J=8.1 Hz, 1H), 8.15(d, J=7.5 Hz, 1H), 7.71(t, J=7.8 Hz, 1H), 5.83(s, 1H), 5.61(s, 1H), 5.12(d, J=19.4 Hz, 1H), 5.04-4.98(m, 1H), 4.92(d, J=19.4 Hz, 1H), 2.49-2.22(m, 4H),  
15        1.46(s, 9H); HPLC, Waters Nova-Pak/C18, 3.9x150 mm, 4 micron, 1 mL/min, 240 nm, 25/75 CH<sub>3</sub>CN/0.1% H<sub>3</sub>PO<sub>4</sub>(aq) 6.75 min(99.94%).

*C. N-(1-Oxo-4-nitroisindolin-2-yl)-L-glutamine*

Hydrogen chloride gas was bubbled into a stirred 5°C solution of *t*-butyl N-(1-oxo-4-nitro-isindolin-2-yl)-L-glutamine (3.6 g, 9.9 mmol) in methylene chloride (60  
20        mL) for 1 hour. The mixture was then stirred at room temperature for another hour. Ether (40 mL) was added and the resulting mixture was stirred for 30 minutes. The slurry was filtered, washed with ether and dried to afford 3.3 g of the product : <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 8.45(d, J=8.1 Hz, 1H), 8.15(d, J=7.5 Hz, 1H), 7.83(t, J=7.9 Hz, 1H), 7.24(s, 1H), 6.76(s, 1H), 4.93(s, 2H), 4.84-4.78(dd, J=4.8 and 10.4 Hz, 1H),  
25        2.34-2.10(m, 4H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 173.03, 171.88, 165.96, 143.35, 137.49, 134.77, 130.10, 129.61, 126.95, 53.65, 48.13, 31.50, 24.69; Anal. Calcd for C<sub>13</sub>H<sub>13</sub>N<sub>3</sub>O<sub>6</sub> : C, 50.82; H, 4.26; N, 13.68. Found : C, 50.53; H, 4.37; N, 13.22.

*D. (S)-3-(1-Oxo-4-nitroisindolin-2-yl)piperidine-2,6-dione*

A stirred suspension mixture of N-(1-oxo-4-nitroisindolin-2-yl)-L-glutamine  
30        (3.2 g, 10.5 mmol) in anhydrous methylene chloride (150 mL) was cooled to -40°C with isopropanol/dry ice bath. Thionyl chloride (0.82 mL, 11.3 mmol) was added dropwise to the cooled mixture followed by pyridine (0.9 g, 11.3 mmol). After 30

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min, triethylamine (1.2 g, 11.5 mmol) was added and the mixture was stirred at -30 to -40°C for 3 hours. The mixture was poured into ice water (200 mL) and the aqueous layer was extracted with methylene chloride (40 mL). The methylene chloride solution was washed with water (2 x 60 mL), brine (60 mL) and dried. The solvent  
5 was removed *in vacuo* and the solid residue was slurried with ethyl acetate (20 mL) to give 2.2 g (75%) of the product as a white solid: mp 285°C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 11.04(s, 1H), 8.49-8.45(dd, J=0.8 and 8.2 Hz, 1H), 8.21-8.17(dd, J=7.3 Hz, 1H), 7.84(t, J=7.6 Hz, 1H), 5.23-5.15(dd, J=4.9 and 13.0 Hz, 1H), 4.96(dd, J=19.3 and 32.4 Hz, 2H), 3.00-2.85(m, 1H), 2.64-2.49(m, 2H), 2.08-1.98(m, 1H); <sup>13</sup>C NMR (DMSO-  
10 d<sub>6</sub>) δ 172.79, 170.69, 165.93, 143.33, 137.40, 134.68, 130.15, 129.60, 127.02, 51.82, 48.43, 31.16, 22.23; HPLC, Waters Nove-Pak/C18, 3.9x150 mm, 4 micron, 1 mL/min, 240 nm, 20/80 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq) 3.67 min(100%); Anal. Calcd for C<sub>13</sub>H<sub>11</sub>N<sub>3</sub>O<sub>5</sub> : C, 53.98; H, 3.83; N, 14.53. Found : C, 53.92; H, 3.70; N, 14.10.

*E. (S)-3-(1-Oxo-4-aminoisoindolin-2-yl)piperidine-2,6 dione*

15 A mixture of (S)-3-(1-oxo-4-nitroisoindolin-2-yl)piperidine-2,6-dione (1.0 g, 3.5 mmol) and 10% Pd/c (0.3 g) in methanol (600 mL) was hydrogenated in a Parr-Shaker apparatus at 50 psi of hydrogen for 5 hours. The mixture was filtered through Celite and the filtrate was concentrated *in vacuo*. The solid was slurried in hot ethyl acetate for 30 min, filtered and dried to afford 0.46 g (51%) of the product as a white  
20 solid: mp 235.5-239°C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 11.01(s, 1H), 7.19(t, J=7.6 Hz, 1H), 6.90(d, J=7.3 Hz, 1H), 6.78(d, J=7.8 Hz, 1H), 5.42(s, 2H), 5.12(dd, J=5.1 and 13.1 Hz, 1H), 4.17(dd, J=17.0 and 28.8 Hz, 2H), 2.92-2.85(m, 1H), 2.64-2.49(m, 1H), 2.34-2.27(m, 1H), 2.06-1.99(m, 1H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 172.85, 171.19, 168.84, 143.58, 132.22, 128.79, 125.56, 116.37, 110.39, 51.48, 45.49, 31.20, 22.74; HPLC,  
25 Waters Nova-Pak/C18, 3.9x150 mm, 4 micron, 1 mL/min, 240 nm, 10/90 CH<sub>3</sub>CN/0.1%H<sub>3</sub>PO<sub>4</sub>(aq) 0.96 min(100%); Chiral analysis, Daicel Chiral Pak AD, 40/60 Hexane/IPA, 6.60 min(99.42%); Anal. Calcd for C<sub>13</sub>H<sub>13</sub>N<sub>3</sub>O<sub>3</sub> : C, 60.23; H, 5.05; N, 16.21. Found : C, 59.96; H, 4.98; N, 15.84.

**EXAMPLE 17****3-(4-Amino-1-oxoisindolin-2-yl)-3-methylpiperidine-2,6-dione***A. N-Benzyloxycarbonyl-3-amino-3-methylpiperidine-2,6-dione*

A stirred mixture of N-benzyloxycarbonyl- $\alpha$ -methyl-isoglutamine (11.3 g, 38.5 mmol), 1,1'-carbonyldiimidazole (6.84 g, 42.2 mmol) and 4-dimethylaminopyridine (0.05 g) in tetrahydrofuran (125 mL) was heated to reflux under nitrogen for 19 hours. The reaction mixture was concentrated in vacuo to an oil. The oil was slurried in water (50 mL) for 1 hour then filtered, washed with water, air dried to afford 7.15 g of white solid. The crude product was purified by flash chromatography (2:8 ethyl acetate:methylene chloride) to afford 6.7 g (63%) of the product as a white solid : mp 151-152 °C;  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  8.24 (s, 1H), 7.35 (s, 5H), 5.6 (s, 1H), 5.09 (s, 2H), 2.82-2.53 (m, 3H), 2.33-2.26 (m, 1H), 1.56 (s, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  174.4, 172.4, 154.8, 136.9, 128.3, 127.8, 127.7, 65.3, 54.6, 29.2, 29.0, 22.18; HPLC : Waters Nova-Pak/ $\text{C}_{18}$  column, 4 micron, 3.9x150 mm, 1ml/min, 240nm, 20/80  $\text{CH}_3\text{CN}/\text{H}_3\text{PO}_{4(\text{aq})}$ , 6.6 min, 100%). Anal. Calcd for  $\text{C}_{14}\text{H}_{16}\text{N}_2\text{O}_4$ . Theory: C, 60.86; H, 5.84; N, 10.14. Found: C, 60.94; H, 5.76; N, 10.10.

*B. 3-Amino-3-methylpiperidine-2,6-dione.*

N-benzyloxycarbonyl-3-amino-3-methylpiperidine-2,6-dione (3.0 g, 10.9 mmol) was dissolved in ethanol (270 mL) with gentle heat and then cooled to room temperature. To this solution was added 4 N HCl (7 mL) followed by 10% Pd/C (0.52 g). The mixture was hydrogenated under 50 psi of hydrogen for 3 hours. To the mixture was then added water (65 mL) to dissolve the product. The mixture was filtered through a celite pad and the celite pad washed with water (100 mL). The filtrate was concentrated in vacuo to a solid residue. This solid was slurried in ethanol (50 mL) for 30 min. The slurry was filtered to afford 3.65 g (94%) of the product as a white solid:  $^1\text{H}$  NMR ( $\text{DMSO}-d_6$ )  $\delta$  11.25 (s, 1H), 8.9 (s, 3H), 2.87-2.57 (m, 2H), 2.35-2.08 (m, 2H), 1.54 (s, 3H); HPLC (Waters Nova-Pak/ $\text{C}_{18}$  column, 4 micron, 1 ml/min, 240 nm, 15/85  $\text{CH}_3\text{CN}/\text{H}_3\text{PO}_{4(\text{aq})}$ , 1.07 min, 100%).

*C. 3-Methyl-3-(4-nitro-1-oxoisindolin-2-yl)piperidine-2,6-dione*

To a stirred mixture of  $\alpha$ -amino- $\alpha$ -methyl-glutarimide hydrochloride (2.5 g, 14.0 mmol) and methyl 2-bromomethyl-3-nitro benzoate (3.87 g, 14 mmol) in dimethylformamide (40 mL) was added triethylamine (3.14 g, 30.8 mmol) under nitrogen. The mixture was heated to reflux for 6 hours. The mixture was cooled and

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then concentrated in vacuo. The solid residue was slurried in water (50 mL) and methylene chloride for 30min. The slurry was filtered and the solid washed with methylene chloride and dried (60 °C, <1mm). Recrystallization from methanol (80 mL) yielded 0.63g (15%) of the product as an off white solid: mp 195-197°C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 10.95 (s, 1H), 8.49-8.46 (d, J = 8.2 Hz, 1H), 8.13-8.09 (d, J = 7.4 Hz, 1H), 7.86-7.79 (t, J = 7.8 Hz, 1H), 5.22-5.0 (dd, J = 19.4 and 34.6 Hz, 2H), 2.77-2.49 (m, 3H), 2.0-1.94 (m, 1H), 1.74 (s, 3H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 173.1, 172.3, 165.0, 143.2, 137.4, 135.2, 130.1, 129.3, 126.9, 57.6, 48.7, 28.9, 27.7, 20.6; HPLC (Waters Nova-Pak/C<sub>18</sub> column, 4micron, 1 ml/min, 240nm, 20/80 CH<sub>3</sub>CN/H<sub>3</sub>PO<sub>4(aq)</sub>, 4.54 min, 99.6%); Anal Calcd. For C<sub>14</sub>H<sub>13</sub>N<sub>3</sub>O<sub>5</sub>; C, 55.45; H, 4.32; N, 13.86. Found: C, 55.30; H, 4.48; N, 13.54.

#### D. 3-Methyl-3-(4-amino-1-oxoisindolin-2-yl)piperidine-2,6-dione.

3-Methyl-3-(4-nitro-1-oxoisindolin-2-yl)piperidine-2,6-dione (1.0 g, 3.3 mmol) was dissolved in methanol (500 mL) with gentle heat and then cooled to room temperature. To this solution was added 10% Pd/C (0.3 g) under nitrogen. The mixture was hydrogenated in a Parr-Shaker apparatus at 50 psi of hydrogen for 4 hours. The mixture was filtered through celite pad and the celite pad washed with methanol (50 mL). The filtrate was concentrated in vacuo to a off white solid. The solid was slurried in methylene chloride (20 mL) for 30 min. The slurry was filtered and the solid dried (60°C, <1 mm). The solid was to recrystallized from methanol (3 times, 100 mL/time) to yield 0.12 g (13.3%) of the product as a white solid: mp 289-292°C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 10.85 (s, 1H), 7.19-7.13 (t, J = 7.6 Hz, 1H), 6.83-6.76 (m, 2H), 5.44 (s, 2H), 4.41(s, 2H), 2.71-2.49 (m, 3H), 1.9-1.8 (m, 1H), 1.67 (s, 3H); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>) δ 173.7, 172.5, 168.0, 143.5, 132.9, 128.8, 125.6, 116.1, 109.9, 57.0, 46.2, 29.0, 27.8, 20.8; HPLC (Waters Nova-Pak/C<sub>18</sub> column, 4 micron, 1 ml/min, 240 nm, 20/80 CH<sub>3</sub>CN/H<sub>3</sub>PO<sub>4(aq)</sub>, 1.5 min, 99.6%); Anal. Calcd. For C<sub>14</sub>H<sub>15</sub>N<sub>3</sub>O<sub>3</sub>; C, 61.53; H, 5.53; N, 15.38. Found: C, 61.22; H, 5.63; N, 15.25.

#### EXAMPLE 18

Tablets, each containing 50 mg of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisindoline, can be prepared in the following manner:

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Constituents (for 1000 tablets)

5	1,3-dioxo-2-(2,6-dioxo-	
	piperidin-3-yl)-5-amino-	
	isoindoline .....	50.0 g
	lactose .....	50.7 g
	wheat starch .....	7.5 g
	polyethylene glycol 6000.....	5.0 g
10	talc.....	5.0 g
	magnesium stearate.....	1.8 g
	demineralized water.....	q.s.

The solid ingredients are first forced through a sieve of 0.6 mm mesh width. The active ingredient, lactose, talc, magnesium stearate and half of the starch then are  
 15 mixed. The other half of the starch is suspended in 40 mL of water and this suspension is added to a boiling solution of the polyethylene glycol in 100 mL of water. The resulting paste is added to the pulverulent substances and the mixture is granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced  
 20 through a sieve of 1.2 mm mesh width and compressed to form tablets of approximately 6 mm diameter which are concave on both sides.

**EXAMPLE 19**

Tablets, each containing 100 mg of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline, can be prepared in the following manner:

25	<u>Constituents</u> (for 1000 tablets)	
	1,3-dioxo-2-(2,6-dioxo-	
	piperidin-3-yl)-5-amino-	
	isoindoline .....	100.0 g
	lactose .....	100.0 g
30	wheat starch .....	47.0 g
	magnesium stearate.....	3.0 g

All the solid ingredients are first forced through a sieve of 0.6 mm mesh width. The active ingredient, lactose, magnesium stearate and half of the starch then  
 35 are mixed. The other half of the starch is suspended in 40 mL of water and this suspension is added to 100 mL of boiling water. The resulting paste is added to the pulverulent substances and the mixture is granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced through a sieve of 1.2 mm

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mesh width and compressed to form tablets of approximately 6 mm diameter which are concave on both sides.

### EXAMPLE 20

Tablets for chewing, each containing 75 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, can be prepared in the following manner:

#### Composition (for 1000 tablets)

	1-oxo-2-(2,6-dioxo-	
	piperidin-3-yl)-4-amino-	
10	isoindoline .....	75.0 g
	mannitol .....	230.0 g
	lactose .....	150.0 g
	talc.....	21.0 g
	glycine.....	12.5 g
15	stearic acid .....	10.0 g
	saccharin .....	1.5 g
	5% gelatin solution .....	q.s.

All the solid ingredients are first forced through a sieve of 0.25 mm mesh width. The mannitol and the lactose are mixed, granulated with the addition of gelatin solution, forced through a sieve of 2 mm mesh width, dried at 50°C and again forced through a sieve of 1.7 mm mesh width. 1-Oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, the glycine and the saccharin are carefully mixed, the mannitol, the lactose granulate, the stearic acid and the talc are added and the whole is mixed thoroughly and compressed to form tablets of approximately 10 mm diameter which are concave on both sides and have a breaking groove on the upper side.

### EXAMPLE 21

Tablets, each containing 10 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline, can be prepared in the following manner:

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Composition (for 1000 tablets)

5	1-oxo-2-(2,6-dioxo-
	piperidin-3-yl)-5-amino-
	isoindoline ..... 10.0 g
	lactose ..... 328.5 g
	corn starch..... 17.5 g
	polyethylene glycol 6000..... 5.0 g
10	talc..... 25.0 g
	magnesium stearate..... 4.0 g
	demineralized water ..... q.s.

The solid ingredients are first forced through a sieve of 0.6 mm mesh width. Then the active imide ingredient, lactose, talc, magnesium stearate and half of the starch are intimately mixed. The other half of the starch is suspended in 65 mL of water and this suspension is added to a boiling solution of the polyethylene glycol in 260 mL of water. The resulting paste is added to the pulverulent substances, and the whole is mixed and granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced through a sieve of 1.2 mm mesh width and compressed to form tablets of approximately 10 mm diameter which are concave on both sides and have a breaking notch on the upper side.

**EXAMPLE 22**

Gelatin dry-filled capsules, each containing 100 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline, can be prepared in the following manner:

25      Composition (for 1000 capsules)

	1-oxo-2-(2,6-dioxo-
	piperidin-3-yl)-6-amino-
	isoindoline ..... 100.0 g
30	microcrystalline cellulose ..... 30.0 g
	sodium lauryl sulfate..... 2.0 g
	magnesium stearate..... 8.0 g

The sodium lauryl sulfate is sieved into the 1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline through a sieve of 0.2 mm mesh width and the two components are intimately mixed for 10 minutes. The microcrystalline cellulose is then added through a sieve of 0.9 mm mesh width and the whole is again intimately mixed for 10 minutes. Finally, the magnesium stearate is added through a sieve of 0.8 mm width



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and, after mixing for a further 3 minutes, the mixture is introduced in portions of 140 mg each into size 0 (elongated) gelatin dry-fill capsules.

**EXAMPLE 23**

5 A 0.2% injection or infusion solution can be prepared, for example, in the following manner:

	1-oxo-2-(2,6-dioxo-	
	piperidin-3-yl)-7-amino-	
	isoindoline .....	5.0 g
10	sodium chloride .....	22.5 g
	phosphate buffer pH 7.4 .....	300.0 g
	demineralized water .....	to 2500.0 mL

1-Oxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline is dissolved in 1000 mL of water and filtered through a microfilter. The buffer solution is added and the  
 15 whole is made up to 2500 mL with water. To prepare dosage unit forms, portions of 1.0 or 2.5 mL each are introduced into glass ampoules (each containing respectively 2.0 or 5.0 mg of imide).

**EXAMPLE 24**

20 Tablets, each containing 50 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline, can be prepared in the following manner:

Constituents (for 1000 tablets)

	1-oxo-2-(2,6-dioxo-	
	piperidin-3-yl)-4,5,6,7-	
25	tetrafluoroisoindoline.....	50.0 g
	lactose .....	50.7 g
	wheat starch .....	7.5 g
	polyethylene glycol 6000.....	5.0 g
	talc.....	5.0 g
30	magnesium stearate.....	1.8 g
	demineralized water.....	q.s.

The solid ingredients are first forced through a sieve of 0.6 mm mesh width. The active ingredient, lactose, talc, magnesium stearate and half of the starch then are  
 35 mixed. The other half of the starch is suspended in 40 mL of water and this suspen-

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sion is added to a boiling solution of the polyethylene glycol in 100 mL of water. The resulting paste is added to the pulverulent substances and the mixture is granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced through a sieve of 1.2 mm mesh width and compressed to form tablets of approximately 6 mm diameter which are concave on both sides.

### EXAMPLE 25

Tablets, each containing 100 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetrachloroisindoline, can be prepared in the following manner:

	<u>Constituents</u> (for 1000 tablets)
10	1-oxo-2-(2,6-dioxopiperidin-3-yl)-
	4,5,6,7-tetrachloroisindoline ..... 100.0 g
	lactose ..... 100.0 g
	wheat starch ..... 47.0 g
15	magnesium stearate ..... 3.0 g

All the solid ingredients are first forced through a sieve of 0.6 mm mesh width. The active ingredient, lactose, magnesium stearate and half of the starch then are mixed. The other half of the starch is suspended in 40 mL of water and this suspension is added to 100 mL of boiling water. The resulting paste is added to the pulverulent substances and the mixture is granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced through a sieve of 1.2 mm mesh width and compressed to form tablets of approximately 6 mm diameter which are concave on both sides.

### EXAMPLE 26

Tablets for chewing, each containing 75 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetrafluoroisindoline, can be prepared in the following manner:

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Composition (for 1000 tablets)

5	1-oxo-2-(2,6-dioxo-
	piperidin-3-yl)- 4,5,6,7-tetra-
	fluoroisoindoline..... 75.0 g
	mannitol .....230.0 g
	lactose .....150.0 g
	talc..... 21.0 g
	glycine.....12.5 g
10	stearic acid ..... 10.0 g
	saccharin .....1.5 g
	5% gelatin solution ..... q.s.

15 All the solid ingredients are first forced through a sieve of 0.25 mm mesh width. The mannitol and the lactose are mixed, granulated with the addition of gelatin solution, forced through a sieve of 2 mm mesh width, dried at 50°C and again forced through a sieve of 1.7 mm mesh width. 1-Oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline, the glycine and the saccharin are carefully mixed, the mannitol, the lactose granulate, the stearic acid and the talc are added and the whole is mixed

20 thoroughly and compressed to form tablets of approximately 10 mm diameter which are concave on both sides and have a breaking groove on the upper side.

**EXAMPLE 27**

Tablets, each containing 10 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetramethylisoindoline, can be prepared in the following manner:

25 Composition (for 1000 tablets)

	1-oxo-2-(2,6-dioxo-
	piperidin-3-yl)- 4,5,6,7-
	tetramethylisoindoline ..... 10.0 g
30	lactose .....328.5 g
	corn starch..... 17.5 g
	polyethylene glycol 6000..... 5.0 g
	talc..... 25.0 g
	magnesium stearate..... 4.0 g
35	demineralized water ..... q.s.

The solid ingredients are first forced through a sieve of 0.6 mm mesh width. Then the active imide ingredient, lactose, talc, magnesium stearate and half of the starch are intimately mixed. The other half of the starch is suspended in 65 mL of

40 water and this suspension is added to a boiling solution of the polyethylene glycol in

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260 mL of water. The resulting paste is added to the pulverulent substances, and the whole is mixed and granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced through a sieve of 1.2 mm mesh width and compressed to form tablets of approximately 10 mm diameter which are concave on both sides and have a breaking notch on the upper side.

### EXAMPLE 28

Gelatin dry-filled capsules, each containing 100 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetramethoxyisoindoline, can be prepared in the following manner:

#### 10                    Composition (for 1000 capsules)

	1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetramethoxy-	
	isoindoline .....	100.0 g
15	microcrystalline cellulose .....	30.0 g
	sodium lauryl sulfate.....	2.0 g
	magnesium stearate.....	8.0 g

The sodium lauryl sulfate is sieved into the 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetramethoxyisoindoline through a sieve of 0.2 mm mesh width and the two components are intimately mixed for 10 minutes. The microcrystalline cellulose is then added through a sieve of 0.9 mm mesh width and the whole is again intimately mixed for 10 minutes. Finally, the magnesium stearate is added through a sieve of 0.8 mm width and, after mixing for a further 3 minutes, the mixture is introduced in portions of 140 mg each into size 0 (elongated) gelatin dry-fill capsules.

### EXAMPLE 30

A 0.2% injection or infusion solution can be prepared, for example, in the following manner:

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	1-oxo-2-(2,6-dioxopiperidin-3-yl)-	
	4,5,6,7-tetrafluoroisoindoline .....	5.0 g
	sodium chloride .....	22.5 g
	phosphate buffer pH 7.4 .....	300.0 g
5	demineralized water .....	to 2500.0 mL

1-Oxo-2-(2,6-dioxopiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline is dissolved in 1000 mL of water and filtered through a microfilter. The buffer solution is added and the whole is made up to 2500 mL with water. To prepare dosage unit forms, portions of 1.0 or 2.5 mL each are introduced into glass ampoules (each containing respectively 2.0 or 5.0 mg of imide).

**EXAMPLE 31**

Tablets, each containing 50 mg of 1-oxo-2-(2,6-dioxo-3-methylpiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline, can be prepared in the following manner:

15	<u>Constituents</u> (for 1000 tablets)	
	1-oxo-2-(2,6-dioxo-3-methyl piperidin-3-yl)-4,5,6,7- tetrafluoroisoindoline.....	50.0 g
20	lactose .....	50.7 g
	wheat starch .....	7.5 g
	polyethylene glycol 6000.....	5.0 g
	talc.....	5.0 g
	magnesium stearate.....	1.8 g
25	demineralized water.....	q.s.

The solid ingredients are first forced through a sieve of 0.6 mm mesh width. The active ingredient, lactose, talc, magnesium stearate and half of the starch then are mixed. The other half of the starch is suspended in 40 mL of water and this suspension is added to a boiling solution of the polyethylene glycol in 100 mL of water. The resulting paste is added to the pulverulent substances and the mixture is granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced through a sieve of 1.2 mm mesh width and compressed to form tablets of approximately 6 mm diameter which are concave on both sides.

**EXAMPLE 32**

Tablets, each containing 100 mg of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, can be prepared in the following manner:

Constituents (for 1000 tablets)

5	1-oxo-2-(2,6-dioxo-	
	piperidin-3-yl)-4-amino	
	isoindoline .....	100.0 g
	lactose .....	100.0 g
10	wheat starch .....	47.0 g
	magnesium stearate.....	3.0 g

All the solid ingredients are first forced through a sieve of 0.6 mm mesh width. The active ingredient, lactose, magnesium stearate and half of the starch then are  
 15 mixed. The other half of the starch is suspended in 40 mL of water and this suspension is added to 100 mL of boiling water. The resulting paste is added to the pulverulent substances and the mixture is granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced through a sieve of 1.2 mm mesh width and compressed to form tablets of approximately 6 mm diameter which are  
 20 concave on both sides.

**EXAMPLE 33**

Tablets for chewing, each containing 75 mg of 2-(2,6-dioxo-3-methylpiperidin-3-yl)-4-aminophthalimide, can be prepared in the following manner:

Composition (for 1000 tablets)

25	2-(2,6-dioxo-3-methylpiperidin-	
	3-yl)-4-aminophthalimide.....	75.0 g
	mannitol .....	230.0 g
	lactose .....	150.0 g
30	talc.....	21.0 g
	glycine.....	12.5 g
	stearic acid .....	10.0 g
	saccharin .....	1.5 g
35	5% gelatin solution .....	q.s.

All the solid ingredients are first forced through a sieve of 0.25 mm mesh width. The mannitol and the lactose are mixed, granulated with the addition of gelatin solu-

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tion, forced through a sieve of 2 mm mesh width, dried at 50°C and again forced through a sieve of 1.7 mm mesh width. 2-(2,6-Dioxo-3-methylpiperidin-3-yl)-4-aminophthalimide, the glycine and the saccharin are carefully mixed, the mannitol, the lactose granulate, the stearic acid and the talc are added and the whole is mixed  
 5 thoroughly and compressed to form tablets of approximately 10 mm diameter which are concave on both sides and have a breaking groove on the upper side.

**EXAMPLE 34**

Tablets, each containing 10 mg of 2-(2,6-dioxoethylpiperidin-3-yl)-4-aminophthalimide, can be prepared in the following manner:

10	<u>Composition</u> (for 1000 tablets)
	2-(2,6-dioxoethylpiperidin-3-yl)-
	4-aminophthalimide..... 10.0 g
	lactose .....328.5 g
15	corn starch..... 17.5 g
	polyethylene glycol 6000..... 5.0 g
	talc..... 25.0 g
	magnesium stearate..... 4.0 g
20	demineralized water..... q.s.

The solid ingredients are first forced through a sieve of 0.6 mm mesh width. Then the active imide ingredient, lactose, talc, magnesium stearate and half of the starch are intimately mixed. The other half of the starch is suspended in 65 mL of water and this suspension is added to a boiling solution of the polyethylene glycol in 260 mL of  
 25 water. The resulting paste is added to the pulverulent substances, and the whole is mixed and granulated, if necessary with the addition of water. The granulate is dried overnight at 35°C, forced through a sieve of 1.2 mm mesh width and compressed to form tablets of approximately 10 mm diameter which are concave on both sides and have a breaking notch on the upper side.

30 **EXAMPLE 35**

Gelatin dry-filled capsules, each containing 100 mg of 1-oxo-2-(2,6-dioxo-3-methylpiperidin-3-yl)-4,5,6,7-tetrafluoroisindoline, can be prepared in the following manner:

- 40 -

Composition (for 1000 capsules)

5	1-oxo-2-(2,6-dioxo-3-methylpiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline.....	100.0 g
	microcrystalline cellulose .....	30.0 g
	sodium lauryl sulfate.....	2.0 g
	magnesium stearate.....	8.0 g

- 10 The sodium lauryl sulfate is sieved into the 1-oxo-2-(2,6-dioxo-3-methylpiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline through a sieve of 0.2 mm mesh width and the two components are intimately mixed for 10 minutes. The microcrystalline cellulose is then added through a sieve of 0.9 mm mesh width and the whole is again intimately mixed for 10 minutes. Finally, the magnesium stearate is added through a sieve of 0.8
- 15 mm width and, after mixing for a further 3 minutes, the mixture is introduced in portions of 140 mg each into size 0 (elongated) gelatin dry-fill capsules.

**EXAMPLE 36**

A 0.2% injection or infusion solution can be prepared, for example, in the following manner:

20	1-oxo-2-(2,6-dioxo-3-methylpiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline .....	5.0 g
	sodium chloride .....	22.5 g
	phosphate buffer pH 7.4 .....	300.0 g
25	demineralized water .....	to 2500.0 mL

- 1-Oxo-2-(2,6-dioxo-3-methylpiperidin-3-yl)-4,5,6,7-tetrafluoroisoindoline is dissolved in 1000 mL of water and filtered through a microfilter. The buffer solution is added and the whole is made up to 2500 mL with water. To prepare dosage unit
- 30 forms, portions of 1.0 or 2.5 mL each are introduced into glass ampoules (each containing respectively 2.0 or 5.0 mg of imide).

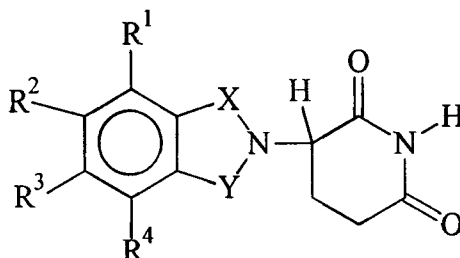


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CLAIMS:

1. A compound of the following formula:



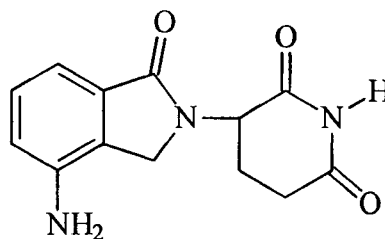
or a pharmaceutically acceptable salt thereof, in which:

one of X and Y is C=O and the other of X and Y is CH<sub>2</sub>;

- one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NHR<sup>5</sup> and the remaining of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> are hydrogen; and

R<sup>5</sup> is hydrogen or alkyl of 1 to 8 carbon atoms.

2. The compound of claim 1, which is 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having the following structure:



- or a pharmaceutically acceptable salt thereof.

3. The compound of claim 1, which is the racemate of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline or a pharmaceutically acceptable salt thereof.

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4. The compound of claim 1, which is the S isomer of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline or a pharmaceutically acceptable salt thereof, having an optical purity of >95%.

5 5. The compound of claim 1, which is the R isomer of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline or a pharmaceutically acceptable salt thereof, having an optical purity of >95%.

6. The compound of claim 1, which is  
10 1-oxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline or a pharmaceutically acceptable salt thereof.

7. The compound of claim 1, which is the racemate of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline or a pharmaceutically acceptable salt thereof.

15 8. The compound of claim 1, which is the S isomer of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline or a pharmaceutically acceptable salt thereof, having an optical purity of >95%.

9. The compound of claim 1, which is the R isomer of  
20 1-oxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline or a pharmaceutically acceptable salt thereof, having an optical purity of >95%.

10. The compound of claim 1, which is  
1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline or a  
25 pharmaceutically acceptable salt thereof.

11. The compound of claim 1, which is the racemate of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline or a pharmaceutically acceptable salt thereof.

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12. The compound of claim 1, which is the S isomer of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline or a pharmaceutically acceptable salt thereof, having an optical purity of >95%.

5 13. The compound of claim 1, which is the R isomer of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline or a pharmaceutically acceptable salt thereof, having an optical purity of >95%.

14. The compound of claim 1, which is  
10 1-oxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline or a pharmaceutically acceptable salt thereof.

15. The compound of claim 1, which is the racemate of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline or a pharmaceutically acceptable salt thereof.

15 16. The compound of claim 1, which is the S isomer of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline or a pharmaceutically acceptable salt thereof, having an optical purity of >95%.

17. The compound of claim 1, which is the R isomer of  
20 1-oxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline or a pharmaceutically acceptable salt thereof, having an optical purity of >95%.

18. The compound of claim 1, which is  
(R)-1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline or  
25 a pharmaceutically acceptable salt thereof.

19. The compound of claim 1, which is  
(S)-1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline or  
a pharmaceutically acceptable salt thereof.

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20. A pharmaceutical composition comprising a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier, diluent or excipient.

5 21. The pharmaceutical composition of claim 20, in unit dosage form comprising from 1 mg to 100 mg of said compound per unit dosage.

22. The pharmaceutical composition of claim 20 or 21, wherein said composition is suitable for oral, parenteral,  
10 topical, rectal, sublingual, buccal, vaginal, transdermal, or basal administration.

23. The pharmaceutical composition of claim 20 or 21, which is in the form of a capsule suitable for oral administration.

15 24. The pharmaceutical composition of claim 20 or 21, wherein said composition is in the form of a tablet, a capsule, a lozenge, a cachet, a solution, a suspension, an emulsion, a powder, an aerosol, a spray, a suppository, a tampon, a pessary, a pastille, an ointment, a cream, a  
20 paste, a foam or a gel.

25. The pharmaceutical composition of any one of claims 20 to 24, which is formulated for reducing levels of TNF $\alpha$  in a mammal.

26. The pharmaceutical composition of any one of  
25 claims 20 to 24, which is formulated for inhibiting angiogenesis in a mammal.

27. The pharmaceutical composition of any one of claims 20 to 24, which is formulated for treating an inflammatory disease in a mammal.

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28. The pharmaceutical composition of any one of claims 20 to 24, which is formulated for treating an autoimmune disease in a mammal.

29. The pharmaceutical composition of any one of  
5 claims 20 to 24, which is formulated for treating a cancerous condition in a mammal.

30. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof in the preparation of a medicament for reducing levels of TNF $\alpha$  in a  
10 mammal.

31. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof for reducing levels of TNF $\alpha$  in a mammal.

32. The use of claim 30 or 31, wherein the mammal has  
15 a condition or disease associated with elevated TNF $\alpha$  levels, wherein said condition or disease is adult respiratory distress syndrome, asthma, autoimmune disease, cachexia, a chronic pulmonary inflammatory disease, congestive heart failure, Crohn's disease, endotoxic shock, ENL in leprosy,  
20 fibrotic disease, graft rejection, hemodynamic shock, hyperoxic alveolar injury, inflammation, malaria, meningitis, multiple sclerosis, mycobacterial infection, an oncogenic or cancerous condition, opportunistic infection in AIDS, osteoarthritis, post ischemic reperfusion injury,  
25 psoriasis, radiation damage, rheumatoid arthritis, rheumatoid spondylitis, septic shock, sepsis, sepsis syndrome, systemic lupus erythrematosis, or ulcerative colitis.

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33. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for inhibiting angiogenesis in a mammal.

5 34. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof for inhibiting angiogenesis in a mammal.

35. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof, in the  
10 preparation of a medicament for treating an inflammatory disease in a mammal.

36. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof, for treating an inflammatory disease in a mammal.

15 37. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for treating an autoimmune disease in a mammal.

38. Use of a compound of any one of claims 1 to 19 or  
20 a pharmaceutically acceptable salt thereof, for treating an autoimmune disease in a mammal.

39. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for treating a cancerous  
25 condition in a mammal.

40. Use of a compound of any one of claims 1 to 19 or a pharmaceutically acceptable salt thereof, for treating a cancerous condition in a mammal.

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41. The use of any one of claims 30 to 40, wherein the mammal is human.

42. A compound according to any one of claims 1 to 19, for use for reducing levels of TNF $\alpha$  in a mammal.

5 43. A compound according to any one of claims 1 to 19, for use for inhibiting angiogenesis in a mammal.

44. A compound according to any one of claims 1 to 19, for use for treating an inflammatory disease in a mammal.

45. A compound according to any one of claims 1 to 19,  
10 for use for treating an autoimmune disease in a mammal.

46. A compound according to any one of claims 1 to 19, for use for treating a cancerous condition in a mammal.

47. The compound of any one of claims 42 to 46, wherein the mammal is a human.

15 48. A commercial package comprising the pharmaceutical composition of claim 25, together with instructions for use for reducing levels of TNF $\alpha$  in a mammal.

49. A commercial package comprising the pharmaceutical composition of claim 26, together with instructions for use  
20 for inhibiting angiogenesis in a mammal.

50. A commercial package comprising the pharmaceutical composition of claim 27, together with instructions for use for treating an inflammatory disease in a mammal.

51. A commercial package comprising the pharmaceutical  
25 composition of claim 28, together with instructions for use for treating an autoimmune disease in a mammal.

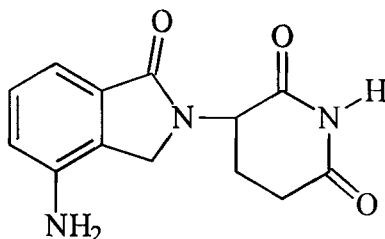
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52. A commercial package comprising the pharmaceutical composition of claim 29, together with instructions for use for treating a cancerous condition in a mammal.

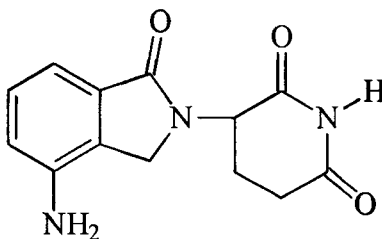
53. The commercial package of any one of claims 48 to 52, wherein the mammal is a human.

54. Use of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having the following structure:



in the preparation of a medicament for treating a cancerous condition in a human.

55. Use of 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having the following structure:



for treating a cancerous condition in a human.

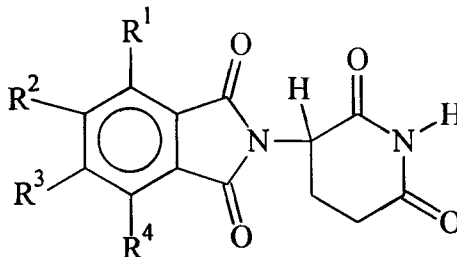


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56. A pharmaceutical composition comprising:

a compound of the following formula:



or a pharmaceutically acceptable salt thereof, in which:

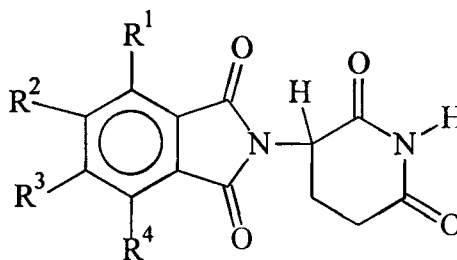
one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NHR<sup>5</sup> and the remaining of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> are hydrogen; and

R<sup>5</sup> is hydrogen or alkyl of 1 to 8 carbon atoms; and

10 a pharmaceutically acceptable carrier, diluent or excipient, wherein said composition is formulated for inhibiting angiogenesis in a mammal.

57. A pharmaceutical composition comprising:

a compound of the following formula:



or a pharmaceutically acceptable salt thereof, in which:

20 one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is -NHR<sup>5</sup> and the remaining of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> are hydrogen; and

R<sup>5</sup> is hydrogen or alkyl of 1 to 8 carbon atoms; and

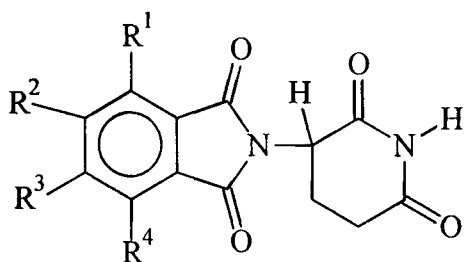
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a pharmaceutically acceptable carrier, diluent or excipient,  
wherein said composition is formulated for treating an  
inflammatory condition in a mammal.

58. A pharmaceutical composition comprising:

5 a compound of the following formula:



10 or a pharmaceutically acceptable salt thereof, in which:

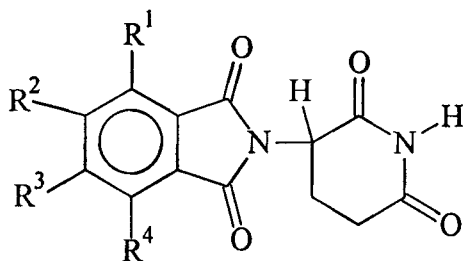
one of  $R^1$ ,  $R^2$ ,  $R^3$ , and  $R^4$  is  $-NHR^5$  and the remaining  
of  $R^1$ ,  $R^2$ ,  $R^3$  and  $R^4$  are hydrogen; and

$R^5$  is hydrogen or alkyl of 1 to 8 carbon atoms; and

a pharmaceutically acceptable carrier, diluent or excipient,  
15 wherein said composition is formulated for treating a  
cancerous condition in a mammal.

59. A pharmaceutical composition comprising:

a compound of the following formula:



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or a pharmaceutically acceptable salt thereof, in which:

one of  $R^1$ ,  $R^2$ ,  $R^3$ , and  $R^4$  is  $-NHR^5$  and the remaining of  $R^1$ ,  $R^2$ ,  $R^3$  and  $R^4$  are hydrogen; and

$R^5$  is hydrogen or alkyl of 1 to 8 carbon atoms; and

5 a pharmaceutically acceptable carrier, diluent or excipient, wherein said composition is formulated for reducing levels of  $TNF\alpha$  in a mammal that has a condition or disease associated with elevated  $TNF\alpha$  levels, wherein said condition or disease is adult respiratory distress syndrome, asthma,  
10 cachexia, a chronic pulmonary inflammatory disease, congestive heart failure, Crohn's disease, endotoxic shock, ENL in leprosy, fibrotic disease, hemodynamic shock, hyperoxic alveolar injury, inflammation, malaria, meningitis, multiple sclerosis, mycobacterial infection, an  
15 oncogenic or cancerous condition, opportunistic infection in AIDS, osteoarthritis, post ischemic reperfusion injury, psoriasis, radiation damage, rheumatoid arthritis, rheumatoid spondylitis, septic shock, sepsis, sepsis syndrome, systemic lupus erythrematosis, or ulcerative  
20 colitis.

60. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline.

61. The pharmaceutical composition of any one of  
25 claims 56 to 59, wherein the compound is the racemate of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline.

62. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the S isomer of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline,  
30 having an optical purity of >95%.

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63. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the R isomer of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having an optical purity of >95%.

5 64. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline.

65. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the racemate of  
10 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline.

66. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the S isomer of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline, having an optical purity of >95%.

15 67. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the R isomer of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-5-aminoisoindoline, having an optical purity of >95%.

68. The pharmaceutical composition of any one of  
20 claims 56 to 59, wherein the compound is 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline.

69. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the racemate of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline.

25 70. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the S isomer of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline, having an optical purity of >95%.

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71. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the R isomer of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-6-aminoisoindoline, having an optical purity of >95%.

5 72. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline.

73. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the racemate of  
10 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline.

74. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the S isomer of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline, having an optical purity of >95%.

15 75. The pharmaceutical composition of any one of claims 56 to 59, wherein the compound is the R isomer of 1,3-dioxo-2-(2,6-dioxopiperidin-3-yl)-7-aminoisoindoline, having an optical purity of >95%.

76. The pharmaceutical composition of any one of  
20 claims 56 to 75 in unit dosage form comprising from 1 mg to 100 mg of said compound per unit dosage.

77. The pharmaceutical composition of any one of claims 56 to 75, wherein said composition is suitable for oral, parenteral, topical, rectal, sublingual, buccal,  
25 vaginal, transdermal, or basal administration.

78. The pharmaceutical composition of any one of claims 56 to 75, which is in the form of a capsule suitable for oral administration.

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79. The pharmaceutical composition of any one of claims 56 to 75, wherein said composition is in the form of a tablet, a capsule, a lozenge, a cachet, a solution, a suspension, an emulsion, a powder, an aerosol, a spray, a  
5 suppository, a tampon, a pessary, a pastille, an ointment, a cream, a paste, a foam or a gel.

80. Use of the compound as defined in any one of claims 56 to 75 in the preparation of a medicament for inhibiting angiogenesis in a mammal.

10 81. Use of the compound as defined in any one of claims 56 to 75 for inhibiting angiogenesis in a mammal.

82. Use of the compound as defined in any one of claims 56 to 75 in the preparation of a medicament for treating an inflammatory condition in a mammal.

15 83. Use of the compound as defined in any one of claims 56 to 75 for treating an inflammatory condition in a mammal.

84. Use of the compound as defined in any one of claims 56 to 75 in the preparation of a medicament for  
20 treating a cancerous condition in a mammal.

85. Use of the compound as defined in any one of claims 56 to 75 for treating a cancerous condition in a mammal.

86. Use of the compound as defined in any one of  
25 claims 56 to 75 in the preparation of a medicament for reducing levels of TNF $\alpha$  in a mammal that has a condition or disease associated with elevated TNF $\alpha$  levels, wherein said condition or disease is adult respiratory distress syndrome, asthma, cachexia, a chronic pulmonary inflammatory disease,  
30 congestive heart failure, Crohn's disease, endotoxic shock,

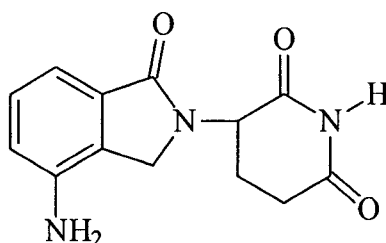
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ENL in leprosy, fibrotic disease, hemodynamic shock, hyperoxic alveolar injury, inflammation, malaria, meningitis, multiple sclerosis, mycobacterial infection, an oncogenic or cancerous condition, opportunistic infection in  
5 AIDS, osteoarthritis, post ischemic reperfusion injury, psoriasis, radiation damage, rheumatoid arthritis, rheumatoid spondylitis, septic shock, sepsis, sepsis syndrome, systemic lupus erythrematosis, or ulcerative colitis.

- 10 87. Use of the compound as defined in any one of claims 56 to 75 for reducing levels of TNF $\alpha$  in a mammal that has a condition or disease associated with elevated TNF $\alpha$  levels, wherein said condition or disease is adult  
15 respiratory distress syndrome, asthma, cachexia, a chronic pulmonary inflammatory disease, congestive heart failure, Crohn's disease, endotoxic shock, ENL in leprosy, fibrotic disease, hemodynamic shock, hyperoxic alveolar injury, inflammation, malaria, meningitis, multiple sclerosis, mycobacterial infection, an oncogenic or cancerous  
20 condition, opportunistic infection in AIDS, osteoarthritis, post ischemic reperfusion injury, psoriasis, radiation damage, rheumatoid arthritis, rheumatoid spondylitis, septic shock, sepsis, sepsis syndrome, systemic lupus erythrematosis, or ulcerative colitis.

- 25 88. A compound, which is 1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having the following structure:



60950-361(S)

-56-

89. A compound, which is the racemate of  
1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline.

90. A compound, which is the S isomer of  
1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having  
5 an optical purity of >95%.

91. A compound, which is the R isomer of  
1-oxo-2-(2,6-dioxopiperidin-3-yl)-4-aminoisoindoline, having  
an optical purity of >95%.

SMART & BIGGAR  
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PATENT AGENTS



