METHODS OF TREATING CANCER AND RELATED METHODS

Cross-References to Related Applications

[0001] This application claims priority to U.S. Provisional Application No. 60/478,916 filed June 16, 2003; U.S. Provisional Application No. 60/460,369 filed April 3, 2003; U.S. Provisional Application No. 60/460,327 filed April 3, 2003; U.S. Provisional Application No. 60/460,493 filed April 3, 2003; U.S. Provisional Application No. 60/460,328 filed April 3, 2003; U.S. Provisional Application No. 60/426,204 filed November 13, 2002; U.S. Provisional Application No. 60/426,226 filed November 13, 2002; U.S. Provisional Application No. 60/426,282 filed November 13, 2002; U.S. Provisional Application No. 60/426,107 filed November 13, 2002, and the U.S. Provisional Application titled "Methods of Treating Cancer and Related Methods" filed on November 7, 2003, each of which is hereby incorporated by reference in its entirety and for all purposes as if fully set forth herein.

Field of the Invention

[0002] This invention relates to methods of treating cancer with a receptor tyrosine kinase inhibitor. The invention also relates to methods of measuring the amounts and concentrations of the inhibitor and its metabolites after administration of the inhibitor to a subject.

Background of the Invention

[0003] Capillaries reach into almost all tissues of the human body and supply tissues with oxygen and nutrients as well as removing waste products. Under typical conditions, the endothelial cells lining the capillaries do not divide, and capillaries, therefore, do not normally increase in number or size in a human adult. Under certain normal conditions, however, such as when a tissue is damaged, or during certain parts of the menstrual cycle, the capillaries begin to proliferate rapidly. This process of forming new capillaries from pre-existing blood vessels is known as angiogenesis or neovascularization. See Folkman, J. Scientific American 275, 150-154 (1996). Angiogenesis during wound healing is an example of

pathophysiological neovascularization during adult life. During wound healing, the additional capillaries provide a supply of oxygen and nutrients, promote granulation tissue, and aid in waste removal. After termination of the healing process, the capillaries normally regress. Lymboussaki, A. "Vascular Endothelial Growth Factors and their Receptors in Embryos, Adults, and in Tumors" Academic Dissertation, University of Helsinki, Molecular/Cancer Biology Laboratory and Department of Pathology, Haartman Institute, (1999).

[0004] Angiogenesis also plays an important role in the growth of cancer cells. It is known that once a nest of cancer cells reaches a certain size, roughly 1 to 2 mm in diameter, the cancer cells must develop a blood supply in order for the tumor to grow larger as diffusion will not be sufficient to supply the cancer cells with enough oxygen and nutrients.

[0005] Receptor tyrosine kinases (RTKs) are transmembrane polypeptides that regulate developmental cell growth and differentiation, remodeling and regeneration of adult tissues. Mustonen, T. et al., J. Cell Biology 129, 895-898 (1995); van der Geer, P. et al. Ann Rev. Cell Biol. 10, 251-337 (1994). Polypeptide ligands known as growth factors or cytokines, are known to activate RTKs. Signaling RTKs involves ligand binding and a shift in conformation in the external domain of the receptor resulting in its dimerization. Lymboussaki, A. "Vascular Endothelial Growth Factors and their Receptors in Embryos, Adults, and in Tumors" Academic Dissertation, University of Helsinki, Molecular/Cancer Biology Laboratory and Department of Pathology, Haartman Institute, (1999); Ullrich, A. et al., Cell 61, 203-212 (1990). Binding of the ligand to the RTK results in receptor trans-phosphorylation at specific tyrosine residues and subsequent activation of the catalytic domains for the phosphorylation of cytoplasmic substrates. Id.

[0006] Two subfamilies of RTKs are specific to the vascular endothelium. These include the vascular endothelial growth factor (VEGF) subfamily and the Tie receptor subfamily. Class III RTKs include VEGFR-1, VEGFR-2, and VEGFR-3. Shibuya, M. et al., Oncogene 5, 519-525 (1990);

Terman, B. et al., Oncogene 6, 1677-1683 (1991); Aprelikova, O. et al., Cancer Res. 52, 746-748 (1992).

[0007] Members of the VEGF subfamily have been described as being able to induce vascular permeability and endothelial cell proliferation and further identified as a major inducer of angiogenesis and vasculogenesis. Ferrara, N. et al., Endocrinol. Rev. 18, 4-25 (1997). VEGF is known to specifically bind to RTKs including VEGFR-1 and VEGFR-2. DeVries, C. et al., Science 255, 989-991 (1992); Quinn, T. et al., Proc. Natl. Acad. Sci. 90, 7533-7537 (1993). VEGF stimulates the migration and proliferation of endothelial cells and induces angiogenesis both *in vitro* and *in vivo*. Connolly, D. et al., J. Biol. Chem. 264, 20017-20024 (1989); Connolly, D. et al., J. Clin. Invest. 84, 1470-1478 (1989); Ferrara, N. et al., Endocrino. Rew. 18, 4-25 (1997); Leung, D. et al., Science 246, 1306-1309 (1989); Plouet, J. et al., EMBO J 8, 3801-3806 (1989).

[0008] Because angiogenesis is known to be critical to the growth of cancer and to be controlled by VEGF and VEGF-RTK, substantial efforts have been undertaken to develop therapeutics that are antagonists of VEGF-RTK to thereby inhibit or retard angiogenesis, and, hopefully, interfere or stop tumor proliferation.

[0009] Platelet derived growth factor receptor kinase (PDGFRK) is another type of RTK. PDGF expression has been shown in a number of different solid tumors, from glioblastomas to prostate carcinomas. In these various tumor types, the biological role of PDGF signaling can vary from autocrine stimulation of cancer cell growth to more subtle paracrine interactions involving adjacent stroma and angiogenesis. Therefore, inhibiting the PDGFR kinase activity with small molecules may interfere with tumor growth and angiogenesis.

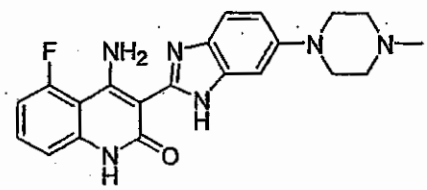
[0010] 4-Amino-5-fluoro-3-[6-(4-methylpiperazin-1-yl)-1H-benzimidazol-2-yl]quinolin-2(1H)-one is a small molecule inhibitor of VEGF-RTK, PDGF-

RTK and other receptor tyrosine kinases such as fibroblast growth factor receptor (FGF-RTK). This compound has been described in a patent and several patent applications, the entire disclosures of which are incorporated herein by reference and for all purposes: U.S. Patent No. 6,605,617, U.S.S.N. 10/644,055, U.S. Provisional Application Nos. 60/405,729, 60/428,210, and 60/484,048. Specific methods for administering this compound are needed as are methods for determining the metabolic profile of this potent anticancer agent.

Summary of the Invention

[0011] The instant invention provides methods of treating cancer, including leukemias and solid tumors. In particular there are provided methods for attaining sufficient blood levels of 4-amino-5-fluoro-3-[6-(4-methylpiperazin-1-yl)-1H-benzimidazol-2-yl]quinolin-2(1H)-one in a subject to inhibit the growth of a cancer. This compound is an inhibitor of receptor tyrosine kinases. There are further provided compounds as biomarkers and methods for the use of such compounds to monitor the distribution and metabolism of the inhibitor in a subject. In addition, the present invention provides pharmaceutical compositions and medicaments comprising the inhibitor and their methods of use.

[0012] Thus, in accordance with the invention, there are provided methods for treating cancer comprising administering to a subject having cancer a sufficient amount of a compound of formula I:



I

a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer to provide a C_{max} of about 20 to 4000 ng/mL of the compound in the subject's plasma or a C_{max} of about 40

to 8000 ng/mL of the compound in the subject's blood. In some embodiments, the amount of the compound administered is sufficient to provide a C_{max} of about 35 to 2000 ng/mL of the compound in the subject's plasma or a C_{max} of about 70 to 4000 ng/mL of the compound in the subject's blood, a C_{max} of about 50 to 500 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 1000 ng/mL of the compound in the subject's blood, a C_{max} of about 50 to 250 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 500 ng/mL of the compound in the subject's blood, a C_{max} of about 75 to 150 ng/mL of the compound in the subject's plasma or a C_{max} of about 150 to 300 ng/mL of the compound in the subject's blood, a C_{max} of about 100 to 2000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 4000 ng/mL of the compound in the subject's blood, or a C_{max} of 100 to 1000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 2000 ng/mL of the compound in the subject's blood. The lactate salt of the compound of formula I is administered to the subject in some embodiments, and in some such embodiments the subject is a human. The compound, tautomers, or salts thereof may be formulated as pills, capsules, tablets, gelcaps, caplets, suspensions, aqueous solutions, or other forms as described herein. In some such embodiments, the lactate salt is in an aqueous solution and is administered orally to the human subject. In other embodiments, the compound may be administered by injection.

[0013] In a further aspect, the present invention provides methods for treating cancer comprising administering to a subject having cancer a sufficient amount of a compound having formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer to provide about 10 to 2,000 ng/mL of the compound in the subject's plasma 24 hours after administration or about 20 to 4,000 ng/mL of the compound in the subject's blood 24 hours after administration. In some embodiments, the amount of the compound administered is sufficient to provide about 20 to 1,000 ng/mL of the compound in the subject's plasma 24 hours after administration or about 40 to 2,000 ng/mL of the compound in the

subject's blood 24 hours after administration, about 40 to 500 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 1,000 ng/mL of the compound in the subject's blood 24 hours after administration, or about 40 to 250 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 500 ng/mL of the compound in the subject's blood 24 hours after administration. In some embodiments, the subject is a human. Commonly, in the present methods of treating cancer, the lactate salt of the compound of formula I is administered to the subject. In some such embodiments, the lactate salt is in a pill, capsule, tablet, gelcap, caplet, suspension, or aqueous solution and is administered orally to the human subject.

[0014] Thus, in certain embodiments of the present methods of treating cancer, the compound of formula I is administered as a pharmaceutical composition or medicament comprising fructose. In some such embodiments, the pharmaceutical composition further comprises a flavoring agent such as tetrarome mandarine flavor. In other embodiments, the pharmaceutical composition further comprises water. Hence, the present methods of treating cancer may further comprise mixing the solid compound of formula I with water to form an aqueous mixture before administering the compound to the subject. The invention further provides the use of the compound of formula I in preparing a medicament for use in treating cancer.

[0015] In other embodiments of the methods of treating cancer described herein, the compound is administered as a pharmaceutical composition selected from granules, powders, suspensions, tablets, pills, capsules, gelcaps, caplets, emulsions, syrups, elixirs, slurries, sprays, aerosols, suppositories, or solutions. Preferably, the pharmaceutical composition is selected from tablets, pills, capsules, gelcaps, or caplets.

[0016] In still other embodiments of the methods of treating cancer described herein, the compound is administered by injection as a short bolus,

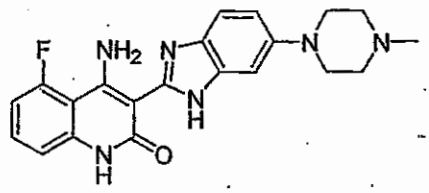
slow infusion, or long-term infusion. The injection may be administered once, twice, three times, or four times daily.

[0017] In some embodiments of the present methods of treating cancer, the amount of the compound of formula I administered to the subject ranges from 0.25 to 30 mg/kg body weight of the subject. In other embodiments, the amount of the compound administered to the subject ranges from about 25 to 1500 mg/day and, preferably, from about 200 to 500 mg/day.

[0018] The present methods of treating cancer are effective against a wide variety of cancers including those in which the cancer to be treated is a solid tumor or leukemia. In particular, the present methods may used to treat cancers such as prostate, colorectal, breast, multiple myeloma, pancreatic, small cell carcinoma, acute myelogenous leukemia, chronic myelogenous leukemia, myelo-proliferative disease, nonsmall cell lung, small cell lung, chronic lymphoid leukemia, sarcoma, melanoma, lymphoma, thyroid, neuroendocrine, renal cell, gastric, gastrointestinal stromal, glioma, brain or bladder.

[0019] In some embodiments, the methods of treating cancer described herein further comprise administering the compound of formula I as part of a treatment cycle. Thus, the treatment cycle may comprise administering the amount of the compound of formula I daily for 7, 14, 21, or 28 days, followed by 7 or 14 days without administration of the compound. In some embodiments, the treatment cycle comprises administering the amount of the compound daily for 7 days, followed by 7 days without administration of the compound. A treatment cycle may be repeated one or more times to provide a course of treatment. In addition, the compound may be administered once, twice, three times, or four times daily during the administration phase of the treatment cycle. In other embodiments, the methods further comprise administering the amount of the compound once, twice, three times, or four times daily or every other day during a course of treatment.

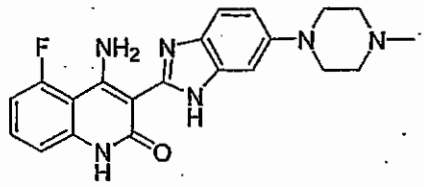
[0020] There are further provided methods for treating cancer comprising administering to a subject having cancer a sufficient amount of a compound having the formula:



a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer to provide an AUC of about 500 to 60,000 ng*h/mL of the compound in the subject's plasma or about 750 to 120,000 ng*h/mL of the compound in the subject's blood. In other such embodiments, the amount of the compound administered is sufficient to provide an AUC of about 1,000 to 30,000 ng*h/mL of the compound in the subject's plasma or about 1,500 to 60,000 ng*h/mL of the compound in the subject's blood. In other such embodiments, the AUC is about 2,000 to 15,000 ng*h/mL of the compound in the subject's plasma or about 3,000 to 30,000 ng*h/mL of the compound in the subject's blood.

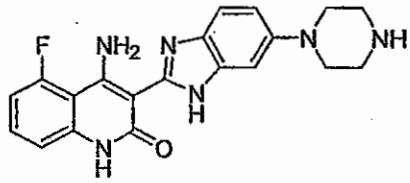
[0021] The present invention further provides methods for treating cancer comprising administering to a subject having cancer a compound having formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, wherein the amount of compound administered in a first treatment cycle is 25 mg per day, and the amount of compound administered is increased with each subsequent treatment cycle until either 1500 mg of compound is administered to the subject per day or dose-limiting toxicity is observed in the subject. Typically in such methods, the amount of compound administered is doubled with each subsequent treatment cycle after the first. In some embodiments, the treatment cycle comprises administering the same amount of the compound daily for 7 days followed by 7 days without administration of the compound.

[0022] In another aspect, the invention provides methods of treating cancer, comprising administering to a subject having cancer, a sufficient amount of a compound having the formula I

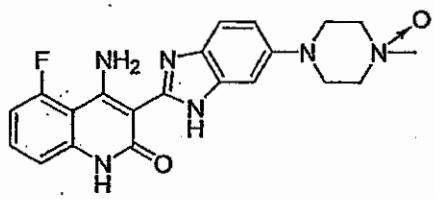


I

a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, and exposing the subject to one or both compounds of formula II and formula III selected from:



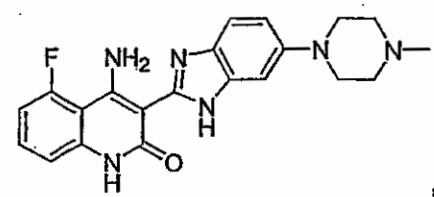
II or

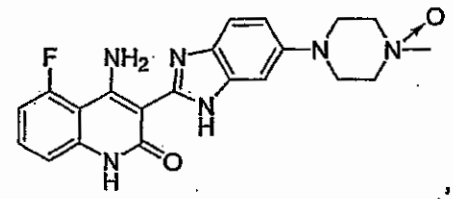


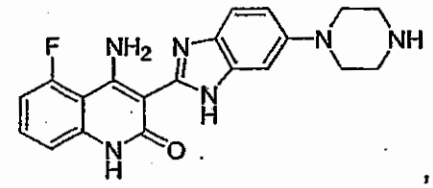
III,

whereby one or both of the compounds of formula II and formula III are produced by metabolism of the compound of formula I by the subject, to provide a combined C_{max} for one or more of the compounds of formula I, formula II, and formula III ranging from about 20 to about 4000 ng/mL in the subject's plasma or a combined C_{max} for one or more of the compounds of formula I, formula II, and formula III ranging from about 40 to about 8000 ng/mL in the subject's blood.

[0023] In yet another aspect, the present invention provides methods for treating cancer comprising exposing a subject having cancer to a sufficient amount of one or more compounds having a formula selected from:



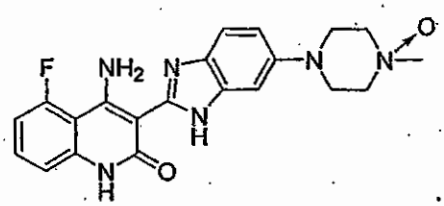




an active metabolite thereof, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, sufficient to provide a combined C_{max} of about 20 to 4000 ng/mL of the one or more compounds in the subject's plasma or a combined C_{max} of about 40 to 8000 ng/mL of the one or more compound in the subject's blood. In some embodiments, the amount of the one or more compounds provides a C_{max} for one of the compounds of about 35 to 2600 ng/mL in the subject's plasma or a C_{max} for one of the compounds of about 35 to 6000 ng/mL in the subject's blood. In other embodiments, the amount of the one or more compounds provides a C_{max} for one of the compounds of about 35 to 1200 ng/mL in the subject's plasma or a C_{max} for one of the compounds of about 50 to 2400 ng/mL in the subject's blood.

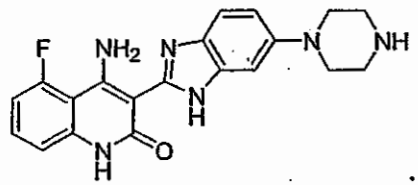
[0024] In other aspects of the invention, there are provided methods for determining a metabolic profile for a compound of formula I, a

pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, in a subject, the method comprising measuring the amount of at least one metabolite of the compound in one or more samples of urine, blood, or tissue taken from the subject. In some such embodiments, at least one metabolite is an N-oxide compound having formula II:



II

[0025] In other such embodiments, at least one metabolite is an N-desmethyl compound having formula III:



III

[0026] In some such embodiments, the at least one metabolite further includes a second metabolite that is an N-oxide compound of formula II. The amount of metabolites may be measured using techniques, including ultraviolet (UV) spectroscopy and/or liquid chromatography-mass spectroscopy (LC-MS).

[0027] In other aspects of the invention, there are provided methods of determining the amount of a compound having formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer in a subject, the method comprising measuring the amount of the compound in a sample of urine, blood, or tissue taken from the subject after the compound has been administered to the subject. This

method may further comprise measuring the amount of a metabolite of the compound in the sample. Metabolites that may be measured include, but are not limited to, the N-oxide compound of formula II and/or the N-desmethyl compound having formula III. In some embodiments, the method further comprises withdrawing two or more samples from the subject at different times after the compound of formula I has been administered to the subject.

[0028] Other objects, features and advantages of the present invention will become apparent from the following detailed description. It should be understood, however, that the detailed description and the specific examples, while indicating certain embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

Brief Description of the Drawings

[0029] FIG. 1 shows KM12L4a tumor inhibition by the compound of formula I.

[0030] FIG. 2 shows the C_{max} and AUC values versus percent inhibition of KM12L4a tumor growth in KM12L4a tumor-bearing mice.

Detailed Description

[0031] The instant invention relates to methods for the treatment of cancer using the compound of formula I, methods for measuring the amount of the compound of formula I and/or its metabolites in biological samples taken from a subject, and pharmaceutical compositions and medicaments comprising the compound of formula I and methods of use thereof.

[0032] The following terms and phrases as defined herein are used throughout this specification.

[0033] As employed herein, "AUC" refers to area under the curve in a graph of the concentration of a compound in blood plasma over time.

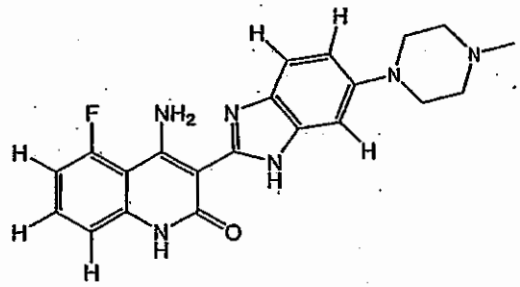
[0034] As employed herein, "C_{max}" refers to the maximum concentration of a compound in the plasma, tissue, or blood of a subject to which the compound has been administered. C_{max} typically occurs within several hours of administration of a compound to a subject.

[0035] Dose limiting toxicity is defined in accordance with the Common Terminology Criteria of Adverse Events Version 3.0 (CTCAE). Thus, dose limiting toxicity occurs upon administration of a compound to a subject if any of the following events are observed within a drug treatment cycle: Grade 4 neutropenia (i.e., absolute neutrophil count (ANC) ≤ 500 cells/mm^3) for 5 or more consecutive days or febrile neutropenia (i.e., fever ≥ 38.5° C with an ANC ≤ 1000 cells/mm^3); Grade 4 thrombocytopenia (i.e., ≤ 25,000 cells/mm^3 or bleeding episode requiring platelet transfusion); Grade 4 fatigue, or a two-point decline in ECOG performance status; Grade 3 or greater nausea, diarrhea, vomiting, and/or myalgia despite the use of adequate/maximal medical intervention; Grade 3 or greater non-hematological toxicity (except fatigue); retreatment delay of more than 2 weeks due to delayed recovery from toxicity related to treatment with compound 1; Grade 2 or greater cardiac toxicity of clinical significance (e.g., a decline in the resting ejection fraction to 40% - ≤ 50% or shortening fraction to 15% - ≤ 24%; cardiac troponin T ≥ 0.05 ng/mL).

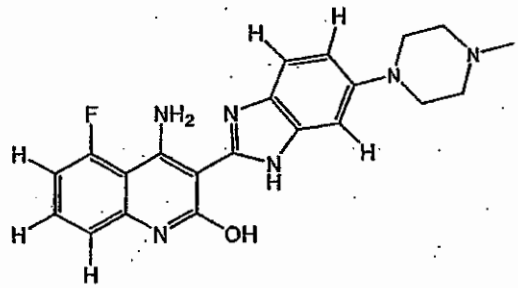
[0036] Pharmaceutically acceptable salts include a salt with an inorganic base, organic base, inorganic acid, organic acid, or basic or acidic amino acid. As salts of inorganic bases, the invention includes, for example, alkali metals such as sodium or potassium, alkali earth metals such as calcium and magnesium, aluminum, and ammonia. As salts of organic bases, the invention includes, for example, trimethylamine, triethylamine, pyridine, picoline, ethanolamine, diethanolamine, and triethanolamine. As salts of inorganic acids, the instant invention includes, for example, hydrochloric acid, hydroboric acid, nitric acid, sulfuric acid, and phosphoric acid. As salts of organic acids, the instant invention includes, for example, lactic acid, formic acid, acetic acid, trifluoroacetic acid, fumaric acid, oxalic acid, tartaric acid,

maleic acid, citric acid, succinic acid, malic acid, methanesulfonic acid, benzenesulfonic acid, and p-toluenesulfonic acid. As salts of basic amino acids, the instant invention includes, for example, arginine, lysine and ornithine. Acidic amino acids include, for example, aspartic acid and glutamic acid.

[0037] It should be understood that the organic compounds according to the invention may exhibit the phenomenon of tautomerism. As the chemical structures within this specification can only represent one of the possible tautomeric forms at a time, it should be understood that the invention encompasses any tautomeric form of the drawn structure. For example, the compound of formula I is shown below with one tautomer, Tautomer Ia:

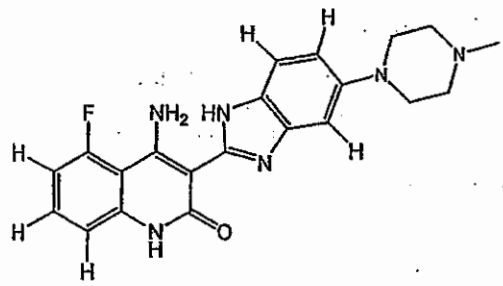


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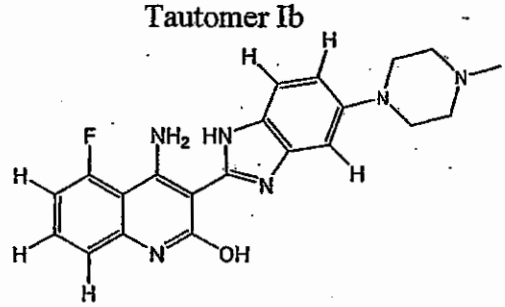


Tautomer Ia

[0038] Other tautomers of the compound of formula I, Tautomer Ib and Tautomer Ic, are shown below:



Tautomer Ib



Tautomer Ic

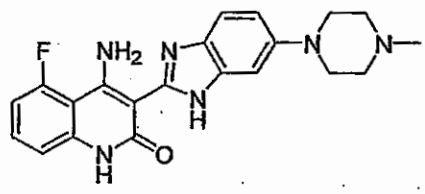
[0039] As readily understood by one skilled in the art, a wide variety of functional groups and other structures may exhibit tautomerism, and all tautomers of compounds having formula I are within the scope of the present invention.

[0040] The term "subject" as used herein refers to any animal that can experience the beneficial effects of the methods of the invention. Thus, a compound of formula I, pharmaceutically acceptable salts thereof, tautomers thereof, or a pharmaceutically acceptable salt of a tautomer can be administered to any animal that can experience the beneficial effects of the compound in accordance with the methods of treating cancer provided by the invention. Preferably, the animal is a mammal, and in particular a human, although the invention is not intended to be so limited. Examples of other suitable animals include, but are not limited to, rats, mice, monkeys, dogs, cats, cattle, horses, pigs, sheep, and the like.

[0041] "Treating" within the context of the instant invention means an alleviation of symptoms associated with a disorder or disease, or halt of further progression or worsening of those symptoms, or prevention or

prophylaxis of the disease or disorder. For example, within the context of cancer, successful treatment may include an alleviation of symptoms or halting the progression of the disease, as measured by a reduction in the growth rate of a tumor, a halt in the growth of the tumor, a reduction in the size of a tumor, partial or complete remission of the cancer, or increased survival rate or clinical benefit.

[0042] In one aspect, the present invention provides methods for treating cancer including administering to a subject having cancer a sufficient amount of a compound of formula I:



I

a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer to provide a C_{max} of about 20 to 4000 ng/mL of the compound in the subject's plasma or a C_{max} of about 40 to 8000 ng/mL of the compound in the subject's blood. In some embodiments, the amount of the compound of formula I administered is sufficient to provide a C_{max} of about 35 to 2000 ng/mL of the compound in the subject's plasma or a C_{max} of about 70 to 4000 ng/mL of the compound in the subject's blood, a C_{max} of about 50 to 500 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 1000 ng/mL of the compound in the subject's blood, a C_{max} of about 50 to 250 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 500 ng/mL of the compound in the subject's blood, a C_{max} of about 75 to 150 ng/mL of the compound in the subject's plasma or a C_{max} of about 150 to 300 ng/mL of the compound in the subject's blood, a C_{max} of about 100 to 2000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 4000 ng/mL of the compound in the subject's blood, or a C_{max} of 100 to 1000 ng/mL of the compound in the

subject's plasma or a C_{max} of about 200 to 2000 ng/mL of the compound in the subject's blood. Preferably the amount of the compound administered is sufficient to provide a C_{max} of about 75 to 150 ng/mL of the compound in the subject's plasma or a C_{max} of about 150 to 300 ng/mL of the compound in the subject's blood. Thus, it is to be understood that the C_{max} provided by the sufficient amount of the compound of formula I, tautomers, and salts thereof falls within the given ranges.

[0043] In a further aspect, the present invention provides methods for treating cancer comprising administering to a subject having cancer a sufficient amount of a compound having formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer to provide about 10 to 2,000 ng/mL of the compound in the subject's plasma 24 hours after administration or about 20 to 4,000 ng/mL of the compound in the subject's blood 24 hours after administration. In some embodiments, the amount of the compound administered is sufficient to provide about 20 to 1,000 ng/mL of the compound in the subject's plasma 24 hours after administration or about 40 to 2,000 ng/mL of the compound in the subject's blood 24 hours after administration, about 40 to 500 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 1,000 ng/mL of the compound in the subject's blood 24 hours after administration, or about 40 to 250 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 500 ng/mL of the compound in the subject's blood 24 hours after administration.

[0044] Typically, in the methods of treating cancer described herein, the compound of formula I or a tautomer thereof is administered as a pharmaceutically acceptable salt. Salts such as lactate, malate, mesylate, acetate, tartrate, phosphate, sulfate, nitrate, HCl, citrate, or maleate in various molar ratios and in their enantiomeric or racemic forms are suitable. Preferably, the lactate salt of the compound of formula I is administered to a subject such as a human subject. The lactate salt is conveniently administered to the patient in a pill, capsule, tablet, gelcap, caplet,

suspension, or aqueous solution and is administered orally. In other embodiments, the compound or salt may be administered by injection as described below.

[0045] Thus, in some embodiments of the present methods of treating cancer, the compound of formula I is administered as a pharmaceutical composition or medicament that includes fructose. Such compositions may also include a flavoring agent such as tetrarome mandarine flavor or the like and/or a diluent, such as water. Hence, the present methods of treating cancer may further include mixing the solid compound of formula I with water to form an aqueous mixture before administering the compound to the subject. The invention further provides the use of the compound of formula I in preparing a medicament for use in treating cancer.

[0046] In some embodiments of the present methods of treating cancer, the amount of the compound of formula I administered to the subject ranges from 0.25 to 30 mg/kg body weight of the subject. In other embodiments, the amount of the compound administered to the subject ranges from about 25 to 1500 mg/subject per day, from about 100 to 1000 mg/subject per day, or from about 200 to 500 mg/subject per day.

[0047] The present methods of treating cancer are effective against a wide variety of cancers including those in which the cancer to be treated is a solid tumor or leukemia. In particular, the present methods may used to treat cancers such as prostate, colorectal, breast, multiple myeloma, pancreatic, small cell carcinoma, acute myelogenous leukemia, chronic myelogenous leukemia, myelo-proliferative disease, nonsmall cell lung, small cell lung, chronic lymphoid leukemia, sarcoma, melanoma, lymphoma, thyroid, neuroendocrine, renal cell, gastric, gastrointestinal stromal, glioma, brain or bladder. While not wishing to be bound by theory, it is believed that the present methods of treating cancer are effective against solid tumors because the compound of formula I acts as an angiogenesis inhibitor. More specifically, the compound of formula I and its active metabolites are believed

to selectively inhibit certain receptor tyrosine kinases involved in tumor angiogenesis and in leukemias.

[0048] In some embodiments, the present methods of treating cancer further include administering the compound of formula I as part of a treatment cycle. A treatment cycle includes an administration phase during which the compound is given to the subject on a regular basis and a holiday, during which the compound is not administered. For example, the treatment cycle may comprise administering the amount of the compound of formula I daily for 7, 14, 21, or 28 days, followed by 7 or 14 days without administration of the compound. In some embodiments, the treatment cycle comprises administering the amount of the compound daily for 7 days, followed by 7 days without administration of the compound. A treatment cycle may be repeated one or more times to provide a course of treatment. In addition, the compound may be administered once, twice, three times, or four times daily during the administration phase of the treatment cycle. In other embodiments, the methods further comprise administering the amount of the compound once, twice, three times, or four times daily or every other day during a course of treatment. A course of treatment refers to a time period during which the subject undergoes treatment for cancer by the present methods. Thus, a course of treatment may extend for one or more treatment cycles or refer to the time period during which the subject receives daily or intermittent doses of the compound of formula I.

[0049] There are further provided methods for treating cancer comprising administering to a subject having cancer a sufficient amount of a compound of formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer to provide an AUC of about 500 to 60,000 ng*h/mL of the compound in the subject's plasma or about 750 to 120,000 ng*h/mL of the compound in the subject's blood. In other such embodiments, the amount of the compound administered is sufficient to provide an AUC of about 1,000 to 30,000 ng*h/mL of the compound in the subject's plasma or about 1,500 to 60,000 ng*h/mL of the

compound in the subject's blood. In other such embodiments, the AUC is about 2,000 to 15,000 ng*h/mL of the compound in the subject's plasma or about 3,000 to 30,000 ng*h/mL of the compound in the subject's blood.

[0050] In another aspect of the invention, there is provided the use of a compound of formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, in the preparation of a medicament, in unit dosage form, for treating cancer, wherein each unit dose of the medicament is sufficient to provide at least one of

(a) a C_{max} of about 20 to 4000 ng/mL of the compound in a subject's plasma or a C_{max} of about 40 to 8000 ng/mL of the compound in the subject's blood when it is administered to the subject,

(b) about 10 to 2,000 ng/mL of the compound in a subject's plasma 24 hours after administration or about 20 to 4,000 ng/mL of the compound in the subject's blood 24 hours after administration to the subject, or

(c) an AUC of about 500 to 60,000 ng*h/mL of the compound in a subject's plasma or about 750 to 120,000 ng*h/mL of the compound in the subject's blood when it is administered to the subject.

[0051] In some embodiments of the use of a compound of formula I in the preparation of a medicament for treating cancer, each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 50 to 500 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 1000 ng/mL of the compound in the subject's blood,

(b) about 20 to 1,000 ng/mL of the compound in the subject's plasma 24 hours after administration or about 40 to 2,000 ng/mL of the compound in the subject's blood 24 hours after administration, or

(c) an AUC of about 1,000 to 30,000 ng*h/mL of the compound in the subject's plasma or about 1,500 to 60,000 ng*h/mL of the compound in the subject's blood.

[0052] In other embodiments, each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 50 to 250 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 500 ng/mL of the compound in the subject's blood,

(b) about 40 to 500 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 1,000 ng/mL of the compound in the subject's blood 24 hours after administration, or

(c) an AUC of about 2,000 to 15,000 ng*h/mL of the compound in the subject's plasma or about 3,000 to 30,000 ng*h/mL of the compound in the subject's blood.

[0053] In still other embodiments, each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 75 to 150 ng/mL of the compound in the subject's plasma or a C_{max} of about 150 to 300 ng/mL of the compound in the subject's blood, or

(b) about 40 to 250 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 500 ng/mL of the compound in the subject's blood 24 hours after administration.

[0054] In another embodiment, each unit dose is sufficient to provide a C_{max} of about 100 to 2000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 4000 ng/mL of the compound in the subject's blood; or a C_{max} of 100 to 1000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 2000 ng/mL of the compound in the subject's blood.

[0055] Typically, in the uses of the compound of formula I described herein, the lactate salt of the compound is used to prepare the medicament. Such medicaments are suitable for oral administration. The unit dosage form of the medicament includes but is not limited to a pill, capsule, tablet, gelcap, caplet, suspension, or aqueous solution. In addition, the medicament is suitable for administration by injection as a short bolus, slow infusion, or long-term infusion.

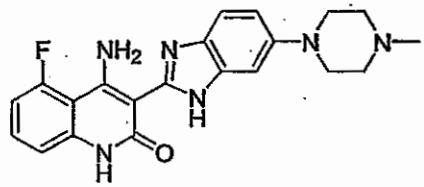
[0056] The compounds of formula I, formula II, and formula III may be accompanied with instructions that describe any of the methods of the invention. Therefore, in some embodiments, the invention provides at least one compound of formula I, formula II, and/or formula III in combination with instructions for use in a method of treating cancer or analyzing the metabolic profile of the compound of formula I.

[0057] The present invention further provides methods for treating cancer comprising administering to a subject having cancer a compound having formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, wherein the amount of compound administered in a first treatment cycle is 25 mg per day, and the amount of compound administered is increased with each subsequent treatment cycle until either 1500 mg of compound is administered to the subject per day or dose-limiting toxicity is observed in the subject. Typically in such methods, the amount of compound administered is doubled with each subsequent treatment cycle after the first. In some embodiments, the treatment cycle comprises administering the same amount of the compound daily for 7 days followed by 7 days without administration of the compound.

[0058] Likewise, in some embodiments of the use of a compound of formula I in the preparation of a medicament as described herein, each unit dose of the medicament includes from 0.25 to 30 mg/kg of the compound, tautomer, and/or salts based on the body weight of the subject. Furthermore, each unit dose of the medicament may include an amount of the compound,

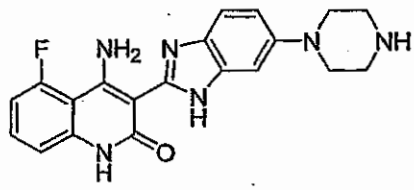
tautomer, and/or salts ranging from 25 to 1500 mg. The medicament may be arranged in a kit comprising 7, 14, 21 or 28 daily amounts of said unit doses, the kit being suitable for use in a treatment cycle comprises administering the daily amount of the compound for each of 7, 14, 21, or 28 days, followed by 7 or 14 days without administration of the compound.

[0059] In another aspect, the invention provides methods of treating cancer, comprising administering to a subject having cancer, a sufficient amount of a compound having the formula I

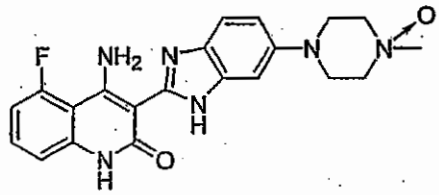


I

a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, and exposing the subject to one or both compounds of formula II and formula III selected from:



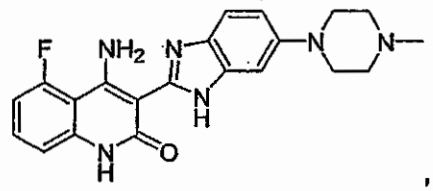
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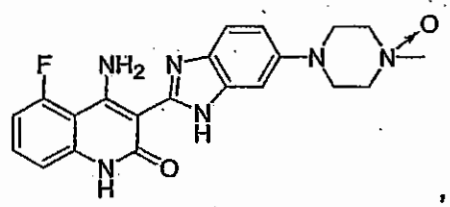


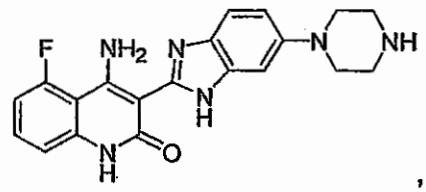
III,

whereby one or both of the compounds of formula II and formula III are produced by metabolism of the compound of formula I by the subject, to provide a combined C_{max} for one or more of the compounds of formula I, formula II, and formula III ranging from about 20 to about 4000 ng/mL in the subject's plasma or a combined C_{max} for one or more of the compounds of formula I, formula II, and formula III ranging from about 40 to about 8000 ng/mL in the subject's blood.

[0060] In yet another aspect, the present invention provides methods for treating cancer comprising exposing a subject having cancer to a sufficient amount of one or more compounds having a formula selected from:

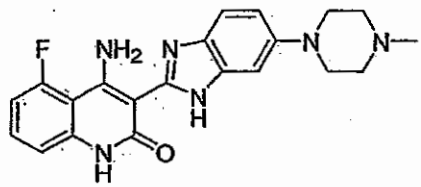




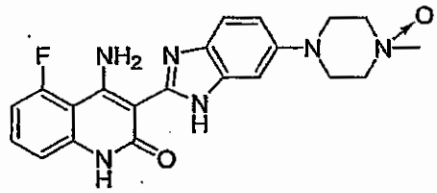


an active metabolite thereof, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, sufficient to provide a combined C_{max} of about 20 to 4000 ng/mL of the one or more compounds in the subject's plasma or a combined C_{max} of about 40 to 8000 ng/mL of the one or more compound in the subject's blood. In some embodiments, the amount of the one or more compounds provides a C_{max} for one of the compounds of about 35 to 2600 ng/mL in the subject's plasma or a

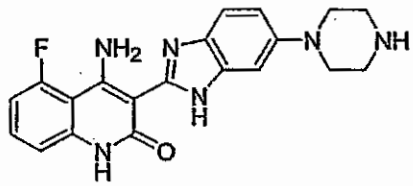
C_{max} for one of the compounds of about 35 to 6000 ng/mL in the subject's blood. In other embodiments, the amount of the one or more compounds provides a C_{max} for one of the compounds of about 35 to 1200 ng/mL in the subject's plasma or a C_{max} for one of the compounds of about 50 to 2400 ng/mL in the subject's blood. In some embodiments, the compound of formula:



a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer is administered to the subject. In other embodiments, the compound of formula:

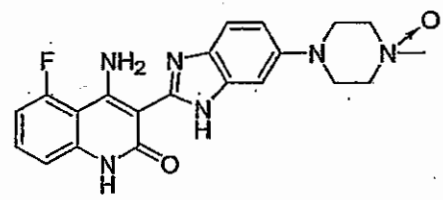


a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer is administered to the subject. In yet other embodiments, the compound of formula:



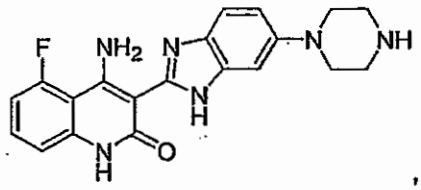
a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer is administered to the subject.

[0061] In determining the safety and/or efficacy of a compound of formula I for a particular disease, it is important to be able to monitor the pharmacokinetics and pharmacodynamics of the compound in a subject after administration of the compound. Thus, in accordance with one aspect of the invention, there are provided methods for determining a metabolic profile for a compound of formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, in a subject. The method includes measuring the amount of at least one metabolite of the compound in one or more samples of urine, blood, or tissue taken from the subject. Metabolites that may be measured by the method include an N-oxide compound having formula II:



II

also known as 4-amino-5-fluoro-3-[6-(4-methyl-4-oxidopiperazin-1-yl)-1H-benzimidazol-2-yl]quinolin-2(1H)-one, and the N-desmethyl compound having formula III:



III

also known as 4-amino-5-fluoro-3-[6-(piperazin-1-yl)-1H-benzimidazol-2-yl]quinolin-2(1H)-one. In some such methods of determining the metabolic profile of a compound of formula I, the methods include measuring the amount of the metabolite of formula II and the metabolite of formula III. The amounts of metabolites may be measured using techniques well known to

those skilled in the art, including ultraviolet (UV) spectroscopy or liquid chromatography-mass spectroscopy (LC-MS).

[0062] In other aspects of the invention, there are provided methods of determining the amount of a compound having formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer in a subject. The method includes measuring the amount of the compound in a sample of urine, blood, or tissue taken from the subject after the compound has been administered to the subject. This method may further include measuring the amount of a metabolite of the compound in the sample. Metabolites that may be measured include, but are not limited to, the N-oxide compound of formula II and/or the N-desmethyl compound of formula III. In some embodiments, the method further includes withdrawing two or more samples from the subject at different times after the compound of formula I has been administered to the subject.

[0063] In another aspect, there is provided the compound having formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, for use in a method of treating cancer comprising administering an amount of said compound to a cancer patient, in an amount sufficient to provide at least one of

(a) a C_{max} of about 20 to 4000 ng/mL of the compound in a subject's plasma or a C_{max} of about 40 to 8000 ng/mL of the compound in the subject's blood when it is administered to the subject,

(b) about 10 to 2,000 ng/mL of the compound in a subject's plasma 24 hours after administration or about 20 to 4,000 ng/mL of the compound in the subject's blood 24 hours after administration to the subject, or

(c) an AUC of about 500 to 60,000 ng*h/mL of the compound in a subject's plasma or about 750 to 120,000 ng*h/mL of the compound in the subject's blood when it is administered to the subject.

[0064] In some embodiments of the compound for use in a method of treating cancer, each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 50 to 500 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 1000 ng/mL of the compound in the subject's blood,

(b) about 20 to 1,000 ng/mL of the compound in the subject's plasma 24 hours after administration or about 40 to 2,000 ng/mL of the compound in the subject's blood 24 hours after administration, or

(c) an AUC of about 1,000 to 30,000 ng*h/mL of the compound in the subject's plasma or about 1,500 to 60,000 ng*h/mL of the compound in the subject's blood.

[0065] In other embodiments of the compound for use in a method of treating cancer, each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 50 to 250 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 500 ng/mL of the compound in the subject's blood,

(b) about 40 to 500 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 1,000 ng/mL of the compound in the subject's blood 24 hours after administration, or

(c) an AUC of about 2,000 to 15,000 ng*h/mL of the compound in the subject's plasma or about 3,000 to 30,000 ng*h/mL of the compound in the subject's blood.

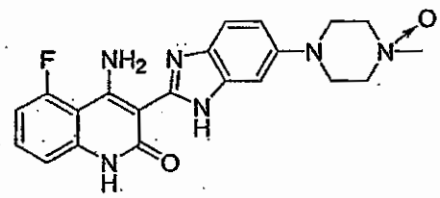
[0066] In still other embodiments of the compound for use in a method of treating cancer, each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 75 to 150 ng/mL of the compound in the subject's plasma or a C_{max} of about 150 to 300 ng/mL of the compound in the subject's blood, or

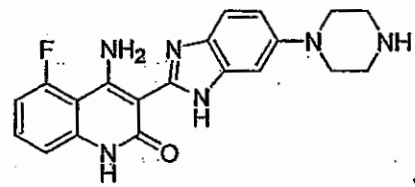
(b) about 40 to 250 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 500 ng/mL of the compound in the subject's blood 24 hours after administration.

In yet other embodiments, each unit dose is sufficient to provide a C_{max} of about 100 to 2000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 4000 ng/mL of the compound in the subject's blood; or each unit dose is sufficient to provide a C_{max} of 100 to 1000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 2000 ng/mL of the compound in the subject's blood.

[0067] There is further provided the use of a metabolite for determining a metabolic profile for a compound having formula I, a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, in a subject, the metabolite comprising at least one of an N-oxide compound of formula:



or an N-desmethyl compound of formula:



[0068] The instant invention also provides for compositions which may be prepared by mixing one or more compounds of the instant invention, or pharmaceutically acceptable salts or tautomers thereof, with pharmaceutically acceptable carriers, excipients, binders, diluents or the like, to treat or ameliorate a variety of disorders. Examples of such disorders include, but are

not limited to cancer, including prostate, colorectal, breast, multiple myeloma, pancreatic, small cell carcinoma, acute myelogenous leukemia, chronic myelogenous leukemia, myelo-proliferative disease, nonsmall cell lung, small cell lung, chronic lymphoid leukemia, sarcoma, melanoma, lymphoma, thyroid, neuroendocrine, renal cell, gastric, gastrointestinal stromal, glioma, brain or bladder. A therapeutically effective dose further refers to that amount of one or more compounds of the instant invention sufficient to result in amelioration of symptoms of the disorder. The pharmaceutical compositions of the instant invention can be manufactured by methods well known in the art such as conventional granulating, mixing, dissolving, encapsulating, lyophilizing, emulsifying or levigating processes, among others. The compositions can be in the form of, for example, granules, powders, tablets, capsules, syrup, suppositories, injections, emulsions, elixirs, suspensions or solutions. The instant compositions can be formulated for various routes of administration, for example, by oral administration, by intranasal administration, by transmucosal administration, by rectal administration, or subcutaneous administration as well as intrathecal, intravenous, intramuscular, intraperitoneal, intranasal, intraocular or intraventricular injection. The compound or compounds of the instant invention can also be administered in a local rather than a systemic fashion, such as by injection as a sustained release formulation. The following dosage forms are given by way of example and should not be construed as limiting the instant invention.

[0069] For oral, buccal, and sublingual administration, powders, suspensions, granules, tablets, pills, capsules, gelcaps, and caplets are acceptable as solid dosage forms. These can be prepared, for example, by mixing one or more compounds of the instant invention, or pharmaceutically acceptable salts or tautomers thereof, with at least one additive or excipient such as a starch or other additive. Suitable additives or excipients are fructose, sucrose, lactose, cellulose sugar, mannitol, maltitol, dextran, sorbitol, starch, agar, alginates, chitins, chitosans, pectins, tragacanth gum, gum arabic, gelatins, collagens, casein, albumin, synthetic or semi-synthetic

polymers or glycerides, methyl cellulose, hydroxypropylmethyl-cellulose, and/or polyvinylpyrrolidone. Optionally, oral dosage forms can contain other ingredients to aid in administration, such as an inactive diluent, or lubricants such as magnesium stearate, or preservatives such as paraben or sorbic acid, or anti-oxidants such as ascorbic acid, tocopherol or cysteine, a disintegrating agent, binders, a thickeners, buffers, a sweeteners, flavoring agents or perfuming agents. Additionally, dyestuffs or pigments may be added for identification. Tablets and pills may be further treated with suitable coating materials known in the art.

[0070] Liquid dosage forms for oral administration may be in the form of pharmaceutically acceptable emulsions, syrups, elixirs, suspensions, slurries and solutions, which may contain an inactive diluent, such as water. Pharmaceutical formulations may be prepared as liquid suspensions or solutions using a sterile liquid, such as, but not limited to, an oil, water, an alcohol, and combinations of these. Pharmaceutically suitable surfactants, suspending agents, emulsifying agents, may be added for oral or parenteral administration.

[0071] As noted above, suspensions may include oils. Such oils include, but are not limited to, peanut oil, sesame oil, cottonseed oil, corn oil and olive oil. Suspension preparation may also contain esters of fatty acids such as ethyl oleate, isopropyl myristate, fatty acid glycerides and acetylated fatty acid glycerides. Suspension formulations may include alcohols, such as, but not limited to, ethanol, isopropyl alcohol, hexadecyl alcohol, glycerol and propylene glycol. Ethers, such as but not limited to, poly(ethyleneglycol), petroleum hydrocarbons such as mineral oil and petrolatum; and water may also be used in suspension formulations.

[0072] For intranasal administration (*e.g.*, to deliver compounds to the brain), or administration by inhalation (*e.g.*, to deliver compounds through the lungs), the pharmaceutical formulations may be a solution, a spray, a dry powder, or aerosol containing any appropriate solvents and optionally other

compounds such as, but not limited to, stabilizers, antimicrobial agents, antioxidants, pH modifiers, surfactants, bioavailability modifiers and combinations of these. Examples of intranasal formulations and methods of administration can be found in WO 01/41782, WO 00/33813, WO 91/97947, U.S. Patent No. 6,180,603, and U.S. Patent No. 5,624,898. A propellant for an aerosol formulation may include compressed air, nitrogen, carbon dioxide, or a hydrocarbon based low boiling solvent. The compound or compounds of the instant invention are conveniently delivered in the form of an aerosol spray presentation from a nebulizer or the like.

[0073] Injectable dosage forms generally include aqueous suspensions or oil suspensions which may be prepared using a suitable dispersant or wetting agent and a suspending agent. Injectable forms may be in solution phase or in the form of a suspension, which is prepared with a solvent or diluent. Acceptable solvents or vehicles include sterilized water, Ringer's solution, or an isotonic aqueous saline solution. Alternatively, sterile oils may be employed as solvents or suspending agents. Preferably, the oil or fatty acid is non-volatile, including natural or synthetic oils, fatty acids, mono-, di- or tri-glycerides.

[0074] For injection, the pharmaceutical formulation may be a powder suitable for reconstitution with an appropriate solution as described above. Examples of these include, but are not limited to, freeze dried, rotary dried or spray dried powders, amorphous powders, granules, precipitates, or particulates. For injection, the formulations may optionally contain stabilizers, pH modifiers, surfactants, bioavailability modifiers and combinations of these. The compounds may be formulated for parenteral administration by injection such as by bolus injection or continuous infusion. A unit dosage form for injection may be in ampoules or in multi-dose containers.

[0075] Thus, in the present methods of treating cancer described herein, the compound may be administered by injection as a short bolus, slow infusion, or long-term infusion. The injection may be administered once,

twice, three times, or four times daily. A short bolus is generally administered over a period of about 1 to 30 minutes; a slow infusion is generally administered over a period of about 30 minutes to 6 hours; and a long-term infusion is generally administered for a period from over 6 hours up to about seven days.

[0076] For rectal administration, the pharmaceutical formulations may be in the form of a suppository, an ointment, an enema, a tablet or a cream for release of compound in the intestines, sigmoid flexure and/or rectum. Rectal suppositories are prepared by mixing one or more compounds of the instant invention, or pharmaceutically acceptable salts or tautomers of the compound, with acceptable vehicles, for example, cocoa butter or polyethylene glycol, which is present in a solid phase at normal storing temperatures, and present in a liquid phase at those temperatures suitable to release a drug inside the body, such as in the rectum. Oils may also be employed in the preparation of formulations of the soft gelatin type and suppositories. Water, saline, aqueous dextrose and related sugar solutions, and glycerols may be employed in the preparation of suspension formulations which may also contain suspending agents such as pectins, carbomers, methyl cellulose, hydroxypropyl cellulose or carboxymethyl cellulose, as well as buffers and preservatives.

[0077] Besides those representative dosage forms described above, pharmaceutically acceptable excipients and carriers are generally known to those skilled in the art and are thus included in the instant invention. Such excipients and carriers are described, for example, in "Remingtons Pharmaceutical Sciences" Mack Pub. Co., New Jersey (1991), which is incorporated herein by reference.

[0078] The formulations of the invention may be designed for to be short-acting, fast-releasing, long-acting, and sustained-releasing as described below. Thus, the pharmaceutical formulations may also be formulated for controlled release or for slow release.

[0079] The instant compositions may also comprise, for example, micelles or liposomes, or some other encapsulated form, or may be administered in an extended release form to provide a prolonged storage and/or delivery effect. Therefore, the pharmaceutical formulations may be compressed into pellets or cylinders and implanted intramuscularly or subcutaneously as depot injections or as implants such as stents. Such implants may employ known inert materials such as silicones and biodegradable polymers.

[0080] A therapeutically effective dose refers to that amount of the compound that results in amelioration of symptoms. Specific dosages may be adjusted depending on conditions of disease, the age, body weight, general health conditions, sex, diet of the subject, dose intervals, administration routes, excretion rate, and combinations of drugs. Any of the above dosage forms containing effective amounts are well within the bounds of routine experimentation and therefore, well within the scope of the instant invention. A therapeutically effective dose may vary depending upon the route of administration and dosage form. The preferred compound or compounds of the instant invention is a formulation that exhibits a high therapeutic index. The therapeutic index is the dose ratio between toxic and therapeutic effects which can be expressed as the ratio between LD_{50} and ED_{50}. The LD_{50} is the dose lethal to 50% of the population and the ED_{50} is the dose therapeutically effective in 50% of the population. The LD_{50} and ED_{50} are determined by standard pharmaceutical procedures in animal cell cultures or experimental animals.

[0081] The present invention also provides methods of enhancing anticancer activity in a human or non-human animal. The method comprises administering an effective amount of a compound, or composition, of the instant invention to said mammal or non-human animal. Effective amounts of the compounds of the instant invention include those amounts that inhibit RTK, which are detectable, for example, by an assay herein described, or any other assay known by those skilled in the art that detect signal transduction, in

a biochemical pathway, through activation of G-protein coupled receptors, for example, by measuring an elevated cAMP level as compared to a control model. Effective amounts may also include those amounts which alleviate symptoms of a RTK disorder treatable by inhibiting RTK.

[0082] An RTK disorder, or RTK-mediated disease, which may be treated by those methods provided, include any biological disorder or disease in which an RTK is implicated, or which inhibition of and RTK potentiates a biochemical pathway that is defective in the disorder or disease state. Examples of such diseases are cancers such as prostate, colorectal, breast, multiple myeloma, pancreatic, small cell carcinoma, acute myelogenous leukemia, chronic myelogenous leukemia, or myelo-proliferative disease.

[0083] Synthesis of compound **1** has been disclosed in U.S. Patent No. 6,605,617. To confirm the identities of compounds 2 and 3, metabolites of compound **1**, compounds 2 and 3, were independently synthesized as shown in Example 6.

[0084] The present invention, thus generally described, will be understood more readily by reference to the following examples, which are provided by way of illustration and are not intended to be limiting of the present invention.

EXAMPLES

[0085] The following abbreviations and terms are used throughout the Examples:

ATP:	Adenosine triphosphate
AUC:	Area under the curve
BSA:	Bovine serum albumin
DMSO:	Dimethylsulfoxide
EDTA:	Ethylenediamine tetraacetic acid
ERK:	Extracellular regulated kinase
Hepes:	N-(2-hydroxyethyl) piperazine-N'-(2-ethanesulfonic acid)
HPLC:	High perfomance liquid chromatography
HMVEC:	Human microvascular endothelial cells
kg:	Kilogram
LC:	Liquid Chromatography
MAPK:	Mitogen activated protein kinase
MS:	Mass Spectroscopy
MeOH:	Methanol
mg:	Milligram
mL:	Milliliter
MTS:	[3-(4,5-dimethyl-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium, inner salt
nM:	Nanomolar
PBS:	Phosphate buffered saline
NMR:	Nuclear magnetic resonance spectroscopy
RT-PCR:	Reverse transcriptase-polymerase chain reaction
SCF:	Stem Cell Factor
TFA:	Trifluoroacetic acid
$T_{1/2}$:	Half life – the time required for 50% of a compound to be eliminated from a biological system.
µg:	Microgram(s)
µL:	Microliter(s)
µM:	Micromolar
UV:	Ultraviolet spectroscopy

Example 1

[0086] The antiproliferative activities of 4-amino-5-fluoro-3-[6-(4-methylpiperazin-1-yl)-1H-benzimidazol-2-yl]quinolin-2(1H)-one (compound **1**) were tested against a large number of cancer cell lines and primary non-malignant cell lines. Methods were as follows: Cells were plated in 96-well plates; after three to five hours gelling time for adherent cell lines delusions of the compounds were added, three days later viable cells were determined by adding MTS solution (Promega). Absorbance at 490 nm was measured and EC_{50} values calculated using non linear regression. For the HMVEC assay, compounds were incubated with the cells for three days in the presence of five ng/mL recombinant VEGF. For the SCF/c-KIT assay the TF-1 and H526 cells were incubated for three days in the presence of 40 ng/mL and 100 ng/mL recombinant SCF, respectively. Proliferation was assayed by adding MTS solution and measuring the absorbance at 490 nm. EC_{50}s were calculated by non-linear regression. Results are shown in Table 1.

[0087] In a subset of the cancer cell lines and the endothelial cells, proliferation was inhibited with $EC_{50} \leq 50$ nM, consistent with their dependence on an RTK targeted by compound **1** (MV4; 11: expression of constitutively active FLT3; HMVEC: VEGFR2 mediated proliferation; TF-1: c-KIT mediated proliferation) with the exception of the KM12L4a cell line. Even though this cell line does express some of the targeted RTKs (e.g., VEGFR ½ and PDGFR determined by RT-PCR), experiments showed that the inhibition of these individual RTKs does not fully explain the potent antiproliferative effects observed with compound **1**. This finding suggests that either the inhibition of multiple RTKs or as yet unidentified effects may be responsible for the antiproliferative effect mediated by compound **1** in this cell line.

[0088] The majority of cell lines showed an antiproliferative response when incubated with compound **1** with EC_{50}s between 1 and 10 μM including two primary cell lines HMEC (human normal mammary epithelial cells) and

PrEC (normal human prostate epithelial cells). Consistent with *in vitro* results, the growth of both the KM12L4a and MV4;11 xenografts in mice were potently inhibited by compound **1** *in vivo*.

Table 1

EC_{50}≤50 nM	EC_{50} 0.4- 1μM	EC_{50} 1-10 μM	EC_{50} > 10 μM
MV4; 11 (AML) KM12L4a (colon cancer) HMVEC (VEGF/VEGF R2 mediated; endothelium) TF-1 (SCF/ c-KIT mediated; AML)	RS4 (ALL) 4T1 (mouse breast cancer)	MDA-MB435 (breast cancer) SKOV3 (ovarian cancer) K562 (CML) Ku812 (CML) MOLT-4 (ALL) ARH77 (multiple myeloma) HCT116 (colon cancer) Du145 (prostate cancer) PC3 (prostate cancer) H209 (lung cancer) H226 (lung cancer) HT29 (colon cancer) SW620 (colon cancer) PrC (normal prostate epithelium) HMEC (normal mammary epithelium)	U87 (brain cancer)

[a]all cell lines tested were of human origin unless otherwise noted.

Example 2

[0089] Two metabolites of compound **1** were identified and partially characterized in pooled rat plasma from a 2 week toxicology study. Day 1 and day 14 dosed animal plasmas were analyzed by UV and LC/MS from once a day 30 or 80 mg/kg, PO, dose groups. The two identified metabolites were the piperazine N-oxide compound of formula II (compound **2**) and the N-

demethylated compound of formula III (compound 3) (see Example 6 for synthesis and characterization of these compounds). Estimated levels of the metabolites (based on UV absorbance and in comparison to known levels of compound 1 quantified in the same samples from previous analyses) are given in Table 2. The N-desmethyl metabolite was found to be in substantially lower abundance than compound 1 in all samples of post dosed pooled plasmas. The N-oxide metabolite was observed to be present in lower abundance than compound 1 except at 24 hours on day 14 in the 80 mg/kg dose group and 1-2 hours on day 1 in the 30 mg/kg dose group (Table 2). The metabolic profile does not change with dose or duration of dose. Generally the metabolite levels increase in tandem with compound 1 levels with dose escalation.

[0090] With both dose groups, the duration of dose, Day 1 vs 14 , does not appear to result in an increase in plasma levels of metabolites alone (Table 2) or as compared to compound 1 levels. Compound 1 levels decrease with duration of dose and this is reflected by a decrease in metabolite levels as well. This suggests that time dependent reduction in exposure of compound 1 is not reflected in increased metabolism. The day 14, 24 hr samples contained compound 1 and metabolites at lower levels than the 24 hour samples on day 1 indicating that there is no accumulation of metabolites or compound 1 with a once a day dosage regimen of 30 or 80 mg/kg. The N-oxide metabolite is present in higher abundance than the N-desmethyl metabolite at all assayed time points in the 80 mg/kg dose group and in all but the 24 hr time points after day 1 in the 30 mg/kg dose group. The N-desmethyl metabolite levels appear to fall more slowly than that of compound 1 suggesting a longer $T_{1/2}$ and indicating that the plasma levels of this metabolite are likely determined by its rate of elimination and not its rate of formation as is, in contrast, likely for the N-oxide.

Table 2.: Compound **1** Levels and Estimated Compound **1** Metabolite Levels in Rat Plasma

Dose (mg/kg)	Day	Sample Time (hr)	Des-CH_3 (ng/ml)[1]	N-oxide (ng/ml)[1]	Compound **1** (ng/ml)[2]
30	1	0	0	0	0
30	1	1-2	14	1090	635
30	1	4-8	48	310	943
30	1	24	22	25	54
30	14	0	6	1.3	20
30	14	1-2	6	135	467
30	14	4-8	12	220	442
30	14	24	4	0.4	8
100	1	0	0	0	0
100	1	1-2	35	424	1212
100	1	4-8	84	779	2075
100	1	24	83	137	500
100	14	0	15	67	162
100	14	1-2	17	122	628
100	14	4-8	19	533	1099
100	14	24	10	102	33

1 : Metabolite levels estimated based on metabolite UV absorbance areas in comparison to compound **1** UV areas and using previously reported compound **1** levels. 2: Compound **1** levels previously quantified in a separate study from the same plasma samples analyzed herein.

Example 3

In vitro kinase assays for receptor tyrosine kinases

[0091] The kinase activity of a number of protein tyrosine kinases was measured by providing ATP and an appropriate peptide or protein containing a tyrosine amino acid residue for phosphorylation, and assaying for the transfer of phosphate moiety to the tyrosine residue. Recombinant proteins corresponding to the cytoplasmic domains of the FLT-1 (VEGFR1), VEGFR2, VEGFR3, Tie-2, PDGFRα, PDGFRβ, and FGFR1 receptors were expressed in Sf9 insect cells using a Baculovirus expression system (InVitrogen) and may be purified via Glu antibody interaction (for Glu-epitope tagged constructs) or by Metal Ion Chromatography (for His_6 (SEQ ID NO: 1) tagged constructs). For each assay, test compounds were serially diluted in DMSO and then mixed with an appropriate kinase reaction buffer plus ATP. Kinase

protein and an appropriate biotinylated peptide substrate were added to give a final volume of 50-100 µL, reactions were incubated for 1-3 hours at room temperature and then stopped by addition of 25-50 µL of 45 mM EDTA, 50 mM Hepes pH 7.5. The stopped reaction mixture (75 µL) was transferred to a streptavidin-coated microtiter plate (Boehringer Mannheim) and incubated for 1 hour. Phosphorylated peptide product was measured with the DELFIA time-resolved fluorescence system (Wallac or PE Biosciences), using a Europium labeled anti-phosphotyrosine antibody PT66 with the modification that the DELFIA assay buffer was supplemented with 1 mM $MgCl_2$ for the antibody dilution. Time resolved fluorescence was read on a Wallac 1232 DELFIA fluorometer or a PE Victor II multiple signal reader. The concentration of each compound for 50% inhibition (IC_{50}) was calculated employing non-linear regression using XL Fit data analysis software.

[0092] FLT-1, VEGFR2, VEGFR3, FGFR3, Tie-2, and FGFR1 kinases were assayed in 50 mM Hepes pH 7.0, 2 mM $MgCl_2$, 10 mM $MnCl_2$, 1 mM NaF, 1 mM DTT, 1 mg/mL BSA, 2 µM ATP, and 0.20-0.50 µM corresponding biotinylated peptide substrate. FLT-1, VEGFR2, VEGFR3, Tie-2, and FGFR1 kinases were added at 0.1 µg/mL, 0.05 µg/mL, or 0.1 µg/mL respectively. For the PDGFR kinase assay, 120 µg/mL enzyme with the same buffer conditions as above was used except for changing ATP and peptide substrate concentrations to 1.4 µM ATP, and 0.25 µM biotin-GGLFDDPSYVNVQNL-NH_2 (SEQ ID NO: 2) peptide substrate. Each of the above compounds displayed an IC_{50} value of less than 10 µM with respect to FLT-1, VEGFR2, VEGFR3, and FGFR1.

[0093] Recombinant and active tyrosine kinases Fyn, and Lck are available commercially and were purchased from Upstate Biotechnology. For each assay, test compounds were serially diluted in DMSO and then mixed with an appropriate kinase reaction buffer plus 10 nM ^{33}P gamma-labeled ATP. The kinase protein and the appropriate biotinylated peptide substrate were added to give a final volume of 150 µL. Reactions were incubated for 3-

4 hours at room temperature and then stopped by transferring to a streptavidin-coated white microtiter plate (Thermo Labsystems) containing 100 µL of stop reaction buffer of 100 mM EDTA and 50 µM unlabeled ATP. After 1 hour incubation, the streptavidin plates were washed with PBS and 200 µL Microscint 20 scintillation fluid was added per well. The plates were sealed and counted using TopCount. The concentration of each compound for 50% inhibition (IC_{50}) was calculated employing non-linear regression using XL Fit data analysis software.

[0094] The kinase reaction buffer for Fyn, Lck, and c-ABL contained 50 mM Tris-HCl pH 7.5, 15 mM MgCl2, 30 mM $MnCl_2$, 2 mM DTT, 2 mM EDTA, 25 mM beta-glycerol phosphate, 0.01% BSA/PBS, 0.5 µM of the appropriate peptide substrate (biotinylated Src peptide substrate: biotin-GGGGKVEKIGEGTYGVVYK-NH_2 (SEQ ID NO: 3) for Fyn and Lck), 1 µM unlabeled ATP, and 1 nM kinase.

[0095] The kinase activity of c-Kit and FLT-3 were measured by providing ATP and a peptide or protein containing a tyrosine amino acid residue for phosphorylation, and assaying for the transfer of phosphate moiety to the tyrosine residue. Recombinant proteins corresponding to the cytoplasmic domains of the c-Kit and FLT-3 receptors were purchased (Proquinase). For testing, an exemplary compound, for example 4-amino-5-fluoro-3-[5-(4-methylpiperazin-1-yl)-1H-benzimidazol-2-yl]quinolin-2(1H)-one, was diluted in DMSO and then mixed with the kinase reaction buffer described below plus ATP. The kinase protein (c-Kit or FLT-3) and the biotinylated peptide substrate (biotin-GGLFDDPSYVNVQNL-NH2 (SEQ ID NO: 2)) were added to give a final volume of 100 µL. These reactions were incubated for 2 hours at room temperature and then stopped by addition of 50 µL of 45 mM EDTA, 50 mM HEPES, pH 7.5. The stopped reaction mixture (75 µL) was transferred to a streptavidin-coated microtiter plate (Boehringer Mannheim) and incubated for 1 hour. Phosphorylated peptide product was measured with the DELPHIA time-resolved fluorescence system (Wallac or

PE Biosciences), using a Europium-labeled anti-phosphotyrosine antibody, PT66, with the modification that the DELFIA assay buffer was supplemented with 1 mM $MgCl_2$ for the antibody dilution. Time resolved fluorescence values were determined on a Wallac 1232 DELFIA fluorometer or a PE Victor II multiple signal reader. The concentration of each compound for 50% inhibition (IC_{50}) was calculated employing non-linear regression using XL Fit data analysis software.

[0096] FLT-3 and c-Kit kinases were assayed in 50 mM Hepes pH 7.5, 1 mM NaF, 2 mM $MgCl_2$, 10 mM $MnCl_2$ and 1mg/mL BSA, 8 μM ATP and 1 μM of corresponding biotinylated peptide substrate (biotin-GGLFDDPSYVNVQNL-NH2 (SEQ ID NO: 2)). The concentration of FLT-3 and c-Kit kinases were assayed at 2 nM.

IC_{50}s were measured for the metabolites of compound **1** and are shown in Table 3 along with IC_{50}s of compound **1** for comparison.

Table 3.

Compound	IC_{50} (μM)					
	VEGFR flt	VEGFR flk1	bFGFR	PDGFR	Flt3	c-kit
Compound **1**	0.010	0.013	0.008	0.027	0.0001	0.0015
Compound **2**	0.004	0.009	0.005	0.010	0.0004	0.0002
Compound **3**	0.019	0.012	0.019	0.037	0.0001	0.0002

Example 4

[0097] This single agent study evaluated daily oral dosing of compound **1** in the KM12L4a human colon tumor model.

[0098] Female Nu/Nu mice, aged 7-8 weeks (Charles River), were implanted with $2x10^6$ KM12L4a cells subcutaneously in the right flank. Treatment began 7 days later when average tumor volume was 125 mm^3. This was designated as study day 1. Compound **1** was formulated as a solution in 10 mM H_3PO_4 and administered by oral gavage.

[0099] Seven treatment groups were included in the study, (n=10/group): vehicle (water) *p.o., q.d.*; and six groups of compound **1** doses: 3, 10, 30, 100, 200, 300 mg/kg *p.o., q.d.*

[0100] Plasma samples were drawn from satellite animals in each dose group on various days to characterize the pharmacokinetics of compound **1** in tumor-bearing mice (N=2/timepoint/dose group). Tissue and tumor concentrations of compound **1** were determined in samples collected from animals in the 100 and 200 mg/kg dose group at 8 and 24 hours post-dose on Day 22 (N=2/timepoint/dose group).

[0101] Plasma compound **1** concentrations were determined by a non-validated LC/MS/MS assay with a calibration range of 1 to 8000 ng/mL and a lower limit of quantitation (LLOQ) of 1 ng/mL (Charles River Laboratories, Worcester, MA. Tissue and tumor compound **1** concentrations were also determined using a non-validated LC/MS/MS assay with a calibration range of 20 to 43740 ng/g and a LLOQ of 20 ng/g.

[0102] Composite pharmacokinetic parameters (C_{max} and AUC) were obtained using standard noncompartmental analysis from mean plasma compound concentration-time data in each dose group on each sampling day (WinNonlin Professional, version 4). The reported AUC values were determined using 3 concentration-time data points. Predose concentration values were reported as those observed immediately prior to dosing.

[0103] Significant dose-dependent inhibition in tumor growth was observed at all doses by 4-7 days of treatment (see Table 4). The calculated ED_{50} was 17 mg/kg. Tumor regressions of > 50% of initial size were observed

in the majority of mice dosed with compound **1** at 200 and 300 mg/kg, however these doses were not tolerated for the entire study duration. By days 12-16, mice treated with 300 mg/kg lost 20-30% body weight and were euthanized. In those treated with 200 mg/kg, 1 of 10 was euthanized on day 14 with 22% wt loss, and the remaining mice were euthanized days 21-24 with > 25% weight loss. Mice were dosed for 37 days with 100 mg/kg and remained at 98% of initial weight; tumors remained stable at this dose (Figure 1). The vehicle group was taken down on day 9, and tumor growth inhibition (TGI) was calculated. (Table 4).

Table 4. Dose response activity of Compound **1**

Daily dose compound **1** (n=9-10/gp)	Tumor Vol Day 9 Mean ± SD (mm^3)	Treated/ Control	% Tumor Growth Inhibition	P value vs. Vehicle
Vehicle	1333 ± 283	-	-	-
3 mg/kg	1168 ± 202	0.88	12	0.1519
10 mg/kg	861 ± 321	0.65	35	0.0037
30 mg/kg	553 ± 213	0.42	58	≤0.00001
100 mg/kg	263 ± 108	0.20	80	≤0.00001
200 mg/kg	98 ± 40	0.07	93	≤0.00001
300 mg/kg	74 ± 30	0.06	94	≤0.00001

[0104] On the second day of dosing (Day 2), plasma concentrations of compound **1** increased proportionally with dose (Table 5) in all dosing groups. Following multiple dosing for at least 2 weeks, plasma concentrations were comparable to those on Day 2, suggesting no accumulation upon once daily dosing in mice (Table 5). Similarly, predose plasma concentration of compound **1** collected on Days 3, 8, and 15 were similar within each dose group, suggesting that steady state was reached after Day 2. Therefore,

these data suggest that compound **1** follows dose-and time-independent pharmacokinetics in tumor-bearing mice.

[0105] Tumor growth inhibition of 35-60% was observed at doses of 10 and 30 mg/kg, respectively. The corresponding plasma exposure of compound **1**, as assessed by C_{max} and AUC values, ranged from 163-742 ng/mL and 1420-5540 ng*hr/mL, respectively (Figure 2). The corresponding plasma predose concentration values ranged from 2-135 ng/mL.

Table 5. Composite Compound 1 Pharmacokinetic Parameters and Plasma Concentrations-Time Data Following Once-Daily Oral Dosing of Compound 1 to Mice Bearing SC KM1214a Tumors

Dose (mg/kg/day)	Day	Composite Pharmacokinetic Parameters		Mean Plasma Concentrations (ng/mL)			
				Time (hr)			
		C_{max} (ng/mL)	AUC (ng*hr/mL)[1]	0*	2	8	24*
3	2	48	420		48.0	12.7	11.1
	8	–	–	1.55			
10	2	163	1420		163	67.3	2.72
	8	–	–	2.37			
	15	–	–	3.95			
	17	–	–		136	65.8	
30	2	742	5540		742	228	8.42
	8	–	–	7.37			
	15	–	–	23.7			
	17	–	–		416	123	
100	2	1560	18500		1560	1050	97.8
	8	–	–	135			
	15	–	–	54.7			
	22	1550	21200		1550	1330	47.7
200	2	2500	47200		2370	2500	1270
	8	–	–	454			
	15	–	–	434			
	22	1940	3 1600		1940	1400	1050
300	2	3450	61300		3450	2900	1950
	8	–	–	911			
	15	–	–	1220			
	18	2980	58400		2440	2250	2980

[1] AUC calculated from 3 concentration-time data pairs
– Not determined

* Predose concentrations

[0106] Tissue concentrations of compound **1** on Day 22 were higher than those in plasma in the 100 and 200 mg/kg dose groups at each of the two sampling times (8 and 24 hours postdose) (Table 6). Brain or heart concentrations of compound **1** were 13- to 34-fold higher than those in plasma; whereas liver, lung, and kidney concentrations were 40- to 126-fold higher than those in plasma at 8 or 24 hours postdose in these two dose groups. In general, the ratio of tissue-to-plasma concentrations at 8 hours

was comparable to that at 24 hours. Furthermore, tissue concentrations at 24 hours were consistently lower compared to those at 8 hours. Taken together, these results suggest that tissue concentrations of compound 1 appeared to decline in parallel with those in plasma. Therefore, compound 1 appears to be widely distributed into tissues (including brain) relative to plasma but does not accumulate in tissues following multiple oral dosing.

Table 6. Mean Tissue, Tumor and Plasma Concentrations on Day 22 Following Once-Daily Oral Administration of 100 or 200 mg/kg/day compound 1 to KM12L4a Tumor-Bearing Mice

Dose	Time	Tissue Concentrations (ng/g)						Plasma Conc
(mg/kg)	(hr)	Brain	Heart	Kidney	Liver	Lung	Tumor	(ng/mL)
100	8	16900	24700	83700	107000	87500	48500	1330
	24	675	1630	3900	5080	3170	16900	47.7
200	8	24200	40400	143000	176000	277000	107000	1400
	24	9160	18700	82800	109000	41600	87900	1050

N=2/timepoint/dose group, except in the 200 mg/kg at 24 hr, where N=1

[0107] Tumor compound 1 concentrations on Day 22 were 37- to 354-fold higher than those in plasma in the 100 and 200 mg/kg dose groups at each of the two sampling times (8 and 24 hours postdose). However, tumor concentrations at 24 hours were only 17 to 65% lower than those at 8 hours postdose in these two dose groups suggesting a somewhat slower elimination rate from tumors compared to that from other normal tissues (such as, brain, heart, liver, lung, and kidneys). Therefore, compound 1 appears to be extensively distributed to tumors relative to plasma but may exhibit preferential retention in tumor relative to plasma or normal tissues.

[0108] In summary, the efficacy and tolerability of compound 1 was dose related, with significant inhibitions after 4 to 7 days of treatment. Tumor regressions were observed at 300 and 200 mg/kg; these doses were tolerated daily for approximately 14 and 21 days, respectively. Weight loss was the

clinical sign associated with toxicity. Doses of 100 mg/kg were tolerated for 37 days with no adverse clinical signs, with tumor growth inhibition of 80% compared to control. 30 mg/kg inhibited growth by 60%. Compound **1** demonstrated dose- and time-independent pharmacokinetics in tumor-bearing mice. Plasma compound **1** C_{max}, AUC, and C_{min} values associated with 35-60% tumor growth inhibition ranged from 163-742 ng/mL, 1420-5540 ng*hr/mL, and 2-135 ng/mL, respectively. Compound **1** was distributed widely to tissues, however did not appear to accumulate in tissues following multiple oral dosing. There was a trend towards preferential retention of compound **1** in tumors relative to other tissues following oral dosing.

Example 5

[0109] This single agent study evaluated intermittent oral dosing of compound **1** in the PC3 human prostate tumor model.

[0110] Male SCID mice, aged 9-10 weeks, were implanted with 5 million PC3 human prostate cells subcutaneously in the flank. Treatment began when tumors reached 150 mm^3. This was designated as study day 1. Compound **1** was formulated as an aqueous solution and administered by oral gavage.

[0111] Five treatment groups were included in the study, (n = 10/group): Vehicle (water) *p.o., q.d.*; and four groups of compound **1** doses of 100 mg/kg q.d., q.2.d., q.3.d., q.4.d.

[0112] As shown in Table 7 significant and similar tumor inhibition results were observed in all treatment groups. The study was suspended for the daily dosing group on day 11. The study was terminated on study day 25 for the remaining groups and mean tumor volume was measured and compared to vehicle. As a clinical indication of toxicity percentage weight loss was measured for each group.

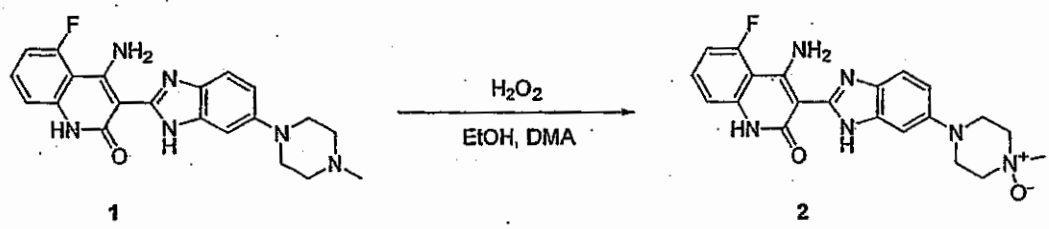
Table 7

Group	n	Total doses compound 1	Mean Tumor Volume day 25	% TGI vs. vehicle	Mean % Wt. loss (range)
Vehicle	10		2011		13 (1-24%)
100 mpk q d, days 1-11	8	11	790	60%	12 (3-35%)
100 mpk q 2 days	10	13	507	75%	4 (0-13%)
100 mpk q 3 days	10	9	645	68%	4 (0-11%)
100 mpk q 4 days	9	7	686	66%	10 (5-17%)

Example 6

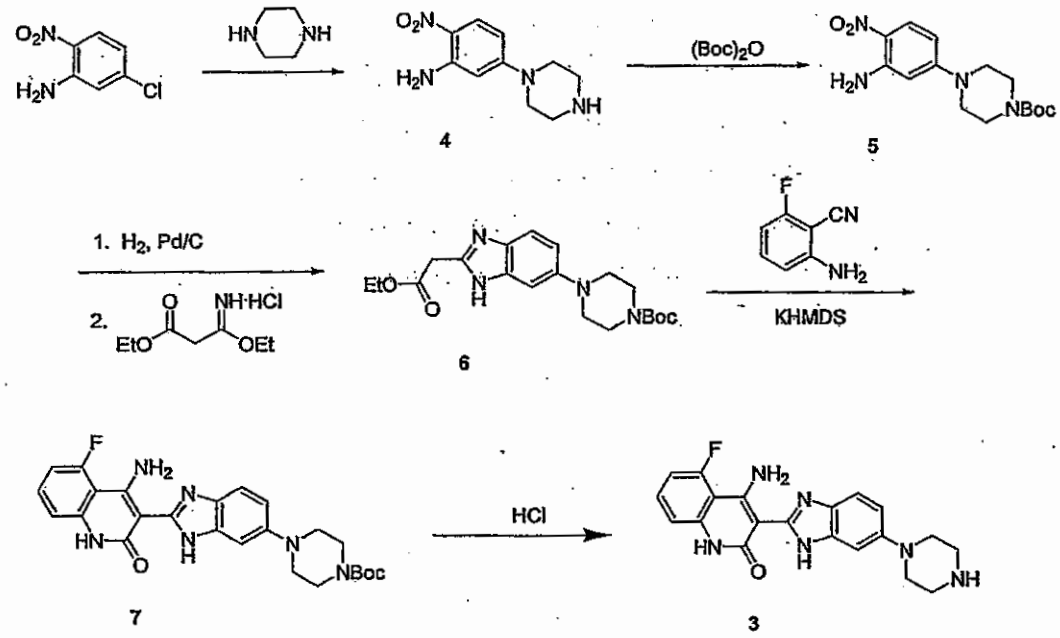
[0113] To confirm the structures of the identified metabolites of compound 1, the metabolites were independently synthesized.

[0114] Compound **2**, the N-oxide metabolite of compound **1**, was synthesized as shown in the scheme below. Compound **1** was heated in a mixture of ethanol, dimethylacetamide and hydrogen peroxide. Upon completion of the reaction, compound **2** was isolated by filtration and washed with ethanol. If necessary, the product could be further purified by column chromatography.



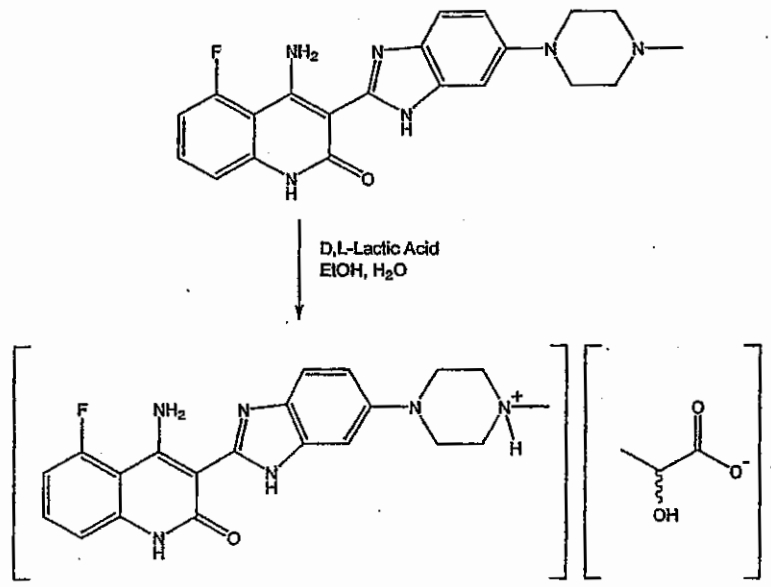
1 2

Compound **3**, the N-desmethyl metabolite of compound **1**, was synthesized as shown in the scheme below. 5-Chloro-2-nitroaniline was treated with piperazine to yield **4** which was subsequently protected with a butyloxycarbonyl (Boc) group to yield **5**. Reduction of the nitro group followed by condensation with 3-ethoxy-3-iminopropionic acid ethyl ester gave **6**. Condensation of **6** with 6-fluoroanthranilonitrile using potassium hexamethyldisilazide as the base yielded **7**. Crude **7** was treated with aqueous HCl to yield the desired metabolite as a yellow/brown solid after purification.



Example 7

Preparation of Lactic Acid salt of Compound 1



[0115] A 3000 mL 4-necked jacketed flask was fitted with a condenser, a temperature probe, a N_2 gas inlet, and a mechanical stirrer. The reaction

vessel was purged with N_2 for at least 15 minutes and then charged with 4-amino-5-fluoro-3-[6-(4-methyl-piperazin-1-yl)-1H-benzimidazol-2-yl]-1H-quinolin-2-one (484 g, 1.23 mol). A solution of D,L-Lactic acid (243.3 g, 1.72 mol of monomer-see the following paragraph), water (339 mL), and ethanol (1211 mL) was prepared and then charged to the reaction flask. Stirring was initiated at a medium rate, and the reaction was heated to an internal temperature of 68-72°C. The internal temperature of the reaction was maintained at 68-72°C for 15-45 minutes and then heating was discontinued. The resulting mixture was filtered through a 10-20 micron frit collecting the filtrate in a 12 L flask. The 12 L flask was equipped with an internal temperature probe, a reflux condenser, an additional funnel, a gas inlet an outlet, and an overhead stirrer. The filtrate was then stirred at a medium rate and heated to reflux (internal temperature of about 78°C). While maintaining a gentle reflux, ethanol (3,596 mL) was charged to the flask over a period of about 20 minutes. The reaction flask was then cooled to an internal temperature ranging from about 64-70°C within 15-25 minutes and this temperature was maintained for a period of about 30 minutes. The reactor was inspected for crystals. If no crystal were present, then crystals of the lactic acid salt of 4-amino-5-fluoro-3-[6-(4-methyl-piperazin-1-yl)-1H-benzimidazol-2-yl]-1H-quinolin-2-one (484 mg, 0.1 mole %) were added to the flask, and the reaction was stirred at 64-70°C for 30 minutes before again inspecting the flask for crystals. Once crystals were present, stirring was reduced to a low rate and the reaction was stirred at 64-70°C for an additional 90 minutes. The reaction was then cooled to about 0°C over a period of about 2 hours, and the resulting mixture was filtered through a 25-50 micron fritted filter. The reactor was washed with ethanol (484 mL) and stirred until the internal temperature was about 0°C. The cold ethanol was used to wash the filter cake, and this procedure was repeated 2 more times. The collected solid was dried to a constant weight at 50°C under vacuum in a vacuum oven yielding 510.7 g (85.7%) of the crystalline yellow lactic acid salt of 4-amino-5-fluoro-3-[6-(4-methyl-piperazin-1-yl)-1H-benzimidazol-2-yl]-1H-quinolin-2-one.

A rubber dam or inert conditions were typically used during the filtration process. While the dry solid did not appear to be very hygroscopic, the wet filter cake tends to pick up water and become sticky. Precautions were taken to avoid prolonged exposure of the wet filter cake to the atmosphere.

[0116] Commercial lactic acid generally contains about 8-12% w/w water, and contains dimers and trimers in addition to the monomeric lactic acid. The mole ratio of lactic acid dimer to monomer is generally about 1.0:4.7. Commercial grade lactic acid may be used in the process described in the preceding paragraph as the monolactate salt preferentially precipitates from the reaction mixture. Lactic acid monomer is purified according to the following procedure.

Example 8

[0117] This study evaluated the antiangiogenic potential of compound **1** in the FGF supplemented Matrigel model.

[0118] Female BDF1 mice, aged 11-12 weeks (Charles River, Wilmington, MA), were subcutaneously implanted with 0.5 mL Matrigel (BD Biosciences, Bedford, MA) supplemented with 2μg FGF-2. The FGF-2 supplemented blood vessel formation (neovascularization or angiogenesis) was quantified by measuring hemoglobin levels in the Matrigel plugs following their removal from the animals.

[0119] Oral administration of test article began one day prior to Matrigel implantation and continued once daily for eight doses. Compound **1** was formulated as a solution in 10 mM H_3PO_4. Twelve treatment groups were included: vehicle (10 mM H_3PO_4) *p.o., q.d.*x 8 days (2 control groups; mice implanted with unsupplemented Matrigel (baseline hemoglobin level) or FGF-supplemented Matrigel (positive control); compound **1** dosed at 3, 10, 30, 100, 200, 300 mg/kg *p.o., q.d.* x 8 days. There were 8 mice per group, except for mice dosed at 200 and 300 mg/kg, which were 4 per group.

[0120] Percent inhibition of hemoglobin levels in compound-treated mice compared to mice treated with vehicle indicates the antiangiogenic potency of the compound. Results are expressed as total hemoglobin (mg/dL) per Matrigel plug. The ED_{50} is defined as the dose that effectively inhibits angiogenesis by approximately 50%. Hemoglobin concentrations were determined in homogenized Matrigel plugs removed from mice and flash frozen, using absorbance spectroscopy with Drabkin's reagent (Sigma Diagnostics, St. Louis MO).

[0121] To evaluate plasma exposures of compound **1**, blood was collected 2 and 24 hours after 8 consecutive doses (Day 8). In the 200 and 300 mg/kg dose groups, blood was collected only at the 2 hour timepoint. Plasma concentrations of **1** were determined by a non-validated LC/MS/MS assay with a calibration range of 1 to 8000 ng/mL and a lower limit of quantitation (LLOQ) of 1 ng/mL (Charles River Laboratories, Worcester, MA).

[0122] On Day 8, hemoglobin levels in Matrigel plugs and plasma concentrations of compound **1** were measured. Animals were observed and body weights were measured throughout the study.

[0123] Compound **1** resulted in significant inhibition of hemoglobin concentration in Matrigel plugs at each dose evaluated compared to plugs from vehicle treated animals (Table 8). The calculated ED_{50} was 2.6 mg/kg. The 3 and 10 mg/kg doses resulted in 54% and 57% inhibition, respectively, whereas the 30, 100, 200 and 300 mg/kg doses reduced hemoglobin to the level of unsupplemented Matrigel, resulting in 70-92% inhibition vs. FGF-supplemented controls. The plasma concentrations of compound **1** at 2 hours post dose on day 8, showed a dose proportional increase with concentrations ranging from 44 ng/mL at 3 mg/kg to 3920 ng/mL at 300 mg/kg (Table 9). All doses were well tolerated and no weight loss was observed.

Table 8. Hemoglobin Concentrations and Dose Dependent Reduction in Hb Concentrations in Matrigel Plugs Inhibition in Matrigel Following Oral Administration of Compound 1

Treatment	n	Mean Hb ±SD mg/dL	% Hb inhibition vs. Vehicle treatment of Matrigel + FGF	p value t-test vs. vehicle treatment Matrigel FGF
Matrigel alone	8	26 ± 15		
Matrigel FGF + Vehicle	8	69 ± 34		
300 mg/kg **1**	4	6 ± 0.8	91 %	0.005
200 mg/kg **1**	4	8 ± 0.3	89 %	0.004
100 mg/kg **1**	8	14 ± 7	80 %	<0.0005
30 mg/kg **1**	8	20 ± 8	71 %	<0.0005
10 mg/kg **1**	8	29 ± 16	58 %	0.010
3 mg/kg **1**	8	32 ± 14	54 %	0.012

Table 9 Plasma Concentrations of Compound 1 Measured After 8 Consecutive Doses

Compound 1 Dose (mg/kg/day)	Mean Plasma Conc @ 2 hr# (ng/mL)	Mean Plasma Conc @ 24 hr# (ng/mL)
3	44	0[a]
10	123	0[a]
30	339	1.4
100	954	24
200	1910	NS
300	3920	NS

[a] Plasma concentrations below lower limit of quantitation (≤ 1 ng/mL)
NS = No samples were collected
#samples collected 2 hours and 24 hours after dosing

[0124] Plasma concentrations of **1** (2 hr postdose) increased proportionally with dose. A dose and plasma concentration dependent reduction in hemoglobin content of Matrigel plugs was observed. Plasma

concentrations (2 hr postdose, Day 8) of 44 ng/mL appear to be associated with antiangiogenic activity in this model.

[0125] In summary, the hemoglobin inhibition of compound **1** was dose-dependent , with significant inhibition after 8 days of treatment. Statistically significant hemoglobin inhibition was observed with all doses of compound **1**. All doses were well tolerated with no weight loss or adverse clinical signs observed. Compound **1** plasma concentrations (2 hr postdose) of 44 ng/mL were associated with antiangiogenic activity in this model.

Example 9

[0126] The metabolite profile of compound **1** in monkey plasma from a 5 mg/kg BID multiple oral dose study was determined in dose day 1 and 14 samples. One metabolite was identified and characterized by LC/UV and LD/MS/MS resulting from demethylation (compound **3**). Parent (P) compound **1** produced an $M+H^+$ ion at m/z = 393.3 with a chromatographic retention time of 18.3 minutes. The demethylated metabolite ($P-CH_3$) was identified with an m/z = 379.3 ($M+H^+$) and a chromatographic retention time of 18.1 min. The mass difference of 14 daltons between the metabolite and compound **1** is consistent with a demethylated compound **1**. The mass and chromatographic retention of the metabolite was identical to independently synthesized compound **3**. The metabolite corresponding to the piperazine N-oxide of compound **1** (N-oxide compound **2**) was not detected in plasma at this dose level. The components producing a UV signal at 17.7 and 18.5 minutes in the absorbance chromatogram at 356 nm were determined to be matrix components and not metabolites based on the UV spectral comparisons to compound 1 and due to their presence in blank plasma (time 0 dose day 1).

[0127] The estimated levels of the demethylated metabolite are given in Table 1. The estimated levels of metabolites (in compound **1** equivalents) are based on UV absorbance peak height ratios of metabolite to that of compound 1 obtained in this analysis and extrapolated by factoring the absorbance ratio to the known levels of compound **1** determined in the same samples in a

previous quantitative analytical study. It was found that parent compound was in greater abundance than the metabolite at all pooled time points. The levels of compound 1 were found to be substantially lower in the day 14 samples in parallel with the N-desmethyl metabolite which was essentially undetectable. No other metabolites including conjugated Phase II type metabolites (glucuronide or sulphate) were detected in these plasma samples on day 1 or 14 of dose administration.

Table 10: compound 1 levels and estimated compound 1 metabolite levels in rat plasma (N=2) with multiple oral doses of compound 1 (5 mg/kg, BID).

Dose (mg/kg/day)[a]	Day	Pooled Sample Time (hr)	($P\text{-}CH_3$) (ng/ml)[b]	compound 1 (ng/ml)[c]
10	1	0	0	0
10	1	1, 2	8.5	28
10	1	4, 8	31	62
10	1	12, 13, 14, 16, 20, 24	10	21
10	14	0	ND	2
10	14	1, 2	ND	4.2
10	14	4, 8	ND	2.2
10	14	12, 13, 14, 16, 20, 24	ND	3.2

a. Rats were dosed with 5/mg/kg compound 1 BID in 12 hour intervals (T=0 and T=12 hours).
b. Metabolite levels estimated based on metabolite/compound 1 UV response ratios obtained in this study and factored by the known compound 1 levels previously determined in a separate quantitative study.
c. Compound 1 levels presented in this table are averaged values of previously quantified levels from a separate study.
ND: Non detectable

Example 10

[0128] Studies with plasma and tumors collected from mice following treatment with compound **1** were performed to evaluate potential pharmacodynamic endpoints. Analysis of target modulation in KM12L4a tumors after compound **1** treatment indicated that phosphorylation of VEGFR1, VEGFR2, PDGFRβ, and FGFR1 were inhibited in a time- and dose-dependent manner. For example, HMVEC cells showed inhibition of VEGF mediated VEGFR2 phosphorylation with an IC_{50} of about 0.1 μM. In addition, treatment of endothelial cells with compound **1** inhibited MAPK and Akt phosphorylation mediated by VEGF.

[0129] Furthermore, a time- and dose- dependent inhibition of ERK (MAPK) activation, a downstream target of receptor tyrosine kinases, was observed with IC_{50}s ranging from 0.1 to 0.5 μM in KM12L4A cells. (KM12L4A cells express PDGFRβ and VEGFR1/2 on their surfaces.) KM12L4A cells were incubated 3 h with compound **1** in serum-free DMEM. After the harvest, lysates were separated by SDS-Page and probed with the phosphor-ERK1/2 and ERK1/2 antibodies. For detection, ECL reagents (Amersham) were used. The inhibitory effects of compound **1** on receptor phosphorylation and ERK activation were maintained for 24 hours after treatment. Phosphorylation of ERK1/2 in MV4-11 cells was inhibited by **1** at IC_{50}s of 0.01 to 0.1 μM in a dose-dependent manner.

[0130] Significant activity was observed *in vivo* in the HCT116 human colon tumor model. In HCT116 tumors, compound **1** inhibited the phosphorylation of ERK (MAPK) in a dose- and time-dependent manner and significant changes in histology analyses of the tumors was observed.

[0131] These PK/PD evaluations in preclinical models indicate that compound **1** showed a dose- and time-dependent inhibition of both the target receptors and the downstream signaling molecule, ERK (MAPK). These studies will aid in the identification of potential biomarkers to support the monitoring of biological activity of compound **1** in clinical trials.

Example 11

[0132] The distribution of radioactivity in tissues after administration of a single oral (PO) dose (5 mg/kg) of ^{14}C-labeled compound **1** (at 4-position of quinolinone ring) to male and female Sprague Dawley (SD) rats was determined by whole-body autoradiography (WBA). Blood and carcasses for WBA were collected at specified time points through 24 hours postdose. Carcasses were frozen in a hexane/dry ice bath, drained, blotted dry, and placed on dry ice or stored at approximately -70°C for at least 2 hours. The frozen carcasses were embedded in chilled carboxymethylcellulose, frozen into blocks along with embedded autoradiographic standards, and stored at -20°C until analysis. Appropriate sections of 40 µm thickness were collected on adhesive tape at 5 levels of interest in the sagital plane. All major tissues, organs and biological fluids were represented. Phosphorimaging screens were exposed to the sections and scanned and a standard curve created for interpolating tissue concentrations of ^{14}C-**1**. Plasma was analyzed for concentration of radioactivity by liquid scintillation counting (LSC). Illustrative results are presented in Table 11.

[0133] Following oral administration of ^{14}C-**1**, radioactivity derived from ^{14}C-**1** was widely distributed throughout all tissues by 1 hour postdose, and had reached C_{max} in most tissues by 4 hours postdose. Overall distribution of radioactivity in the tissues of males and females was similar. ^{14}C-**1**-derived radioactivity was cleared more slowly from tissues than from plasma. In males and females, the highest tissue concentrations of ^{14}C-**1**, excluding the gastrointestinal tract through 24 hours were detected in the harderian gland, adrenal gland, renal medulla, intra-orbital lacrimal gland, and exorbital lacrimal gland. ^{14}C-**1**-derived radioacitivity crossed the blood/brain barrier after oral dose administration.

Table 11. Tissue: plasma concentration ratios determined by whole-body autoradiography at specified times following a single oral dose of Compound 1 (5 mg/kg) to male rats

	Tissue: Plasma Concentration Ratios			
	Animal Number (Sacrifice Time)			
	1	2	3	4
Tissue	(1 Hour)	4 (Hours)	(10 Hours)	(24 Hours)
Adrenal gland	34.3	33.5	56.0	68.8
Blood	1.84	1.04	1.35	1.06
Bone	0.826	0.679	1.00	1.23
Bone marrow	13.8	23.3	29.7	26.9
Cecum	16.9	11.3	23.7	15.9
Cecum contents	0.484	15.7	356	130
Cerebellum	4.86	2.63	2.47	1.51
Cerebrum	6.16	3.39	3.21	1.71
Cerebral spinal fluid (CSF)	13.7	18.0	24.0	11.5
Diaphragm	14.1	9.00	12.2	6.49
Epididymis	3.61	6.57	9.05	8.53
Esophageal contents	2.90	6.82	1.08	1.15
Esophagus	98.1	17.7	12.3	7.26
Exorbital lacrimal gland	17.0	28.9	39.2	59.9
Eye	0.535	1.01	1.20	1.51
Fat (abdominal)	3.08	1.89	2.04	1.44
Fat (brown)	16.2	20.2	16.2	8.85

	Tissue: Plasma Concentration Ratios			
	Animal Number (Sacrifice Time)			
	1	2	3	4
Tissue	(1 Hour)	4 (Hours)	(10 Hours)	(24 Hours)
Harderian gland	14.3	34.2	128	300
Intra-orbital lacrimal gland	16.3	30.4	42.4	63.0
Kidney	45.1	32.4	49.1	24.3
Large intestinal contents	NA	7.00	454	238
Large intestine	11.6	12.8	21.8	10.9
Liver	121	48.9	45.0	44.7
Lung	47.2	26.9	28.8	16.8
Medulla	4.08	2.76	2.88	1.51
Muscle	5.93	4.64	5.77	2.64
Myocardium	16.8	11.5	11.8	4.62
Nasal turbinates	4.44	6.29	11.9	11.0
Olfactory lobe	3.77	2.27	2.15	1.15
Pancreas	25.7	20.5	29.3	10.5
Pineal gland	23.0	NA	NA	NA
Pituitary gland	20.5	33.9	48.1	21.5
Preputial gland	NA	NA	23.3	41.3
Prostate	7.29	11.4	14.2	11.2

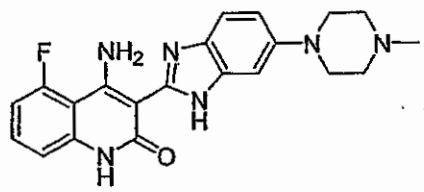
NA Not applicable.

[0134] It is understood that the invention is not limited to the embodiments set forth herein for illustration, but embraces all such forms thereof as come within the scope of the following claims.

CLAIMS

What is claimed is:

1. Use of a compound of formula



a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, in the preparation of a medicament, in unit dosage form, for treating cancer, wherein each unit dose of the medicament is sufficient to provide at least one of

(a) a C_{max} of about 20 to 4000 ng/mL of the compound in a subject's plasma or a C_{max} of about 40 to 8000 ng/mL of the compound in the subject's blood when it is administered to the subject,

(b) about 10 to 2,000 ng/mL of the compound in a subject's plasma 24 hours after administration or about 20 to 4,000 ng/mL of the compound in the subject's blood 24 hours after administration to the subject, or

(c) an AUC of about 500 to 60,000 ng*h/mL of the compound in a subject's plasma or about 750 to 120,000 ng*h/mL of the compound in the subject's blood when it is administered to the subject.

2. The use of claim 1, wherein each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 50 to 500 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 1000 ng/mL of the compound in the subject's blood,

(b) about 20 to 1,000 ng/mL of the compound in the subject's plasma 24 hours after administration or about 40 to 2,000 ng/mL of the compound in the subject's blood 24 hours after administration, or

(c) an AUC of about 1,000 to 30,000 ng*h/mL of the compound in the subject's plasma or about 1,500 to 60,000 ng*h/mL of the compound in the subject's blood.

3. The use of claim 1, wherein each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 50 to 250 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 500 ng/mL of the compound in the subject's blood,

(b) about 40 to 500 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 1,000 ng/mL of the compound in the subject's blood 24 hours after administration, or

(c) an AUC of about 2,000 to 15,000 ng*h/mL of the compound in the subject's plasma or about 3,000 to 30,000 ng*h/mL of the compound in the subject's blood.

4. The use of claim 1, wherein each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 75 to 150 ng/mL of the compound in the subject's plasma or a C_{max} of about 150 to 300 ng/mL of the compound in the subject's blood, or

(b) about 40 to 250 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 500 ng/mL of the compound in the subject's blood 24 hours after administration.

5. The use of claim 1, wherein each unit dose is sufficient to provide a C_{max} of about 100 to 2000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 4000 ng/mL of the compound in the subject's blood.

6. The use of claim 1, wherein each unit dose is sufficient to provide a C_{max} of 100 to 1000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 2000 ng/mL of the compound in the subject's blood.

7. The use of any of any one of claims 1-6, wherein the lactate salt of the compound is used to prepare the medicament.

8. The use of any one of claims 1-7, wherein the medicament is suitable for oral administration.

9. The use of claim 8, wherein the unit dosage form of the medicament is a pill, capsule, tablet, gelcap, caplet, suspension, or aqueous solution.

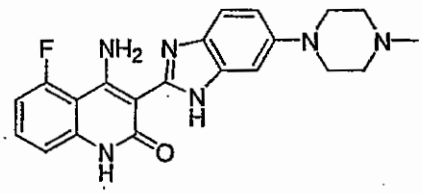
10. The use of any one of claims 1-7, wherein the medicament is suitable for administration by injection as a short bolus, slow infusion, or long-term infusion.

11. The use of any one of claims 1-10, wherein each unit dose of the medicament comprises from 0.25 to 30 mg/kg of the compound, tautomer, and/or salts based on the body weight of the subject.

12. The use of any one of claims 1-10, wherein each unit dose of the medicament comprises an amount of the compound, tautomer, and/or salts ranging from 25 to 1500 mg.

13. The use of any one of claims 1-12, wherein the medicament is arranged in a kit comprising 7, 14, 21 or 28 daily amounts of said unit doses, the kit being suitable for use in a treatment cycle comprises administering the daily amount of the compound for each of 7, 14, 21, or 28 days, followed by 7 or 14 days without administration of the compound.

14. A compound having the formula



a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, for use in a method of treating cancer comprising administering an amount of said compound to a cancer patient, in an amount sufficient to provide at least one of

(a) a C_{max} of about 20 to 4000 ng/mL of the compound in a subject's plasma or a C_{max} of about 40 to 8000 ng/mL of the compound in the subject's blood when it is administered to the subject,

(b) about 10 to 2,000 ng/mL of the compound in a subject's plasma 24 hours after administration or about 20 to 4,000 ng/mL of the compound in the subject's blood 24 hours after administration to the subject, or

(c) an AUC of about 500 to 60,000 ng*h/mL of the compound in a subject's plasma or about 750 to 120,000 ng*h/mL of the compound in the subject's blood when it is administered to the subject.

15. The compound of claim 14, wherein each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 50 to 500 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 1000 ng/mL of the compound in the subject's blood,

(b) about 20 to 1,000 ng/mL of the compound in the subject's plasma 24 hours after administration or about 40 to 2,000 ng/mL of the compound in the subject's blood 24 hours after administration, or

(c) an AUC of about 1,000 to 30,000 ng*h/mL of the compound in the subject's plasma or about 1,500 to 60,000 ng*h/mL of the compound in the subject's blood.

16. The compound of claim 14, wherein each unit dose is sufficient to provide at least one of

(a) a C_{max} of about 50 to 250 ng/mL of the compound in the subject's plasma or a C_{max} of about 100 to 500 ng/mL of the compound in the subject's blood,

(b) about 40 to 500 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 1,000 ng/mL of the compound in the subject's blood 24 hours after administration, or

(c) an AUC of about 2,000 to 15,000 ng*h/mL of the compound in the subject's plasma or about 3,000 to 30,000 ng*h/mL of the compound in the subject's blood.

17. The compound of claim 14, wherein each unit dose is sufficient to provide at least one of

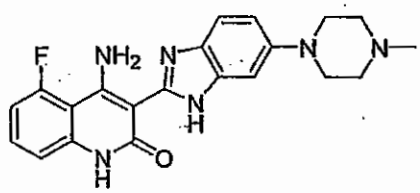
(a) a C_{max} of about 75 to 150 ng/mL of the compound in the subject's plasma or a C_{max} of about 150 to 300 ng/mL of the compound in the subject's blood, or

(b) about 40 to 250 ng/mL of the compound in the subject's plasma 24 hours after administration or about 80 to 500 ng/mL of the compound in the subject's blood 24 hours after administration.

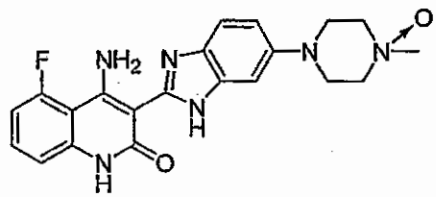
18. The compound of claim 14, wherein each unit dose is sufficient to provide a C_{max} of about 100 to 2000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 4000 ng/mL of the compound in the subject's blood.

19. The compound of claim 14, wherein each unit dose is sufficient to provide a C_{max} of 100 to 1000 ng/mL of the compound in the subject's plasma or a C_{max} of about 200 to 2000 ng/mL of the compound in the subject's blood.

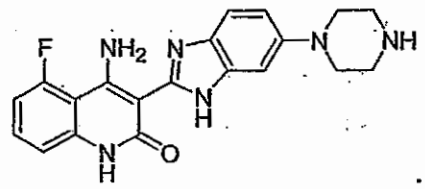
20. The use of a metabolite for determining a metabolic profile for a compound having the formula:



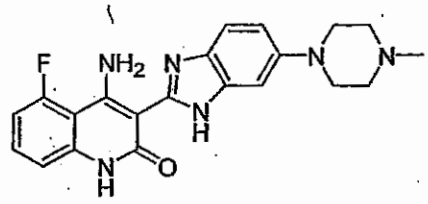
a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, in a subject, the metabolite comprising at least one of an N-oxide compound of formula:



or an N-desmethyl compound of formula:

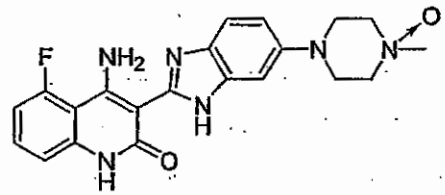


21. A method for determining a metabolic profile for a compound having the formula:

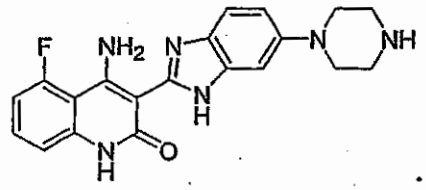


a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, in a subject, the method comprising measuring the amount of at least one metabolite of the compound in one or more samples of urine, blood, or tissue taken from the subject.

22. The method of claim 21, wherein the at least one metabolite is an N-oxide compound having the formula:



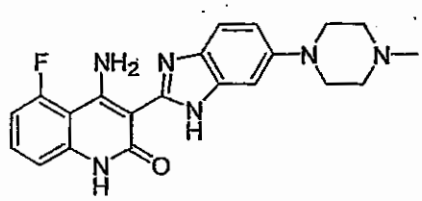
or is an N-desmethyl compound having the formula:



23. The method of claim 22, wherein the method comprises measuring the amount of both the N-oxide compound and the N-desmethyl compound.

24. The method of any one of claims 21-23, wherein the metabolite is measured by ultraviolet spectroscopy or liquid chromatography-mass spectroscopy.

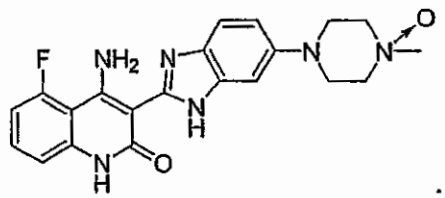
25. A method of determining the amount of a compound having the formula:



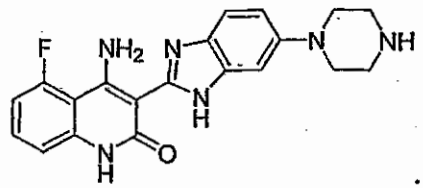
a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer in a subject, the method comprising measuring the amount of the compound in a sample of urine, blood, or tissue taken from the subject after the compound has been administered to the subject.

26. The method of claim 25, further comprising measuring the amount of a metabolite of the compound in the sample.

27. The method of claim 26, wherein the metabolite is an N-oxide compound having the formula:

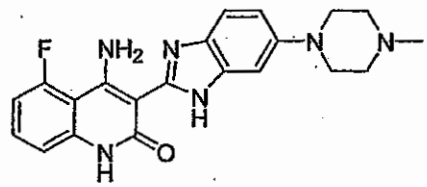


28. The method of claim 26, wherein the metabolite is an N-desmethyl compound having the formula:



29. The method of claim 25, further comprising withdrawing two or more samples from the subject at different times after the compound has been administered to the subject.

30. Use of a compound of formula



a pharmaceutically acceptable salt thereof, a tautomer thereof, or a pharmaceutically acceptable salt of the tautomer, in the preparation of a medicament, in unit dosage form, for treating cancer, wherein each unit dose of the medicament comprises the compound in an amount of from 25 mg to 1000 mg.