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(54) **CYTOTOXIC COMPOUNDS**
ZYTOTOXISCHE VERBINDUNGEN
COMPOSES CYTOTOXIQUES

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(73) Proprietor: **Medarex, Inc.**
Princeton, NJ 08540 (US)

(72) Inventors:
• **GANGWAR, Sanjeev**
Foster City, CA 94404 (US)

• **SUFI, Bilal**
Santa Clara, CA 95051 (US)

(74) Representative: **Reitstötter - Kinzebach**
Patentanwälte
Sternwartstrasse 4
81679 München (DE)

(56) References cited:
WO-A-98/11101 WO-A-02/096910
WO-A-2006/110476

• **ATWELL ET AL: "5-Amino-1-(chloromethyl)-1,2-**
dihydro-3H-benz[e]indoles:" JOURNAL OF
MEDICINAL CHEMISTRY, AMERICAN CHEMICAL
SOCIETY. WASHINGTON, US, vol. 42, no. 17,
1999, pages 3400-3411, XP002294767 ISSN:
0022-2623

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EP 1 948 242 B9

Description**FIELD OF THE INVENTION**

[0001] The present invention provides cytotoxic compounds.

BACKGROUND OF THE INVENTION

[0002] Many therapeutic agents, particularly those that are especially effective in cancer chemotherapy, often exhibit acute toxicity *in vivo*, especially bone marrow and mucosal toxicity, as well as chronic cardiac and neurological toxicity. Such high toxicity can limit their applications. Development of more and safer specific therapeutic agents, particularly antitumor agents, is desirable for greater effectiveness against tumor cells and a decrease in the number and severity of the side effects of these products (toxicity, destruction of non-tumor cells, etc.). Another difficulty with some existing therapeutic agents is their less than optimal stability in plasma. Addition of functional groups to stabilize these compounds resulted in a significant lowering of the activity. Accordingly, it is desirable to identify ways to stabilize compounds while maintaining acceptable therapeutic activity levels.

[0003] The search for more selective cytotoxic agents has been extremely active for many decades, the dose limiting toxicity (i.e. the undesirable activity of the cytotoxins on normal tissues) being one of the major causes of failures in cancer therapy. For example, CC-1065 and the duocarmycins are known to be extremely potent cytotoxins.

[0004] CC-1065 was first isolated from *Streptomyces zelensis* in 1981 by the Upjohn Company (Hanka et al., J. Antibiot. 31: 1211 (1978); Martin et al., J. Antibiot. 33: 902 (1980); Martin et al., J. Antibiot. 34: 1119 (1981)) and was found to have potent antitumor and antimicrobial activity both *in vitro* and in experimental animals (Li et al., Cancer Res. 42: 999 (1982)). CC-1065 binds to double-stranded B-DNA within the minor groove (Swenson et al., Cancer Res. 42: 2821 (1982)) with the sequence preference of 5'-d(A/GNTTA)-3' and 5'-d(AAAAA)-3' and alkylates the N3 position of the 3'-adenine by its CPI left-hand unit present in the molecule (Hurley et al., Science 226: 843 (1984)). Despite its potent and broad antitumor activity, CC-1065 cannot be used in humans because it causes delayed death in experimental animals.

[0005] Many analogues and derivatives of CC-1065 and the duocarmycins are known in the art. The research into the structure, synthesis and properties of many of the compounds has been reviewed. See, for example, Boger et al., Angew. Chem. Int. Ed. Engl. 35: 1438 (1996); and Boger et al., Chem. Rev. 97: 787 (1997).

[0006] Analogues of CC-1065 and duocarmycins are also disclosed in WO98/11101 and WO 02/096910, respectively.

[0007] A group at Kyowa Hakko Kogyo Co., Ltd. has prepared a number of CC-1065 derivatives. See, for example, U.S. Pat. No. 5,101,038; 5,641,780; 5,187,186; 5,070,092; 5,703,080; 5,070,092; 5,641,780; 5,101,038; and 5,084,468; and published PCT application, WO 96/10405 and published European application 0 537 575 A1.

[0008] The Upjohn Company (Pharmacia Upjohn) has also been active in preparing derivatives of CC-1065. See, for example, U.S. Patent No. 5,739,350; 4,978,757, 5,332,837 and 4,912,227.

[0009] The Scripps Research Institute also has described a variety of derivatives and analogs of CC-1065 and the duocarmycins. See, for example, U.S. Patent No. 5,985,908; 6,060,608; 6,262,271; 6,281,354; 6,310,209; and 6,486,326; and PCT Publication No. WO 97/32850; WO 97/45411; WO 98/52925; WO 99/19298; WO 99/29642 and WO 01/83482. In particular, analogs that incorporate the 1,2,9,9a-tetrahydrocyclopropa[c]benz[e]indole-4-one (CBI) alkylation subunit, referred to as CBI analogs of CC-1065 and the duocarmycins, have been described. See, for example, U.S. Patent No. 6,548,530 and PCT Publication No. WO 97/12862; WO 03/022806; and WO 04/101767.

[0010] Research has also focused on the development of new therapeutic agents which are in the form of prodrugs, compounds that are capable of being converted to drugs (active therapeutic compounds) *in vivo* by certain chemical or enzymatic modifications of their structure. For purposes of reducing toxicity, this conversion is preferably confined to the site of action or target tissue rather than the circulatory system or non-target tissue. However, even prodrugs are problematic as many are characterized by a low stability in blood and serum, due to the presence of enzymes that degrade or activate the prodrugs before the prodrugs reach the desired sites within the patient's body.

[0011] Bristol-Myers Squibb has described particular lysosomal enzyme-cleavable antitumor drug conjugates. See, for example, U.S. Patent No. 6,214,345. This patent provides an aminobenzyl oxycarbonyl.

[0012] Seattle Genetics has published applications U.S. Pat. Appl. 2003/0096743 and U.S. Pat. Appl. 2003/0130189, which describe p-aminobenzylethers in drug delivery agents. The linkers described in these applications are limited to aminobenzyl ether compositions.

[0013] Other groups have also described linkers. See for example de Groot et al., J. Med. Chem. 42, 5277 (1999); de Groot et al. J. Org. Chem. 43, 3093 (2000); de Groot et al., J. Med. Chem. 66, 8815, (2001); WO 02/083180; Carl et al., J. Med. Chem. Lett. 24, 479, (1981); Dubowchik et al., Bioorg & Med. Chem. Lett. 8, 3347 (1998). These linkers include aminobenzyl ether spacer, elongated electronic cascade and cyclization spacer systems, cyclisation eliminations spacers, such as w-amino aminocarbonyls, and a p aminobenzyl oxycarbonyl linker.

[0014] Stability of cytotoxin drugs, including *in vivo* stability, is still an important issue that needs to be addressed. In addition, the toxicity of many compounds makes them less useful, so compositions that will reduce drug toxicity, such as the formation of a cleaveable prodrug, are needed. Therefore, in spite of the advances in the art, there continues to be a need for the development of improved therapeutic agents for the treatment of mammals, and humans in particular, more specifically cytotoxins that exhibit high specificity of action, reduced toxicity, and improved stability in blood relative to known compounds of similar structure. The instant invention addresses those needs.

SUMMARY OF THE INVENTION

[0015] The present invention relates to cytotoxic compounds according to claim 1 useful as drugs.

DETAILED DESCRIPTION OF THE INVENTION

Abbreviations

[0016] As used herein, "Ala," refers to alanine.

"Boc," refers to *t*-butyloxycarbonyl.

"CPI," refers to cyclopropapyrroloindole.

"Cbz," is carbobenzoxy.

[0017] As used herein, "DCM," refers to dichloromethane.

"DDQ," refers to 2,3-dichloro-5,6-dicyano-1,4-benzoquinone.

DIPEA is diisopropylethylamine

"DMDA" is N,N'-dimethylethylene diamine

"RBF" is a round bottom flask

"DMF" is N,N-dimethylformamide

"HATU" is N-[[[(dimethylamino)-1H-1,2,3-triazolo[4,5-b]pyridin-1-yl]methylene]-N-methylmethanaminium hexafluorophosphate N-oxide

[0018] As used herein, the symbol "E," represents an enzymatically cleaveable group.

"EDCP" is 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide.

As used herein, "Fmoc," refers to 9-fluorenylmethoxycarbonyl.

"Fmoc" refers to 9-fluorenylmethoxycarbonyl.

"HOAt" is 7-Aza-1-hydroxybenzotriazole.

"Leu" is leucine.

"PABA" refers to *para*-aminobenzoic acid.

PEG refers to polyethylene glycol

"PMB," refers to *para*-methoxybenzyl.

"TBAF," refers to tetrabutylammonium fluoride.

[0019] The abbreviation "TBSO," refers to *t*-butyldimethylsilyl ether.

[0020] As used herein, "TEA," refers to triethylamine.

[0021] "TFA," refers to trifluoroacetic acid.

[0022] The symbol "Q" refers to a therapeutic agent, diagnostic agent or detectable label.

Definitions

[0023] Unless defined otherwise, all technical and scientific terms used herein generally have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Generally, the nomenclature used herein and the laboratory procedures in cell culture, molecular genetics, organic chemistry and nucleic acid chemistry and hybridization described below are those well known and commonly employed in the art. Standard techniques are used for nucleic acid and peptide synthesis. Generally, enzymatic reactions and purification steps are performed according to the manufacturer's specifications. The techniques and procedures are generally performed according to conventional methods in the art and various general references (*see generally*, Sambrook et al. MOLECULAR CLONING: A LABORATORY MANUAL, 2d ed. (1989) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y.), which are

provided throughout this document. The nomenclature used herein and the laboratory procedures in analytical chemistry, and organic synthetic described below are those well known and commonly employed in the art. Standard techniques, or modifications thereof, are used for chemical syntheses and chemical analyses.

[0024] The term "therapeutic agent" is intended to mean a compound that, when present in a therapeutically effective amount, produces a desired therapeutic effect on a mammal. For treating carcinomas, it is desirable that the therapeutic agent also be capable of entering the target cell.

[0025] The term "cytotoxin" is intended to mean a therapeutic agent having the desired effect of being cytotoxic to cancer cells. Cytotoxic means that the agent arrests the growth of, or kills the cells. Exemplary cytotoxins include, by way of example, combretastatins, duocarmycins, the CC-1065 anti-tumor antibiotics, anthracyclines, and related compounds. Other cytotoxins include mycotoxins, ricin and its analogues, calicheamycins, doxorubicin and maytansinoids.

[0026] The term "prodrug" and the terms "drug conjugate" and "drug-cleavable substrate conjugate" are used herein interchangeably. Both refer to a compound that is relatively innocuous to cells while still in the conjugated form but which is selectively degraded to a pharmacologically active form by conditions, e.g., enzymes, located within or in the proximity of target cells.

[0027] The term "marker" is intended to mean a compound useful in the characterization of tumors or other medical condition, for example, diagnosis, progression of a tumor, and assay of the factors secreted by tumor cells. Markers are considered a subset of "diagnostic agents."

[0028] The term "selective" as used in connection with enzymatic cleavage means that the rate of cleavage of the linker moiety is greater than the rate of cleavage of a peptide having a random sequence of amino acids.

[0029] The term "self-immolative spacer" refers to a bifunctional chemical moiety that is capable of covalently linking two chemical moieties into a normally stable tripartate molecule. The self-immolative spacer is capable of spontaneously separating from the second moiety if the bond to the first moiety is cleaved.

[0030] The terms "polypeptide," "peptide" and "protein" are used interchangeably herein to refer to a polymer of amino acid residues. The terms apply to amino acid polymers in which one or more amino acid residue is an artificial chemical mimetic of a corresponding naturally occurring amino acid, as well as to naturally occurring amino acid polymers and non-naturally occurring amino acid polymer. These terms also encompass the term "antibody."


[0031] The term "amino acid" refers to naturally occurring and synthetic amino acids, as well as amino acid analogs and amino acid mimetics that function in a manner similar to the naturally occurring amino acids. Naturally occurring amino acids are those encoded by the genetic code, as well as those amino acids that are later modified, e.g., hydroxyproline, γ -carboxyglutamate, and O-phosphoserine. Amino acid analogs refers to compounds that have the same basic chemical structure as a naturally occurring amino acid, i.e., an α carbon that is bound to a hydrogen, a carboxyl group, an amino group, and an R group, e.g., homoserine, norleucine, methionine sulfoxide, methionine methyl sulfonium. Such analogs have modified R groups (e.g., norleucine) or modified peptide backbones, but retain the same basic chemical structure as a naturally occurring amino acid. One amino acid that may be used in particular is citrulline, which is a precursor to arginine and is involved in the formation of urea in the liver. Amino acid mimetics refers to chemical compounds that have a structure that is different from the general chemical structure of an amino acid, but functions in a manner similar to a naturally occurring amino acid. The term "unnatural amino acid" is intended to represent the "D" stereochemical form of the twenty naturally occurring amino acids described above. It is further understood that the term unnatural amino acid includes homologues of the natural amino acids, and synthetically modified forms of the natural amino acids. The synthetically modified forms include, amino acids having alkylene chains shortened or lengthened by up to two carbon atoms, amino acids comprising optionally substituted aryl groups, and amino acids comprised halogenated groups, preferably halogenated alkyl and aryl groups. When attached to a linker or conjugate of the invention, the amino acid is in the form of an "amino acid side chain", where the carboxylic acid group of the amino acid has been replaced with a keto (C(O)) group. Thus, for example, an alanine side chain is $-C(O)-CH(NH_2)-CH_3$, and so forth.

[0032] Amino acids and peptides may be protected by blocking groups. A blocking group is an atom or a chemical moiety that protects the N-terminus of an amino acid or a peptide from undesired reactions and can be used during the synthesis of a drug-cleavable substrate conjugate. It should remain attached to the N-terminus throughout the synthesis, and may be removed after completion of synthesis of the drug conjugate by chemical or other conditions that selectively achieve its removal. The blocking groups suitable for N-terminus protection are well known in the art of peptide chemistry. Exemplary blocking groups include, hydrogen, D-amino acid, and carbobenzoxy (Cbz) chloride.

[0033] "Nucleic acid" refers to deoxyribonucleotides or ribonucleotides and polymers thereof in either single- or double-stranded form. The term encompasses nucleic acids containing known nucleotide analogs or modified backbone residues or linkages, which are synthetic, naturally occurring, and non-naturally occurring, which have similar binding properties as the reference nucleic acid, and which are metabolized in a manner similar to the reference nucleotides. Examples of such analogs include, phosphorothioates, phosphoramidates, methyl phosphonates, chiral-methyl phosphonates, 2-O-methyl ribonucleotides, peptide-nucleic acids (PNAs).

[0034] Unless otherwise indicated, a particular nucleic acid sequence also implicitly encompasses conservatively modified variants thereof (e.g., degenerate codon substitutions) and complementary sequences, as well as the sequence

explicitly indicated. Specifically, degenerate codon substitutions may be achieved by generating sequences in which the third position of one or more selected (or all) codons is substituted with mixed-base and/or deoxyinosine residues (Batzer et al., Nucleic Acid Res. 19:5081 (1991); Ohtsuka et al., J. Biol. Chem. 260: 2605-2608 (1985); Rossolini et al., Mol. Cell. Probes 8: 91-98 (1994)). The term nucleic acid is used interchangeably with gene, cDNA, mRNA, oligonucleotide, and polynucleotide.

[0035] The symbol , whether utilized as a bond or displayed perpendicular to a bond indicates the point at which the displayed moiety is attached to the remainder of the molecule, solid support, etc.

[0036] The term "alkyl," by itself or as part of another substituent, means, unless otherwise stated, a straight or branched chain, or cyclic hydrocarbon radical, or combination thereof, which may be fully saturated, mono- or polyunsaturated and can include di- and multivalent radicals, having the number of carbon atoms designated (*i.e.* C₁-C₁₀ means one to ten carbons). Examples of saturated hydrocarbon radicals include, groups such as methyl, ethyl, n-propyl, isopropyl, n-butyl, t-butyl, isobutyl, sec-butyl, cyclohexyl, (cyclohexyl)methyl, cyclopropylmethyl, homologs and isomers of, for example, n-pentyl, n-hexyl, n-heptyl, n-octyl, and the like. An unsaturated alkyl group is one having one or more double bonds or triple bonds. Examples of unsaturated alkyl groups include, vinyl, 2-propenyl, crotyl, 2-isopentenyl, 2-(butadienyl), 2,4-pentadienyl, 3-(1,4-pentadienyl), ethynyl, 1- and 3-propynyl, 3-butylnyl, and the higher homologs and isomers. The term "alkyl," unless otherwise noted, is also meant to include those derivatives of alkyl defined in more detail below, such as "heteroalkyl." Alkyl groups, which are limited to hydrocarbon groups are termed "homoalkyl".

[0037] The term "alkylene" by itself or as part of another substituent means a divalent radical derived from an alkane, as exemplified, by -CH₂CH₂CH₂CH₂-, and further includes those groups described below as "heteroalkylene." Typically, an alkyl (or alkylene) group will have from 1 to 24 carbon atoms, with those groups having 10 or fewer carbon atoms being preferred in the present invention. A lower alkylene is a shorter chain alkylene group, generally having eight or fewer carbon atoms.

[0038] The term "heteroalkyl," by itself or in combination with another term, means, unless otherwise stated, a stable straight or branched chain, or cyclic hydrocarbon radical, or combinations thereof, consisting of the stated number of carbon atoms and at least one heteroatom selected from the group consisting of O, N, Si and S, and wherein the nitrogen, carbon and sulfur atoms may optionally be oxidized and the nitrogen heteroatom may optionally be quaternized. The heteroatom(s) O, N and S and Si may be placed at any interior position of the heteroalkyl group or at the position at which the alkyl group is attached to the remainder of the molecule. Examples include, -CH₂-CH₂-O-CH₃, -CH₂-CH₂-NH-CH₃, -CH₂-CH₂-N(CH₃)-CH₃, -CH₂-S-CH₂-CH₃, -CH₂-CH₂-S(O)-CH₃, -CH₂-CH₂-S(O)₂-CH₃, -CH=CH-O-CH₃, -Si(CH₃)₃, -CH₂-CH=N-OCH₃, and -CH=CH-N(CH₃)-CH₃. Up to two heteroatoms may be consecutive, such as, for example, -CH₂-NH-OCH₃ and -CH₂-O-Si(CH₃)₃. Similarly, the term "heteroalkylene" by itself or as part of another substituent means a divalent radical derived from heteroalkyl, as exemplified, by, -CH₂-CH₂-S-CH₂-CH₂- and -CH₂-S-CH₂-CH₂-NH-CH₂-. For heteroalkylene groups, heteroatoms can also occupy either or both of the chain termini (*e.g.*, alkyleneoxy, alkyleneedioxy, alkyleneamino, alkylene diamino, and the like). The terms "heteroalkyl" and "heteroalkylene" encompass poly(ethylene glycol) and its derivatives (see, for example, Shearwater Polymers Catalog, 2001). Still further, for alkylene and heteroalkylene linking groups, no orientation of the linking group is implied by the direction in which the formula of the linking group is written. For example, the formula -C(O)₂R'- represents both -C(O)₂R'- and -R'C(O)₂-,

[0039] The term "lower" in combination with the terms "alkyl" or "Heteroalkyl" refers to a moiety having from 1 to 6 carbon atoms.

[0040] The terms "alkoxy," "alkylamino," "alkylsulfonyl," and "alkylthio" (or thioalkoxy) are used in their conventional sense, and refer to those alkyl groups attached to the remainder of the molecule via an oxygen atom, an amino group, an SO₂ group or a sulfur atom, respectively. The term "arylsulfonyl" refers to an aryl group attached to the remainder of the molecule via an SO₂ group, and the term "sulfhydryl" refers to an SH group.

[0041] In general, an "acyl substituent" is also selected from the group set forth above. As used herein, the term "acyl substituent" refers to groups attached to, and fulfilling the valence of a carbonyl carbon that is either directly or indirectly attached to the polycyclic nucleus of the compounds of the present invention.

[0042] The terms "cycloalkyl" and "heterocycloalkyl", by themselves or in combination with other terms, represent, unless otherwise stated, cyclic versions of substituted or unsubstituted "alkyl" and substituted or unsubstituted "heteroalkyl", respectively. Additionally, for heterocycloalkyl, a heteroatom can occupy the position at which the heterocycle is attached to the remainder of the molecule. Examples of cycloalkyl include, cyclopentyl, cyclohexyl, 1-cyclohexenyl, 3-cyclohexenyl, cycloheptyl, and the like. Examples of heterocycloalkyl include, but are not limited to, 1-(1,2,5,6-tetrahydropyridyl), 1-piperidinyl, 2-piperidinyl, 3-piperidinyl, 4-morpholinyl, 3-morpholinyl, tetrahydrofuran-2-yl, tetrahydrofuran-3-yl, tetrahydrothien-2-yl, tetrahydrothien-3-yl, 1-piperazinyl, 2-piperazinyl. The heteroatoms and carbon atoms of the cyclic structures are optionally oxidized.

[0043] The terms "halo" or "halogen," by themselves or as part of another substituent, mean, unless otherwise stated, a fluorine, chlorine, bromine, or iodine atom. Additionally, terms such as "haloalkyl," are meant to include monohaloalkyl and polyhaloalkyl. For example, the term "halo(C₁-C₄)alkyl" is mean to include, trifluoromethyl, 2,2,2-trifluoroethyl, 4-chlorobutyl, 3-bromopropyl.

[0044] The term "aryl" means, unless otherwise stated, a substituted or unsubstituted polyunsaturated, aromatic, hydrocarbon substituent which can be a single ring or multiple rings (preferably from 1 to 3 rings) which are fused together or linked covalently. The term "heteroaryl" refers to aryl groups (or rings) that contain from one to four heteroatoms selected from N, O, and S, wherein the nitrogen, carbon and sulfur atoms are optionally oxidized, and the nitrogen atom(s) are optionally quaternized. A heteroaryl group can be attached to the remainder of the molecule through a heteroatom. Examples of aryl and heteroaryl groups include phenyl, 1-naphthyl, 2-naphthyl, 4-biphenyl, 1-pyrrolyl, 2-pyrrolyl, 3-pyrrolyl, 3-pyrazolyl, 2-imidazolyl, 4-imidazolyl, pyrazinyl, 2-oxazolyl, 4-oxazolyl, 2-phenyl-4-oxazolyl, 5-oxazolyl, 3-isoxazolyl, 4-isoxazolyl, 5-isoxazolyl, 2-thiazolyl, 4-thiazolyl, 5-thiazolyl, 2-furyl, 3-furyl, 2-thienyl, 3-thienyl, 2-pyridyl, 3-pyridyl, 4-pyridyl, 2-pyrimidyl, 4-pyrimidyl, 5-benzothiazolyl, purinyl, 2-benzimidazolyl, 5-indolyl, 1-isoquinolyl, 5-isoquinolyl, 2-quinoxalyl, 5-quinoxalyl, 3-quinolyl, and 6-quinolyl. Substituents for each of the above noted aryl and heteroaryl ring systems are selected from the group of acceptable substituents described below. "Aryl" and "heteroaryl" also encompass ring systems in which one or more non-aromatic ring systems are fused, or otherwise bound, to an aryl or heteroaryl system.

[0045] For brevity, the term "aryl" when used in combination with other terms (e.g., aryloxy, arylthioxy, arylalkyl) includes both aryl and heteroaryl rings as defined above. Thus, the term "arylalkyl" is meant to include those radicals in which an aryl group is attached to an alkyl group (e.g., benzyl, phenethyl, pyridylmethyl) including those alkyl groups in which a carbon atom (e.g., a methylene group) has been replaced by, for example, an oxygen atom (e.g., phenoxyethyl, 2-pyridyloxyethyl, 3-(1-naphthyloxy)propyl).

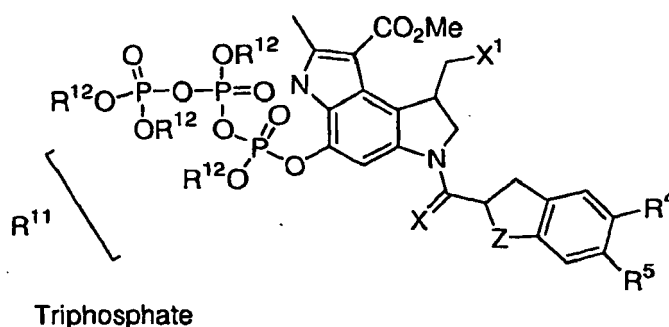
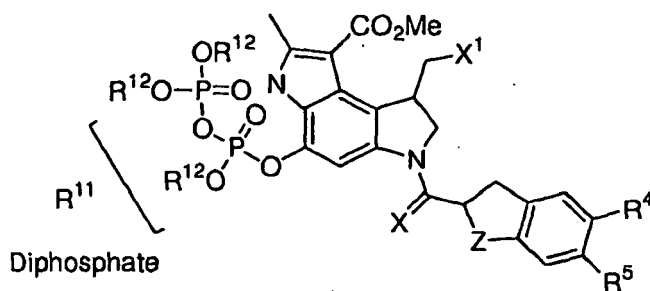
[0046] Each of the above terms (e.g., "alkyl," "heteroalkyl," "aryl" and "heteroaryl") include both substituted and unsubstituted forms of the indicated radical. Preferred substituents for each type of radical are provided below.

[0047] Substituents for the alkyl, and heteroalkyl radicals (including those groups often referred to as alkylene, alkenyl, heteroalkylene, heteroalkenyl, alkynyl, cycloalkyl, heterocycloalkyl, cycloalkenyl, and heterocycloalkenyl) are generally referred to as "alkyl substituents" and "heteroalkyl substituents," respectively, and they can be one or more of a variety of groups selected from, -OR', =O, =NR', =N-OR', -NR'R', -SR', -halogen, -SiR'R''R''', -OC(O)R', -C(O)R', -CO₂R', -CONR'R', -OC(O)NR'R', -NR'C(O)R', -NR'-C(O)NR''R''', -NR'C(O)₂R', -NR-C(NR'R''R''')=NR''', -NR-C(NR'R'')=NR''', -S(O)R', -S(O)₂R', -S(O)₂NR'R', -NRSO₂R', -CN and -NO₂ in a number ranging from zero to (2m'+1), where m' is the total number of carbon atoms in such radical. R', R'', R''' and R'''' each preferably independently refer to hydrogen, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, e.g., aryl substituted with 1-3 halogens, substituted or unsubstituted alkyl, alkoxy or thioalkoxy groups, or arylalkyl groups. When a compound of the invention includes more than one R group, for example, each of the R groups is independently selected as are each R', R'', R''' and R'''' groups when more than one of these groups is present. When R' and R'' are attached to the same nitrogen atom, they can be combined with the nitrogen atom to form a 5-, 6-, or 7-membered ring. For example, -NR'R'' is meant to include, 1-pyrrolidinyl and 4-morpholinyl. From the above discussion of substituents, one of skill in the art will understand that the term "alkyl" is meant to include groups including carbon atoms bound to groups other than hydrogen groups, such as haloalkyl (e.g., -CF₃ and -CH₂CF₃) and acyl (e.g., -C(O)CH₃, -C(O)CF₃, -C(O)CH₂OCH₃).

[0048] Similar to the substituents described for the alkyl radical, the aryl substituents and heteroaryl substituents are generally referred to as "aryl substituents" and "heteroaryl substituents," respectively and are varied and selected from, for example: halogen, -OR', =O, =NR', =N-OR', -NR'R', -SR', -halogen, -SiR'R''R''', -OC(O)R', -C(O)R', -CO₂R', -CONR'R', -OC(O)NR'R', -NR'C(O)R', -NR'-C(O)NR''R''', -NR'C(O)₂R', -NR-C(NR'R'')=NR''', -S(O)R', -S(O)₂R', -S(O)₂NR'R', -NRSO₂R', -CN and -NO₂, -R', -N₃, -CH(Ph)₂, fluoro(C₁-C₄)alkoxy, and fluoro(C₁-C₄)alkyl, in a number ranging from zero to the total number of open valences on the aromatic ring system; and where R', R'', R''' and R'''' are preferably independently selected from hydrogen, (C₁-C₈)alkyl and heteroalkyl, unsubstituted aryl and heteroaryl, (unsubstituted aryl)-(C₁-C₄)alkyl, and (unsubstituted aryl)oxy-(C₁-C₄)alkyl. When a compound of the invention includes more than one R group, for example, each of the R groups is independently selected as are each R', R'', R''' and R'''' groups when more than one of these groups is present.

[0049] Two of the aryl substituents on adjacent atoms of the aryl or heteroaryl ring may optionally be replaced with a substituent of the formula -T-C(O)-(CRR')_q-U-, wherein T and U are independently -NR-, -O-, -CRR'- or a single bond, and q is an integer of from 0 to 3. Alternatively, two of the substituents on adjacent atoms of the aryl or heteroaryl ring may optionally be replaced with a substituent of the formula -A-(CH₂)_r-B-, wherein A and B are independently -CRR'-, -O-, -NR-, -S-, -S(O)-, -S(O)₂-, -S(O)₂NR'- or a single bond, and r is an integer of from 1 to 4. One of the single bonds of the new ring so formed may optionally be replaced with a double bond. Alternatively, two of the substituents on adjacent atoms of the aryl or heteroaryl ring may optionally be replaced with a substituent of the formula -(CRR')_s-X-(CR''R''')_d-, where s and d are independently integers of from 0 to 3, and X is -O-, -NR'-, -S-, -S(O)-, -S(O)₂-, or -S(O)₂NR'-. The substituents R, R', R'' and R''' are preferably independently selected from hydrogen or substituted or unsubstituted (C₁-C₆) alkyl.

[0050] As used herein, the term "diphosphate" includes an ester of phosphoric acid containing two phosphate groups. The term "triphosphate" includes an ester of phosphoric acid containing three phosphate groups. For example, particular drugs having a diphosphate or a triphosphate include:



[0051] As used herein, the term "heteroatom" includes oxygen (O), nitrogen (N), sulfur (S) and silicon (Si).

[0052] The symbol "R" is a general abbreviation that represents a substituent group that is selected from substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, and substituted or unsubstituted heterocyclyl groups.

[0053] The term "pharmaceutically acceptable carrier", as used herein means a pharmaceutically-acceptable material, composition or vehicle, such as a liquid or solid filler, diluent, excipient, solvent or encapsulating material, involved in carrying or transporting a chemical agent. Pharmaceutically acceptable carriers include pharmaceutically acceptable salts, where the term "pharmaceutically acceptable salts" includes salts of the active compounds which are prepared with relatively nontoxic acids or bases, depending on the particular substituents found on the compounds described herein. When compounds of the present invention contain relatively acidic functionalities, base addition salts can be obtained by contacting the neutral form of such compounds with a sufficient amount of the desired base, either neat or in a suitable inert solvent. Examples of pharmaceutically acceptable base addition salts include sodium, potassium, calcium, ammonium, organic amino, or magnesium salt, or a similar salt. When compounds of the present invention contain relatively basic functionalities, acid addition salts can be obtained by contacting the neutral form of such compounds with a sufficient amount of the desired acid, either neat or in a suitable inert solvent. Examples of pharmaceutically acceptable acid addition salts include those derived from inorganic acids like hydrochloric, hydrobromic, nitric, carbonic, monohydrogencarbonic, phosphoric, monohydrogenphosphoric, dihydrogenphosphoric, sulfuric, monohydrogensulfuric, hydriodic, or phosphorous acids, as well as the salts derived from relatively nontoxic organic acids like acetic, propionic, isobutyric, maleic, malonic, benzoic, succinic, suberic, fumaric, lactic, mandelic, phthalic, benzenesulfonic, p-tolylsulfonic, citric, tartaric, methanesulfonic. Also included are salts of amino acids such as arginate, and salts of organic acids like glucuronic or galactunoric acids (see, for example, Berge et al., "Pharmaceutical Salts", Journal of Pharmaceutical Science, 1977, 66, 1-19). Certain specific compounds of the present invention contain both basic and acidic functionalities that allow the compounds to be converted into either base or acid addition salts.

[0054] The neutral forms of the compounds are preferably regenerated by contacting the salt with a base or acid and isolating the parent compound in the conventional manner. The parent form of the compound differs from the various salt forms in certain physical properties, such as solubility in polar solvents, but otherwise the salts are equivalent to the parent form of the compound for the purposes of the present invention.

[0055] In addition to salt forms, the present invention provides compounds, which are in a prodrug form. Prodrugs of the compounds described herein are those compounds that readily undergo chemical changes under physiological conditions to provide the compounds of the present invention. Additionally, prodrugs can be converted to the compounds

of the present invention by chemical or biochemical methods in an *ex vivo* environment. For example, prodrugs can be slowly converted to the compounds of the present invention when placed in a transdermal patch reservoir with a suitable enzyme or chemical reagent.

[0056] Certain compounds of the present invention can exist in unsolvated forms as well as solvated forms, including hydrated forms. In general, the solvated forms are equivalent to unsolvated forms and are encompassed within the scope of the present invention. Certain compounds of the present invention may exist in multiple crystalline or amorphous forms. In general, all physical forms are equivalent for the uses contemplated by the present invention and are intended to be within the scope of the present invention.

[0057] Certain compounds of the present invention possess asymmetric carbon atoms (optical centers) or double bonds; the racemates, diastereomers, geometric isomers and individual isomers are encompassed within the scope of the present invention.

[0058] The compounds of the present invention may also contain unnatural proportions of atomic isotopes at one or more of the atoms that constitute such compounds. For example, the compounds may be radiolabeled with radioactive isotopes; such as for example tritium (^3H), iodine-125 (^{125}I) or carbon-14 (^{14}C). All isotopic variations of the compounds of the present invention, whether radioactive or not, are intended to be encompassed within the scope of the present invention.

[0059] As used herein, the term "leaving group" refers to a portion of a substrate that is cleaved from the substrate in a reaction.

[0060] The term "antibody" as referred to herein includes whole antibodies and any antigen binding fragment (*i.e.*, "antigen-binding portion") or single chains thereof. An "antibody" refers to a glycoprotein comprising at least two heavy (H) chains and two light (L) chains interconnected by disulfide bonds, or an antigen binding portion thereof. Each heavy chain is comprised of a heavy chain variable region (V_H) and a heavy chain constant region. The heavy chain constant region is comprised of three domains, C_{H1} , C_{H2} and C_{H3} , and may be of the mu, delta, gamma, alpha or epsilon isotype. Each light chain is comprised of a light chain variable region (V_L) and a light chain constant region. The light chain constant region is comprised of one domain, C_L , which may be of the kappa or lambda isotype. The V_H and V_L regions can be further subdivided into regions of hypervariability, termed complementarity determining regions (CDR), interspersed with regions that are more conserved, termed framework regions (FR). Each V_H and V_L is composed of three CDRs and four FRs, arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4. The variable regions of the heavy and light chains contain a binding domain that interacts with an antigen. The constant regions of the antibodies may mediate the binding of the immunoglobulin to host tissues or factors, including various cells of the immune system (*e.g.*, effector cells) and the first component (C1q) of the classical complement system.

[0061] The terms "antibody fragment" or "antigen-binding portion" of an antibody (or simply "antibody portion"), as used herein, refers to one or more fragments of an antibody that retain the ability to specifically bind to an antigen. It has been shown that the antigen-binding function of an antibody can be performed by fragments of a full-length antibody. Examples of binding fragments encompassed within the term "antibody fragment" or "antigen-binding portion" of an antibody include (i) a Fab fragment, a monovalent fragment consisting of the V_L , V_H , C_L and C_{H1} domains; (ii) a $F(ab')_2$ fragment, a bivalent fragment comprising two Fab fragments linked by a disulfide bridge at the hinge region; (iii) a Fd fragment consisting of the V_H and C_{H1} domains; (iv) a Fv fragment consisting of the V_L and V_H domains of a single arm of an antibody, (v) a dAb fragment (Ward et al., (1989) Nature 341 :544-546), which consists of a V_H domain; and (vi) an isolated complementarity determining region (CDR). Furthermore, although the two domains of the Fv fragment, V_L and V_H , are coded for by separate genes, they can be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the V_L and V_H regions pair to form monovalent molecules (known as single chain Fv (scFv); *see e.g.*, Bird et al. (1988) Science 242:423-426; and Huston et al. (1988) Proc. Natl. Acad. Sci. USA 85:5879-5883). Such single chain antibodies are also intended to be encompassed within the term "antigen-binding portion" of an antibody. These antibody fragments are obtained using conventional techniques known to those with skill in the art, and the fragments are screened for utility in the same manner as are intact antibodies.

[0062] The terms "monoclonal antibody" as used herein refers to a preparation of antibody molecules of single molecular composition. A monoclonal antibody composition displays a single binding specificity and affinity for a particular epitope.

[0063] "Solid support," as used herein refers to a material that is substantially insoluble in a selected solvent system, or which can be readily separated (*e.g.*, by precipitation) from a selected solvent system in which it is soluble. Solid supports useful in practicing the present invention can include groups that are activated or capable of activation to allow selected species to be bound to the solid support. A solid support can also be a substrate, for example, a chip, wafer or well, onto which an individual, or more than one compound, of the invention is bound.

[0064] "Reactive functional group," as used herein refers to groups including olefins, acetylenes, alcohols, phenols, ethers, oxides, halides, aldehydes, ketones, carboxylic acids, esters, amides, cyanates, isocyanates, thiocyanates, isothiocyanates, amines, hydrazines, hydrazones, hydrazides, diazo, diazonium, nitro, nitriles, mercaptans, sulfides, disulfides, sulfoxides, sulfones, sulfonic acids, sulfinic acids, acetals, ketals, anhydrides, sulfates, sulfenic acids isoni-

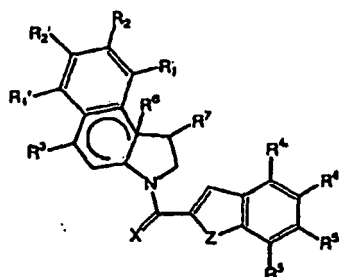
triles, amidines, imides, imidates, nitrones, hydroxylamines, oximes, hydroxamic acids thiohydroxamic acids, allenes, ortho esters, sulfites, enamines, ynamines, ureas, pseudoureas, semicarbazides, carbodiimides, carbamates, imines, azides, azo compounds, azoxy compounds, and nitroso compounds. Reactive functional groups also include those used to prepare bioconjugates, e.g., N-hydroxysuccinimide esters, maleimides (see, for example, Hermanson, BIOCONJUGATE TECHNIQUES, Academic press, San Diego, 1996). Methods to prepare each of these functional groups are well known in the art and their application to or modification for a particular purpose is within the ability of one of skill in the art (see, for example, Sandler and Karo, eds. ORGANIC FUNCTIONAL GROUP PREPARATIONS, Academic Press, San Diego, 1989). The reactive functional groups may be protected or unprotected.

[0065] The compounds of the invention are prepared as a single isomer (e.g., enantiomer, cis-trans, positional, diastereomer) or as a mixture of isomers. In a preferred embodiment, the compounds are prepared as substantially a single isomer. Methods of preparing substantially isomerically pure compounds are known in the art. For example, enantiomerically enriched mixtures and pure enantiomeric compounds can be prepared by using synthetic intermediates that are enantiomerically pure in combination with reactions that either leave the stereochemistry at a chiral center unchanged or result in its complete inversion. Alternatively, the final product or intermediates along the synthetic route can be resolved into a single stereoisomer. Techniques for inverting or leaving unchanged a particular stereocenter, and those for resolving mixtures of stereoisomers are well known in the art and it is well within the ability of one of skill in the art to choose and appropriate method for a particular situation. See, generally, Furniss *et al.* (eds.), VoGEL's ENCYCLOPEDIA OF PRACTICAL ORGANIC CHEMISTRY 5TH ED., Longman Scientific and Technical Ltd., Essex, 1991, pp. 809-816; and Heller, *Acc. Chem. Res.* **23**: 128 (1990).

CBI Analogues

[0066] The compounds described herein are generally CBI analogues in that they incorporate the 1,2,9,9a-tetrahydro-cyclopropa[e]benz[e]indole-4-one (CBI) alkylating domain or alkylation subunit. The compounds may be used as drugs. Preferred drugs of the current invention include cytotoxic drugs useful in cancer therapy. Cytotoxic drugs useful in the current invention include, for example, CBI (1,2,9,9a-tetrahydmcycloptopa[c]benz[e]indol-4-one)-based analogues, MC-BI (7-methoxy-1,2,9,9a-tetra-hydrocyclopropa[c]benzMindol-4-one)-based analogues and CCBI (7-cyano-1,2,9,9a-tetra-hydrocyclo-propa[c]benz[e]-indol-4-one)-based analogues.

[0067] In one embodiment, a compound of the invention has the following formula (1):



(1)

wherein X is selected from O, S and NR²³ wherein R²³ is a member selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, and acyl; 11 Z is O;

R¹ is H, substituted or unsubstituted C₁₋₆ alkyl, C(O)R⁸, or CO₂R⁸,

R^{1'} is H, substituted or unsubstituted C₁₋₆ alkyl, or C(O)R⁸,

each R³ is a member independently selected from NR⁹R¹⁰ and OR⁹ and R⁹ and R¹⁰ are members independently selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl;

R² is H, substituted or unsubstituted C₁₋₆ alkyl, unsubstituted heteroalkyl, cyano, or alkoxy;

R^{2'} is H, substituted or unsubstituted C₁₋₆ alkyl, or unsubstituted heteroalkyl,

R³ is a member selected from the group consisting of SR¹¹, NHR¹¹ and OR¹¹, wherein R¹¹ is a member selected from the group consisting of H, substituted alkyl, unsubstituted alkyl, substituted heteroalkyl, unsubstituted heteroalkyl diphosphates, triphosphates, acyl, C(O)R¹²R¹³, C(O)OR¹², C(O)NR¹²R¹¹, P(O)(OR¹²)₂, C(O)CHR¹²R¹³, SR¹² and SiR¹²R¹³R¹⁴, in which R¹², substituted or unsubstituted heteroalkyl and substituted or unsubstituted aryl, or R¹² and R¹³ together with the nitrogen or carbon atom to which they are attached are joined to form a substituted or unsubstituted heterocycloalkyl ring system having from 4 to 6 members, optionally containing two or more heteroatoms;

R⁶ is a single bond which is either present or absent and when present R⁶ and R⁷ are joined to form a cyclopropyl ring; and R⁷ is CH₂-X¹ or -CH₂- joined in said cyclopropyl ring with R⁶, wherein X¹ is a leaving group,

R⁴, R^{4'}, R⁵ and R^{5'} are members independently selected from the group consisting of H, substituted alkyl, unsubstituted

alkyl, substituted aryl, unsubstituted aryl, substituted heteroaryl, unsubstituted heteroaryl, substituted heterocycloalkyl, unsubstituted heterocycloalkyl, halogen, NO₂, NR¹⁵R¹⁶, NC(O)R¹⁵, OC(O)NR¹⁵R¹⁶, OC(O)OR¹⁵, C(O)R¹⁵, SR¹⁵, OR¹⁵, CR¹⁵=NR¹⁶, and O(CH₂)_nNR²⁴R²⁵ wherein n is an integer from 1 to 20, preferably, n is an integer from 2 to 6;

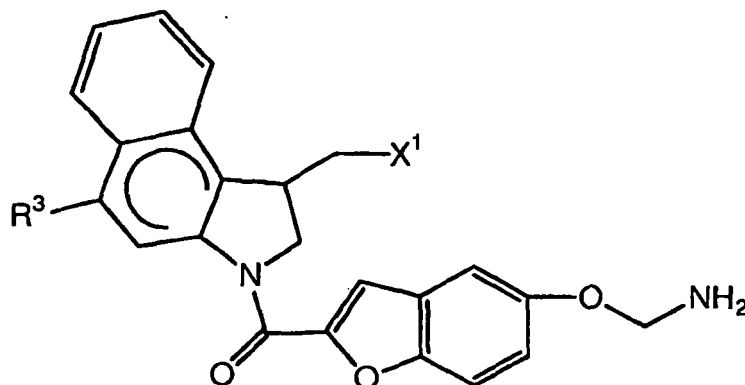
R¹⁵ and R¹⁶ are independently selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, substituted or unsubstituted heterocycloalkyl, and substituted or unsubstituted peptidyl, wherein R¹⁵ and R¹⁶ together with the nitrogen atom to which they are attached are optionally joined to form a substituted or unsubstituted heterocycloalkyl ring system having from 4 to 6 members, optionally containing two or more heteroatoms;

and R²⁴ and R²⁵ are independently selected from hydrogen and unsubstituted alkyl, wherein at least one of R²⁴ and R²⁵ is hydrogen, and

wherein at least one of R⁴, R^{4'}, R⁵ and R^{5'} is O(CH₂)_nNR²⁴R²⁵.

[0068] As discussed above, X¹ may be a leaving group. Useful leaving groups include, , halogens, azides, sulfonic esters (e.g., alkylsulfonyl, arylsulfonyl), oxonium ions, alkyl perchlorates, ammonioalkanesulfonate esters, alkylfluorosulfonates and fluorinated compounds (e.g., triflates, nonaflates, tresylates) Particular halogens useful as leaving groups are F, Cl and Br. The choice of these and other leaving groups appropriate for a particular set of reaction conditions is within the abilities of those of skill in the art (see; for example, March J, ADVANCED ORGANIC CHEMISTRY, 2nd Edition, John Wiley and Sons, 1992; Sandler SR, Karo W, ORGANIC FUNCTIONAL GROUP PREPARATIONS, 2nd Edition, Academic Press, Inc., 1983; and Wade LG, COMPENDIUM OF ORGANIC SYNTHETIC METHODS, John Wiley and Sons, 1980).

[0069] A preferred embodiment of the compound of claim 1 is the following:



PHARMACEUTICAL FORMULATIONS AND ADMINISTRATION

[0070] In another preferred embodiment, the present invention provides a pharmaceutical formulation comprising a compound of the invention and a pharmaceutically acceptable carrier.

[0071] The compounds described herein including pharmaceutically acceptable carriers such as addition salts or hydrates thereof, can be delivered to a patient using a wide variety of routes or modes of administration. Suitable routes of administration include, inhalation, transdermal, oral, rectal, transmucosal, intestinal and parenteral administration, including intramuscular, subcutaneous and intravenous injections. Preferably, the conjugates of the invention are administered parenterally, more preferably intravenously.

[0072] As used herein, the terms "administering" or "administration" are intended to encompass all means for directly and indirectly delivering a compound to its intended site of action.

[0073] The compounds described herein, or pharmaceutically acceptable salts and/or hydrates thereof, may be administered singly, in combination with other compounds of the invention, and/or in cocktails combined with other therapeutic agents. Of course, the choice of therapeutic agents that can be co-administered with the compounds of the invention will depend, in part, on the condition being treated.

[0074] For example, when administered to patients suffering from a disease state caused by an organism that relies on an autoinducer, the compounds of the invention can be administered in cocktails containing agents used to treat the pain, infection and other symptoms and side effects commonly associated with the disease. Such agents include, e.g., analgesics, antibiotics, etc.

[0075] When administered to a patient undergoing cancer treatment, the compounds may be administered in cocktails

containing anti-cancer agents and/or supplementary potentiating agents. The compounds may also be administered in cocktails containing agents that treat the side-effects of radiation therapy, such as anti-emetics, radiation protectants, etc.

[0076] Supplementary potentiating agents that can be co-administered with the compounds of the invention include, *e.g.*, tricyclic anti-depressant drugs (*e.g.*, imipramine, desipramine, amitriptyline, clomipramine, trimipramine, doxepin, nortriptyline, protriptyline, amoxapine and maprotiline); non-tricyclic and anti-depressant drugs (*e.g.*, sertraline, trazodone and citalopram); Ca^{+2} antagonists (*e.g.*, verapamil, nifedipine, nitrendipine and caroverine); amphotericin; triparanol analogues (*e.g.*, tamoxifen); antiarrhythmic drugs (*e.g.*, quinidine); antihypertensive drugs (*e.g.*, reserpine); thiol depleters (*e.g.*, buthionine and sulfoximine); and calcium leucovorin.

[0077] The active compound(s) of the invention are administered *per se* or in the form of a pharmaceutical composition wherein the active compound(s) is in admixture with one or more pharmaceutically acceptable carriers, excipients or diluents. Pharmaceutical compositions for use in accordance with the present invention are typically formulated in a conventional manner using one or more physiologically acceptable carriers comprising excipients and auxiliaries, which facilitate processing of the active compounds into preparations which, can be used pharmaceutically. Proper formulation is dependent upon the route of administration chosen.

[0078] For transmucosal administration, penetrants appropriate to the barrier to be permeated are used in the formulation. Such penetrants are generally known in the art.

[0079] For oral administration, the compounds can be formulated readily by combining the active compound(s) with pharmaceutically acceptable carriers well known in the art. Such carriers enable the compounds of the invention to be formulated as tablets, pills, dragees, capsules, liquids, gels, syrups, slurries, suspensions and the like, for oral ingestion by a patient to be treated. Pharmaceutical preparations for oral use can be obtained solid excipient, optionally grinding a resulting mixture, and processing the mixture of granules, after adding suitable auxiliaries, if desired to obtain tablets or dragee cores. Suitable excipients are, in particular, fillers such as sugars, including lactose, sucrose, mannitol, or sorbitol; cellulose preparations such as, for example, maize starch, wheat starch, rice starch, potato starch, gelatin, gum tragacanth, methyl cellulose, hydroxypropylmethyl-cellulose, sodium carboxymethylcellulose, and/or polyvinylpyrrolidone (PVP). If desired, disintegrating agents may be added, such as the cross-linked polyvinyl pyrrolidone, agar, or alginic acid or a salt thereof such as sodium alginate.

[0080] Dragee cores are provided with suitable coatings. For this purpose, concentrated sugar solutions may be used, which may optionally contain gum arabic, talc, polyvinyl pyrrolidone, carbopol gel, polyethylene glycol, and/or titanium dioxide, lacquer solutions, and suitable organic solvents or solvent mixtures. Dyestuffs or pigments may be added to the tablets or dragee coatings for identification or to characterize different combinations of active compound doses.

[0081] Pharmaceutical preparations, which can be used orally, include push-fit capsules made of gelatin, as well as soft, sealed capsules made of gelatin and a plasticizer, such as glycerol or sorbitol. The push-fit capsules can contain the active ingredients in admixture with filler such as lactose, binders such as starches, and/or lubricants such as talc or magnesium stearate and, optionally, stabilizers. In soft capsules, the active compounds may be dissolved or suspended in suitable liquids, such as fatty oils, liquid paraffin, or liquid polyethylene glycols. In addition, stabilizers may be added. All formulations for oral administration should be in dosages suitable for such administration.

[0082] For buccal administration, the compositions may take the form of tablets or lozenges formulated in conventional manner.

[0083] For administration by inhalation, the compounds for use according to the present invention are conveniently delivered in the form of an aerosol spray presentation from pressurized packs or a nebulizer, with the use of a suitable propellant, *e.g.*, dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, carbon dioxide or other suitable gas. In the case of a pressurized aerosol the dosage unit may be determined by providing a valve to deliver a metered amount. Capsules and cartridges of *e.g.*, gelatin for use in an inhaler or insufflator may be formulated containing a powder mix of the compound and a suitable powder base such as lactose or starch.

[0084] The compounds may be formulated for parenteral administration by injection, *e.g.*, by bolus injection or continuous infusion. Injection is a preferred method of administration for the compositions of the current invention. Formulations for injection may be presented in unit dosage form, *e.g.*, in ampoules or in multi-dose containers, with an added preservative. The compositions may take such forms as suspensions, solutions or emulsions in oily or aqueous vehicles, and may contain formulatory agents such as suspending, stabilizing and/or dispersing agents may be added, such as the cross-linked polyvinyl pyrrolidone, agar, or alginic acid or a salt thereof such as sodium alginate.

[0085] Pharmaceutical formulations for parenteral administration include aqueous solutions of the active compounds in water-soluble form. Additionally, suspensions of the active compounds may be prepared as appropriate oily injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acid esters, such as ethyl oleate or triglycerides, or liposomes. Aqueous injection suspensions may contain substances, which increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol, or dextran. Optionally, the suspension may also contain suitable stabilizers or agents, which increase the solubility of the compounds to allow for the preparation of highly, concentrated solutions. For injection, the agents of the invention may be formulated in aqueous solutions, preferably in physiologically compatible buffers such as Hanks's solution, Ringer's solution, or physiological

saline buffer.

[0086] Alternatively, the active ingredient may be in powder form for constitution with a suitable vehicle, *e.g.*, sterile pyrogen-free water, before use.

[0087] The compounds may also be formulated in rectal compositions such as suppositories or retention enemas, *e.g.*, containing conventional suppository bases such as cocoa butter or other glycerides.

[0088] In addition to the formulations described previously, the compounds may also be formulated as a depot preparation. Such long acting formulations may be administered by implantation or transcutaneous delivery (*e.g.*, subcutaneously or intramuscularly), intramuscular injection or a transdermal patch. Thus, for example, the compounds may be formulated with suitable polymeric or hydrophobic materials (*e.g.*, as an emulsion in an acceptable oil) or ion exchange resins, or as sparingly soluble derivatives, for example, as a sparingly soluble salt.

[0089] The pharmaceutical compositions also may comprise suitable solid or gel phase carriers or excipients. Examples of such carriers or excipients include calcium carbonate, calcium phosphate, various sugars, starches, cellulose derivatives, gelatin, and polymers such as polyethylene glycols.

[0090] A preferred pharmaceutical composition is a composition formulated for injection such as intravenous injection and includes about 0.01% to about 100% by weight of the drug conjugate, based upon 100% weight of total pharmaceutical composition. The drug conjugate may be an antibody-cytotoxin conjugate where the antibody has been selected to target a particular cancer.

DRUG METHODS OF USE

[0091] The current invention is particularly useful for the treatment of cancer and for the inhibition of the multiplication of a tumor cell or cancer cell in an animal. Cancer, or a precancerous condition, includes, a tumor, metastasis, or any disease or disorder characterized by uncontrolled cell growth, can be treated or prevented by administration the drug

[0092] Representative examples of precancerous conditions that may be targeted by the present invention, include metaplasia, hyperplasia, dysplasia, colorectal polyps, actinic ketatosis, actinic cheilitis, human papillomaviruses, leukoplakia, lichen planus and Bowen's disease.

[0093] Representative examples of cancer or tumors that may be targeted by the present invention include: lung cancer, colon cancer, prostate cancer, lymphoma, melanoma, breast cancer, ovarian cancer, testicular cancer, CNS cancer, renal cancer, kidney cancer, pancreatic cancer, stomach cancer, oral cancer, nasal cancer, cervical cancer and leukemias. It

[0094] The compounds of the present invention can be used in a method of killing a cell. The method includes administering to the cell an amount of a compound of the invention sufficient to kill said cell. In an exemplary embodiment, the compound is administered to a subject bearing the cell. In a further exemplary embodiment, the administration serves to retard or stop the growth of a tumor that includes the cell (*e.g.*, the cell can be a tumor cell). For the administration to retard the growth, the rate of growth of the cell should be at least 10% less than the rate of growth before administration. Preferably, the rate of growth will be retarded at least 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or completely stopped.

Effective Dosages

[0095] Pharmaceutical compositions suitable for use with the present invention include compositions wherein the active ingredient is contained in a therapeutically effective amount, *i.e.*, in an amount effective to achieve its intended purpose. The actual amount effective for a particular application will depend, *inter alia*, on the condition being treated. Determination of an effective amount is well within the capabilities of those skilled in the art, especially in light of the detailed disclosure herein.

[0096] For any compound described herein, the therapeutically effective amount can be initially determined from cell culture assays. Target plasma concentrations will be those concentrations of active compound(s) that are capable of inhibition cell growth or division. In preferred embodiments, the cellular activity is at least 25% inhibited. Target plasma concentrations of active compound(s) that are capable of inducing at least about 50%, 75%, or even 90% or higher inhibition of cellular activity are presently preferred. The percentage of inhibition of cellular activity in the patient can be monitored to assess the appropriateness of the plasma drug concentration achieved, and the dosage can be adjusted upwards or downwards to achieve the desired percentage of inhibition.

[0097] As is well known in the art, therapeutically effective amounts for use in humans can also be determined from animal models. For example, a dose for humans can be formulated to achieve a circulating concentration that has been found to be effective in animals. The dosage in humans can be adjusted by monitoring cellular inhibition and adjusting the dosage upwards or downwards, as described above.

[0098] A therapeutically effective dose can also be determined from human data for compounds which are known to exhibit similar pharmacological activities. The applied dose can be adjusted based on the relative bioavailability and potency of the administered compound as compared with the known compound.

[0099] Adjusting the dose to achieve maximal efficacy in humans based on the methods described above and other methods as are well-known in the art is well within the capabilities of the ordinarily skilled artisan.

[0100] In the case of local administration, the systemic circulating concentration of administered compound will not be of particular importance. In such instances, the compound is administered so as to achieve a concentration at the local area effective to achieve the intended result.

[0101] For use in the prophylaxis and/or treatment of diseases related to abnormal cellular proliferation, a circulating concentration of administered compound of about 0.001 μM to 20 μM is preferred, with 0.01 μM to 5 μM being preferred.

[0102] Patient doses for oral administration of the compounds described herein, typically range from 1 mg/day to 10,000 mg/day, more typically from about 10 mg/day to 1,000 mg/day, and most typically from 50 mg/day to 500 mg/day. Stated in terms of patient body weight, typical dosages range from 0.01 to 150 mg/kg/day, more typically from 0.1 to 15 mg/kg/day, and most typically from 1 to 10 mg/kg/day, , for example 5 mg/kg/day or 3 mg/kg/day.

[0103] In at least some embodiments, patient doses that retard or inhibit tumor growth can be 1 $\mu\text{mol/kg/day}$ or less. For example, the patient doses can be 0.9, 0.6, 0.5, 0.45, 0.3, 0.2, 0.15, or 0.1 $\mu\text{mol/kg/day}$ or less (referring to moles of the drug) of the drug or a drug conjugate, such as an antibody-drug conjugate. Preferably, the drug or drug conjugate growth of the tumor when administered in the daily dosage amount over a period of at least five days. In at least some embodiments, the tumor is a human-type tumor in a SCID mouse. As an example, the SCID mouse can be a CB17.SCID mouse (available from Taconic, Germantown, NY).

[0104] For other modes of administration, dosage amount and interval can be adjusted individually to provide plasma levels of the administered compound effective for the particular clinical indication being treated. For example, in one embodiment, a compound according to the invention can be administered in relatively high concentrations multiple times per day. Alternatively, it may be more desirable to administer a compound of the invention at minimal effective concentrations and to use a less frequent administration regimen. This will provide a therapeutic regimen that is commensurate with the severity of the individual's disease.

[0105] Utilizing the teachings provided herein, an effective therapeutic treatment regimen can be planned which does not cause substantial toxicity and yet is entirely effective to treat the clinical symptoms demonstrated by the particular patient. This planning should involve the careful choice of active compound by considering factors such as compound potency, relative bioavailability, patient body weight, presence and severity of adverse side effects, preferred mode of administration and the toxicity profile of the selected agent.

[0106] The compounds, compositions and methods of the present invention are further illustrated by the examples that follow. These examples are offered to illustrate, claimed invention.

EXAMPLES

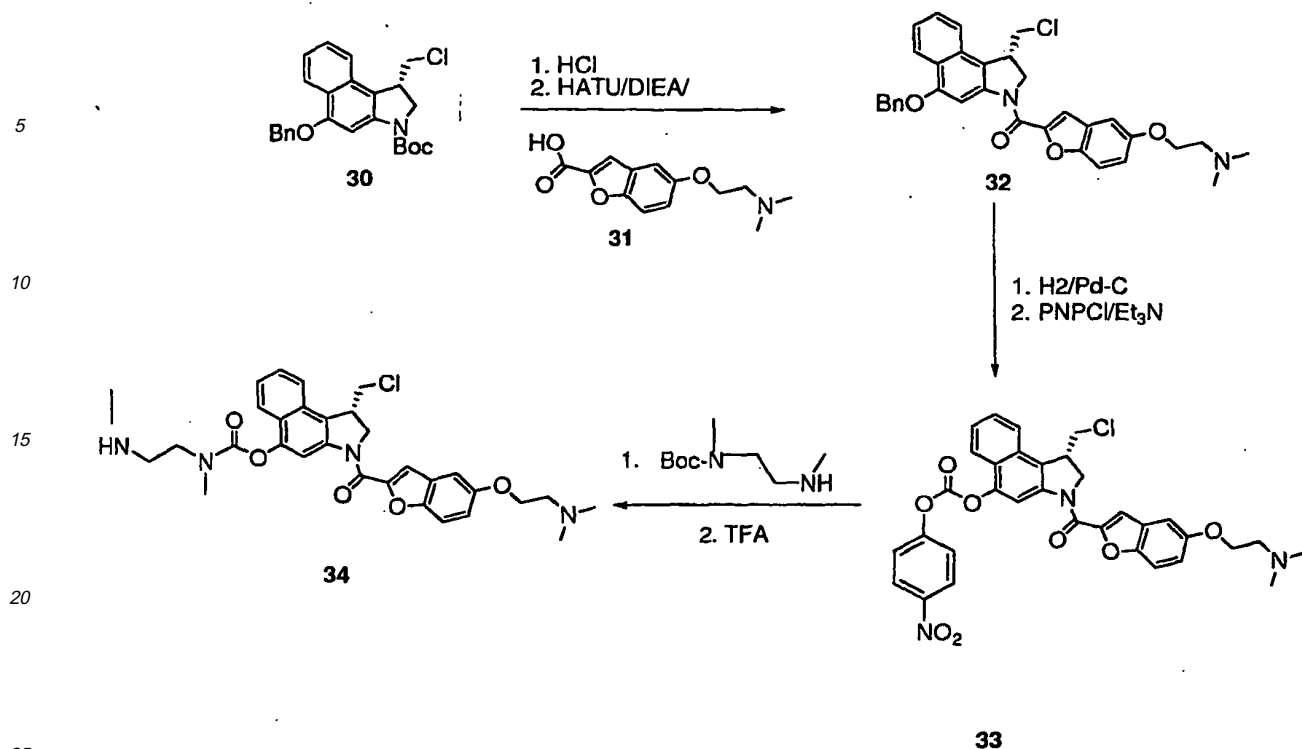
Material and Methods

[0107] In the examples below, unless otherwise stated, temperatures are given in degrees Celsius ($^{\circ}\text{C}$); operations were carried out at room or ambient temperature (typically a range of from about 18-25 $^{\circ}\text{C}$; evaporation of solvent was carried out using a rotary evaporator under reduced pressure (typically, 4.5-30 mmHg) with a bath temperature of up to 60 $^{\circ}\text{C}$; the course of reactions was typically followed by TLC and reaction times are provided for illustration only; melting points are uncorrected; products exhibited satisfactory $^1\text{H-NMR}$ and/or microanalytical data; yields are provided for illustration only; and the following conventional abbreviations are also used: mp (melting point), L (liter(s)), mL (milliliters), mmol (millimoles), g (grams), mg (milligrams), min (minutes), LC-MS (liquid chromatography-mass spectrometry) and h (hours).

[0108] $^1\text{H-NMR}$ spectra were measured on a Varian Mercury 300 MHz spectrometer and were consistent with the assigned structures. Chemical shifts were reported in parts per million (ppm) downfield from tetramethylsilane. Electrospray mass spectra were recorded on a Perkin Elmer Sciex API 365 mass spectrometer. Elemental analyses were performed by Robertson Microlit Laboratories, Madison, NJ. Silica gel for flash chromatography was E. Merck grade (230-400 mesh). Reverse-Phase analytical HPLC was performed on either a HP 1100 or a Varian ProStar 210 instrument with a Phenomenex Lunar 5 μm C-18(2) 150 mm x 4.6 mm column or a Varian Microsorb-MV 0.1 μm C-18 150 mm x 4.6 mm column. A flow rate of 1 mL/min was with either a gradient of 0% to 50% buffer B over 15 minutes or 10% to 100% buffer B over 10 minutes with detection by UV at 254nm. Buffer A, 20 mM ammonium formate + 20% acetonitrile or 0.1% trifluoroacetic acid in acetonitrile; buffer B, 20 mM ammonium formate + 80% acetonitrile or 0.1% aqueous trifluoroacetic acid. Reverse phase preparative HPLC were performed on a Varian ProStar 215 instrument with a Waters Delta Pak 15 μm C-18 300 mm x 7.8 mm column.

Reference Example 1

[0109]



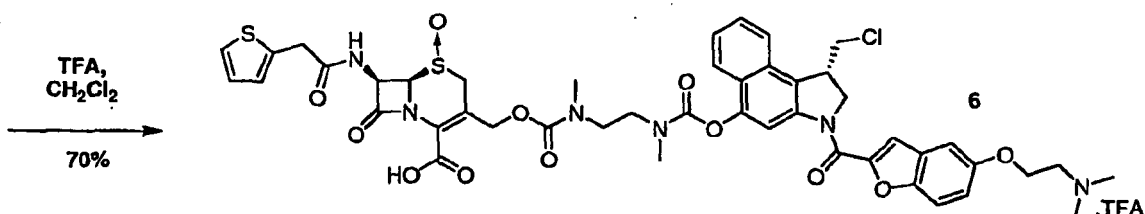
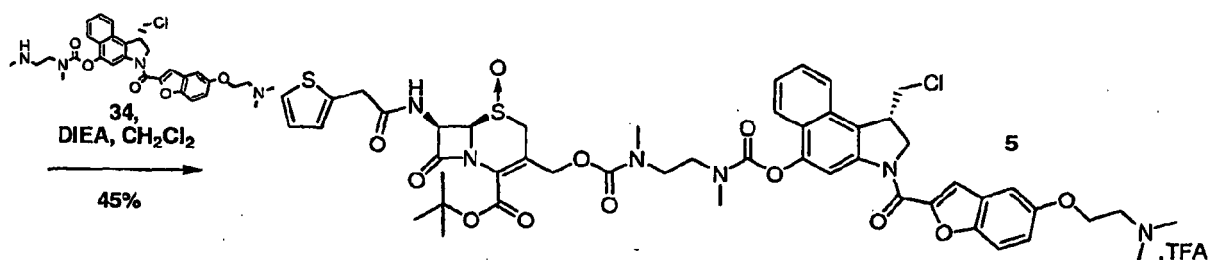
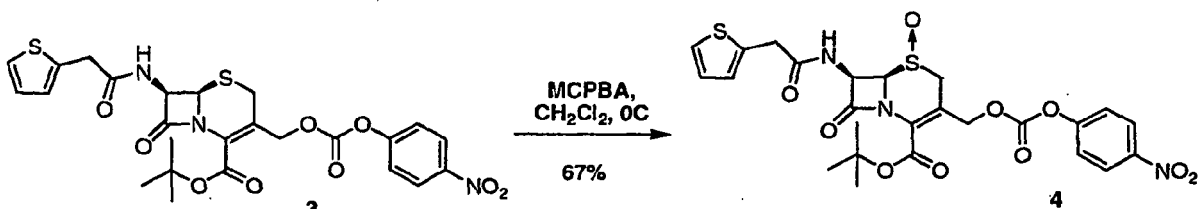
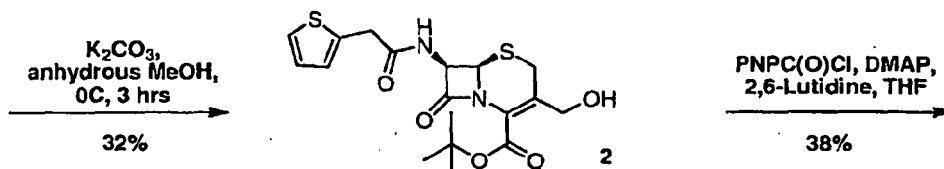
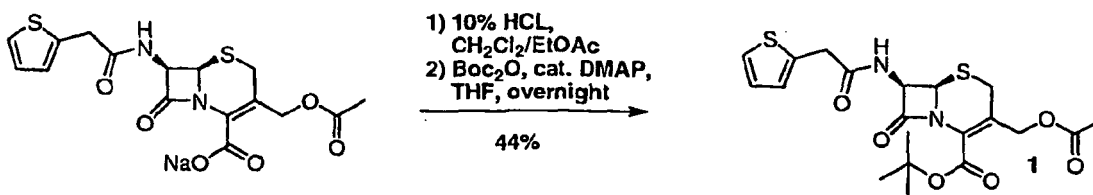
[0110] Synthesis of Compound 32. To a solution of Compound 30 (120 mg, 0.28 mmole) in ethyl acetate (10 mL) was bubbled HCl gas for 5 min. The reaction mixture was stirred at RT for another 30 min and then the mixture was concentrated. Ether was added to the reaction mixture and the white precipitate was collected on a filter funnel. Solid was dried overnight under vacuum to give 100mg of the desired product which was confirmed by LC-MS (ESI) 324 (M+H⁺) and used in next step without further purification. To a solution of this compound (100 mg, 0.24 mmole) in DMF (5 mL) were added compound **31** (65 mg, 0.26 mmole), HATU (100 mg, 0.26 mmole) and TEA (91 μ L, 0.52 mmole). The mixture thus obtained was stirred at room temperature for 3 hrs. The solvent was evaporated and the residue was purified on semi-preparative HPLC with 0.1% TFA in water and acetonitrile as eluent to give compound **32** as an oil (110 mg, 80%). The desired product was confirmed by LC-MS (ESI) 555 (M+H⁺).

[0111] Synthesis of Compound 33. A solution of Compound **32** (110 mg, 0.2 mmole) and palladium on charcoal (20 mg) in DCM (10 mL) and methanol (5 mL) was stirred under hydrogen atmospheric pressure at room temperature for 12 hrs. The palladium was filtrated and the reaction mixture was concentrated and the residue was purified on semi-preparative HPLC with 0.1 % TFA in water and acetonitrile as eluent to give the desired compound as an oil (80 mg, 78%) LC-MS (ESI) 465 (M+H⁺). To a solution of the residue (80 mg, 0.17 mmole) in dichloromethane (10 mL) and THF (5 mL) was added PNPCl (4-nitrophenyl chloroformate) (137 mg, 0.68 mmole) and triethyl amine (144 μ L, 1.02 mmol) at 0°C. The mixture thus obtained was stirred for 30 min at 0°C and then at room temperature for 12 hrs. The reaction mixture was concentrated under vacuum, and the residue was precipitated using ethyl ether (100 mL) to give compound **33** as a yellow solid (90 mg, 82%) which was dried under vacuum and confirmed by LC-MS (ESI) 631 (M+H⁺).

[0112] Synthesis of Compound 34. To a solution of compound 33 (60 mg, 0.1 mmole) in dichloromethane (10 mL) was added Boc-N,N dimethyl entyl diamine (84 mg, 0.38 mmole) and triethyl amine (26 μ L, 0.1 mmol) at room temperature. The mixture thus obtained was stirred at room temperature for 12 hrs. The reaction mixture was concentrated under vacuum, and the residue was precipitated using ethyl ether (100 mL) to give Boc protected compound 34 which was used for the next step without further purification. Boc protected compound 34 was dissolved in 10 mL of TFA and the reaction mixture was stirred at room temperature for 60 min. The reaction mixture was concentrated under vacuum, and the residue was precipitated using ethyl ether (100 mL) to give compound **34** as a yellow solid which was dried under vacuum and confirmed by LC-MS (ESI) 631 (M+H⁺).

Reference EXAMPLE 2:

[0113]



[0114] **Synthesis of Compound 1** Cephalotin Sodium salt (0.5 g, 1.2 mole) was dissolved in water (10 mL) and poured into a separative funnel. The solution was acidified with 1N HCl aqueous solution and the desired compound was extracted with Dichloromethane (100 mL) and Ethyl Acetate (40 mL). The organic layer was dried over Na₂SO₄ anhydrous, filtered and concentrated to dryness to give the title compound as a white solid (474 mg, 99%). To a solution of the white compound (1.2 mmole) and *tert*-Boc₂O (0.3 g, 1.37 mmole) in Tetrahydrofuran (20 mL) was added Dimethylaminopyridine (15 mg, 0.12 mmole). The mixture thus obtained was stirred at room temperature overnight. The solvent was evaporated and the residue was purified on semi-preparative HPLC with 0.1 % TFA in Water and Acetonitrile as eluent to give the title compound as an oil (238 mg, 44%). ¹H NMR (CD₃OD) δ 1.49 (s, 9H), 2.05 (s, 3H), 3.80 (s, 2H), 4.60 (d, 1H), 4.77 (d, 1H), 4.93 (d, 1H), 5.28 (d, 1H), 5.49 (m, 1H), 6.59 (s, 1H), 6.96 (m, 2H), 7.27 (dd, 1H), 9.18 (bd, 1H); LC-MS (ESI)

453 (M+H⁺), 475 (M+Na⁺), 491 (M+K⁺).

[0115] Synthesis of Compound 2 To a solution of Compound 1 (204 mg, 0.45 mmole) in Methanol (40 mL) was added Potassium Carbonate (25 mg, 0.18 mmole) at 0°C. The mixture thus obtained was stirred for 3 hours. The reaction mixture was neutralized with Acetic Acid (600 µL) and concentrated. The solvent was evaporated and the residue was purified on semi-preparative HPLC with 0.1% TFA in Water and Acetonitrile as eluent to give the title compound as an oil (59 mg, 32%). ¹H NMR (CD₃OD) δ 1.49 (s, 9H), 3.80 (s, 2H), 4.15 (m, 2H), 4.95 (d, 1H), 5.28 (d, 1H), 5.46 (m, 1H), 6.39 (d, 1H), 6.95 (m, 2H), 7.26 (m, 1H), 9.09 (bd, 1H); LC-MS (ESI) 410 (M+H⁺), 433 (M+Na⁺), 449 (M+K⁺).

[0116] Synthesis of Compound 3 To a solution of Compound 2 (15 mg, 0.036 mmole) in THF (0.2 mL) was added Dimethylaminopyridine (0.13 mg, 0.001 mmole), para-Nitrophenyl chloroformate (11 mg, 0.054 mmole) and 2,6-Lutidine (6.4 µL, 0.054 mmole) at room temperature. The mixture thus obtained was stirred overnight. The solvent was evaporated and the residue was purified on semi-preparative HPLC with 0.1% TFA in Water and Acetonitrile as eluent to give the title compound as an oil (8 mg, 38%). ¹H NMR (CDCl₃) δ 1.49 (s, 9H), 3.88 (s, 2H), 4.76 (d, 1H), 4.94 (d, 1H), 4.95 (s, 1H), 5.29 (m, 1H), 5.67 (m, 1H), 6.41 (d, 1H), 6.52 (s, 1H), 7.00 (m, 2H), 7.28 (m, 1H), 7.37 (dd, 2H), 8.29 (dd, 2H); LC-MS (ESI) 575 (M+H⁺), 598 (M+Na⁺), 614 (M+K⁺).

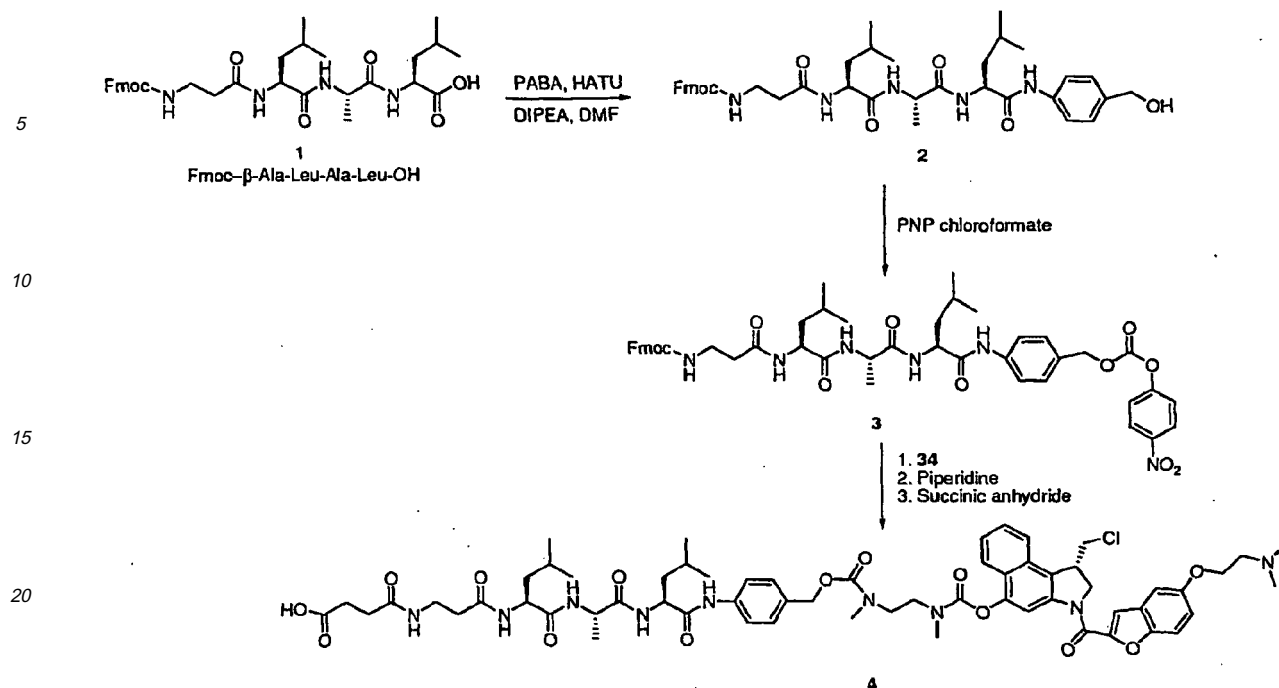
[0117] Synthesis of Compound 4 To a solution of Compound 3 (18 mg, 0.031 mmole) in dichloromethane (0.5 mL) cooled to 0°C was added *m*-Chloroperoxybenzoic acid (9 mg, 0.052 mmole). The mixture thus obtained was stirred for 2 hours at 0°C. The solvent was evaporated and the residue was purified on semi-preparative HPLC with 0.1% TFA in Water and Acetonitrile as eluent to give the title compound as an oil (12 mg, 67%). ¹H NMR (CDCl₃) δ 1.54 (s, 9H), 3.31 (d, 1H), 3.87 (s, 2H), 3.88 (d, 1H), 4.53 (d, 1H), 4.88 (d, 1H), 4.59 (d, 1H), 6.10 (dd, 1H), 6.92 (d, 1H), 6.99 (m, 2H), 7.27 (d, 1H), 7.37 (dd, 2H), 8.28 (d, 2H); LC-MS (ESI) 591 (M+H⁺), 614 (M+Na⁺), 630 (M+K⁺).

[0118] Synthesis of Compound 5 To a solution of Compound 34 (11 mg, 0.013 mmole) in 10% Dimethylformamide in Dichloromethane (0.2 mL) was added a solution of compound 4 (10 mg, 0.017 mmole) in Dichloromethane (0.2 mL), and Diisopropylethylamine (3.5 µL, 0.020 mmole) at room temperature. The mixture thus obtained was stirred overnight. The solvent was evaporated and the residue was purified on semi-preparative HPLC with 0.1 % TFA in Water and Acetonitrile as eluent to give the title compound as an oil (7 mg, 45%). LC-MS (ESI) 1031 (M+H⁺), 1054 (M+Na⁺), 1070 (M+K⁺).

[0119] Synthesis of Compound 6 To a solution of Compound 5 (6.5 mg, 0.0056 mmole) in Dichloromethane (0.2 mL) was added Trifluoroacetic Acid (0.1 mL) at 0°C. The mixture thus obtained was let warmed to room temperature and stirred for 30 min. The solvent was evaporated and the residue was purified on semi-preparative HPLC with 0.1% TFA in Water and Acetonitrile as eluent to give the title compound as an oil (4 mg, 70%). LC-MS (ESI) 975 (M+H⁺), 998 (M+Na⁺), 1014 (M+K⁺).

Reference EXAMPLE 3:

[0120]



[0121] Synthesis of compound 2. In a 50 ml round bottom flask equipped with stir bar and nitrogen inlet, Fmoc-βAlaLeuAlaLeu-OH (5 gm, 0.0082 moles, Abbott Labs) was dissolved in DMF (30 ml). HATU (3.13 gm, 0.0082 moles) then DIPEA (2.86 ml, 0.0164 moles) were added and the solution stirred for 10 minutes. 4-Aminobenzyl alcohol (1.5 gm, 0.0122 moles) was added and the reaction stirred at room temperature for 18 hrs. The solvent was concentrated in vacuo and the residue dissolved in DMF (20 ml). The product was precipitated with diethyl ether (200 ml) and collected by filtration to give 4.5 gm (77%) of product. The product was confirmed by mass spec: m/z 714.4 $[M + 1]^+$

[0122] Synthesis of compound 3. In a 25 ml RBF equipped with stir bar and nitrogen inlet, 2 (0.3 gm, 0.4 mmoles) was dissolved in 1.5 ml DMF. A 1:1 solution of DCM/THF was added followed by 4-nitrophenylchloroformate (0.2 gm, 1 mmole) and pyridine (0.2 ml, 2.5 mmoles). The reaction was stirred at room temperature for 6 hr. The solvent was removed in vacuo and the residue purified by column chromatography (10% MeOH/DCM) to yield 0.104 gm (28%) of **3**. The product was confirmed by mass spec: m/z 879.6 $[M + 1]^+$

[0123] Synthesis of Compound 4. To a solution of Compound 34 (11 mg, 0.013 mmole) in 10% Dimethylformamide in Dichloromethane (0.2 mL) was added a solution of compound 3 (15 mg, 0.017 mmole) in Dichloromethane (0.2 mL), and Diisopropylethylamine (3.5 μ L, 0.020 mmole) at room temperature. The mixture thus obtained was stirred overnight. The solvent was evaporated and the residue was purified on semi-preparative HPLC with 0.1% TFA in Water and Acetonitrile as eluent to give the title compound as an oil. The product was confirmed by LC/MS. This product was dissolved in DMF (10 mL) and Piperidine (0.5 ml, 0.5 moles) was added and the solution stirred for 30 minutes. The solution was concentrated in vacuo, washed with hexane and dried under vacuum for 1.2 hrs. The deprotected amine prepared above was dissolved in anhydrous DMF (10 ml) followed by the addition of succinic anhydride (20 mg, 0.2 mmoles) and the reaction mixture was stirred at room temperature for 24 hr. After 24 hrs HPLC showed no starting material and the reaction was purified by preparative HPLC to yield compound **4**. Compound **4** was confirmed by mass spec: m/z 1196 $[M + 1]^+$

EXAMPLE 4: Proliferation Assays

[0124] The biological activity of the cytotoxic compounds of the invention can be assayed using the well established ^3H -thymidine proliferation assay. This is a convenient method for quantitating cellular proliferation, as it evaluates DNA synthesis by measuring the incorporation of exogenous radiolabeled ^3H -thymidine. This assay is highly reproducible and can accommodate large numbers of compounds.

[0125] To carry out the assay, promyelocytic leukemia cells, HL-60, are cultured in RPMI media containing 10 % heat inactivated fetal calf serum (FCS). On the day of the study, the cells are collected, washed and resuspended at a concentration of 0.5×10^6 cells/ml in RPMI containing 10% FCS. 100 μ l of cell suspension is added to 96 well plates. Serial dilutions (3-fold increments) of doxorubicin (as a positive control) or test compounds are made and 100 μ l of compounds are added per well. Finally 10 μ l of a 100 μ Ci/ml ^3H -thymidine is added per well and the plates are incubated

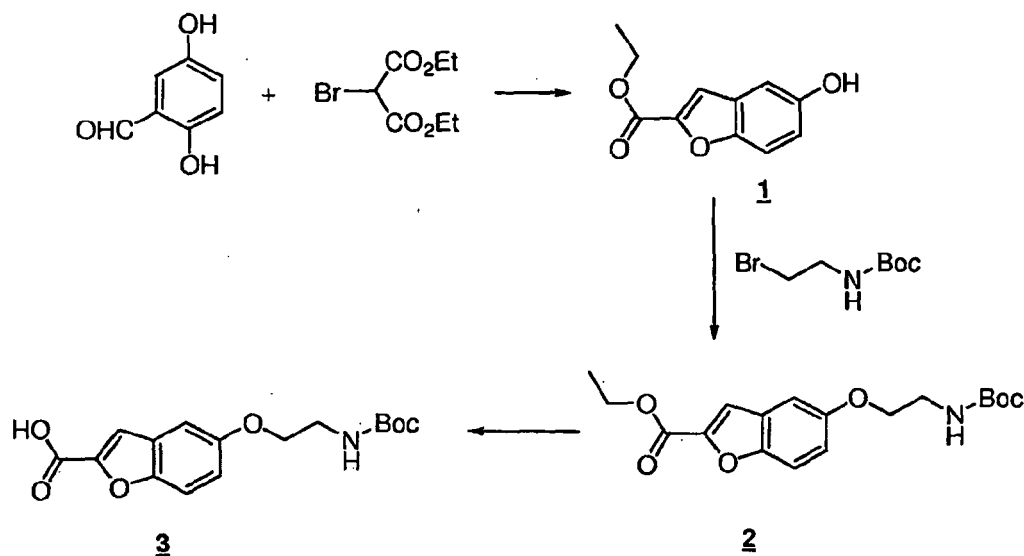
for 24 hours. The plates are harvested using a 96 well Harvester (Packard Instruments) and counted on a Packard Top Count counter. Four parameter logistic curves are fitted to the ^3H -thymidine incorporation as a function of drug molarity using Prism software to determine IC_{50} values.

[0126] The compounds of the invention generally have an IC_{50} value in the above assay of from about 1 pM to about 100 nM, preferably from about 10 pM to about 10 nM.

EXAMPLE 5

[0127]

Scheme 1



Synthesis of compound 1

[0128] 2,5-dihydroxybenzaldehyde (5.6g, 40.57 mmoles) was dissolved in *N*-methylpyrrolidone 45 mL followed by addition of potassium carbonate (5.6g, 40.5 mmoles). This was followed by addition of tetrabutyl ammonium bromide 260 mg (0.8 mmoles) and then of diethyl 2-bromomalonate (10.5g, 7.5 mL, 44 mmoles). All the above additions were done at room temperature. The reaction mixture was stirred at 140°C for 5 hours. TLC and HPLC revealed no starting material left and formation of a new peak. The reaction mixture was filtered through a silica pad and concentrated. 400 mL of 1N HCl was added to the crude and extracted with ethyl acetate. The organic phase was washed with brine and evaporated dry over anhydrous sodium sulfate. The crude product was purified by Silica Gel Flash Chromatography (hexanes/ethyl acetate, 5/1 respectively) to give 2 grams of compound 1 (23 % yield). ^1H NMR, Acetone- d_6 : 1.37 (t, 3H), 4.37 (dd, 2H), 7.51 (s, 1H), 7.4 (d, 1H), 7.06 (s, 1H), 7.02 (d, 1H), 8.41 (s, 1H)

Synthesis of compound 2

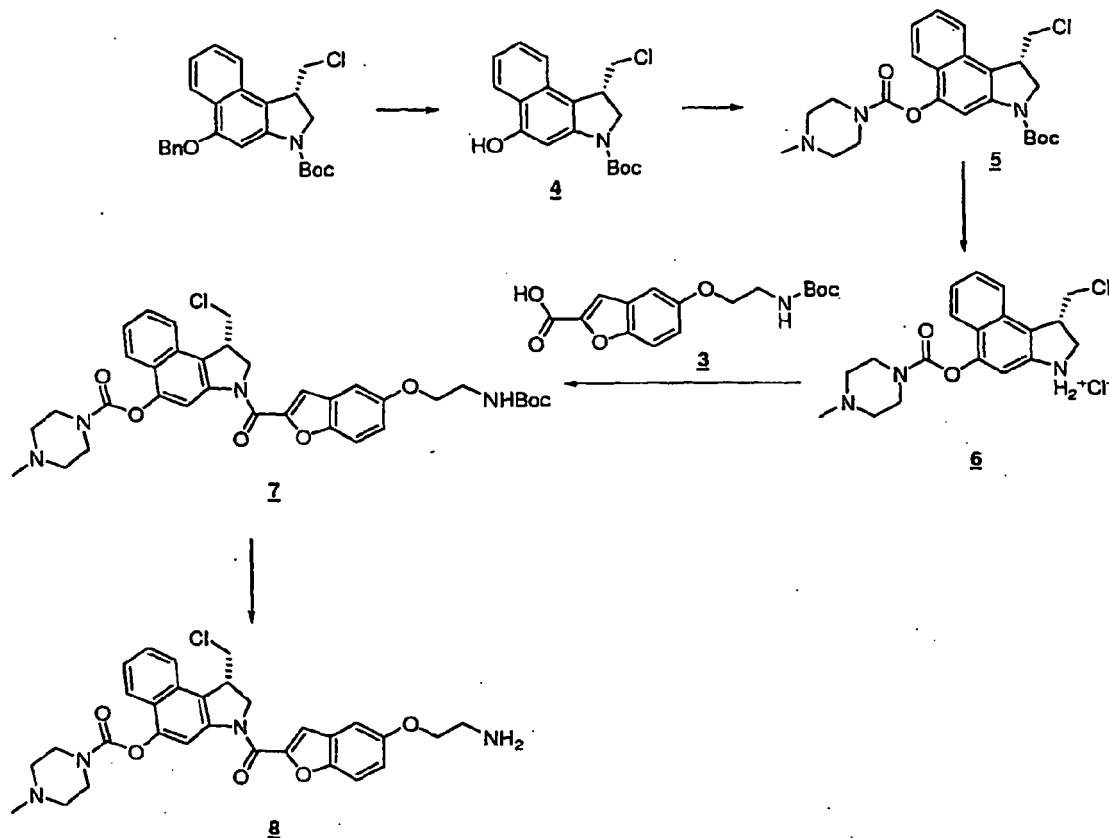
[0129] 2-(tert-butoxycarbonylamino)ethyl bromide (344 mg, 1.53 mmoles) was added dropwise to stirring reaction mixture of compound 1 (100 mg, 0.48 mmoles) in DMF 5 mL, and potassium carbonate (132 mg, 0.955 mmoles) at 45 °C and the allowed to stir over the weekend. The solvent was evaporated. The crude was dissolved in ethyl acetate and washed with 0.2 N NaOH several times. The solvent was evaporated and the crude reaction mixture was purified by Silica Gel Flash Chromatography using ethyl acetate/hexanes (1:4, 2:4) giving 137 mg (81 %) of compound 2. Mass Spec. M^{+1} = 350.9. ^1H NMR, CDCl_3 : 1.43 (s, 9H), 1.39 (t, 3H), 3.54 (m, 2H), 4.02 (t, 2H), 4.41 (dd, 2H), 7.01-7.03 (aromatic, 2H), 7.42-7.46 (aromatic, 2H)

Synthesis of compound 3

[0130] Compound 2 was dissolved in MeOH and stirred for 2-3 hours in aqueous 2N NaOH solution. The solvent was

evaporated, 10 % citric acid solution was added, and the compound extracted with ethyl acetate. The product was further purified by reverse phase HPLC to give compound 3. Mass Spec, $M^{[+Na]}$ 344.5, $M^{[+K]}$ 360.5, 1H NMR, Acetone- d_6 : 1.41 (s, 9H), 3.49 (dd, 2H), 4.10 (t, 2H), 6.24 (broad, 1H), 7.13 (1H, aromatic), 7.29 (1H, aromatic), 7.54 (1H, aromatic), 7.58 (1H, aromatic).

Scheme 2

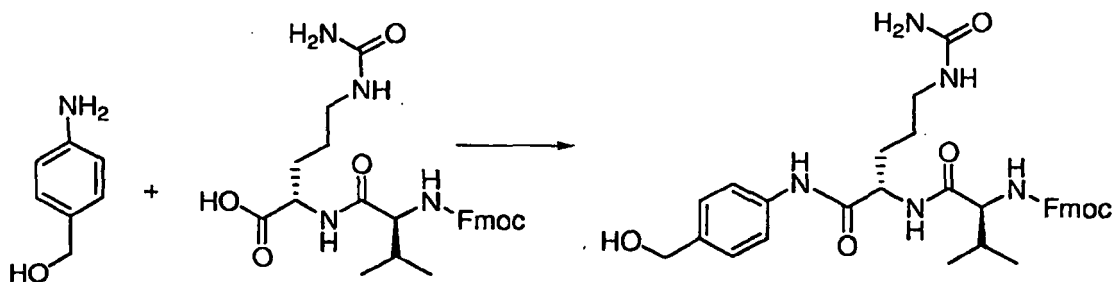


[0131] Boc, benzyl CBI (200 mg, 0.4728 mMoles) was debenzylated by hydrogenolysis using 10% Pd/C in DCM/MeOH 2:1 over a period of 8 hours. (Methods for making Boc, benzyl CBI or similar compounds are described in, for example, U.S. Provisional Patent Application Serial No. 60/730,804; U.S. Patent No. 6,534,660; and D.L. Boger et al., J. Org. Chem. 57, 2873-2876 (1992), all of which are incorporated by reference.) The catalyst was filtered and the crude greenish product was purified by Silica Gel chromatography with 5-20 % ethyl acetate in hexanes give the desired compound 4 (150 mg 95 % yield). Compound 4 (76 mg, 0.23 mMoles) was dissolved in DCM 8mL and allyl alcohol 0.3 mL followed by the addition of 4-methyl piperazine carbonyl chloride, HCl salt (183 mg, 0.93 mMoles), pyridine (187 μ L, 2.32 mMoles) and allowed to stir overnight. The crude product was purified by reverse phase chromatography on a C-18 column to give compound 5 (95 mg, 89 % overall yield. Mass Spec: $M^{[+1]}$ = 461, $M^{[+Na]}$ = 482, $M^{[+K]}$ = 498. Compound 5 was deprotected using a freshly prepared HCl-ethyl acetate solution to give compound 6.

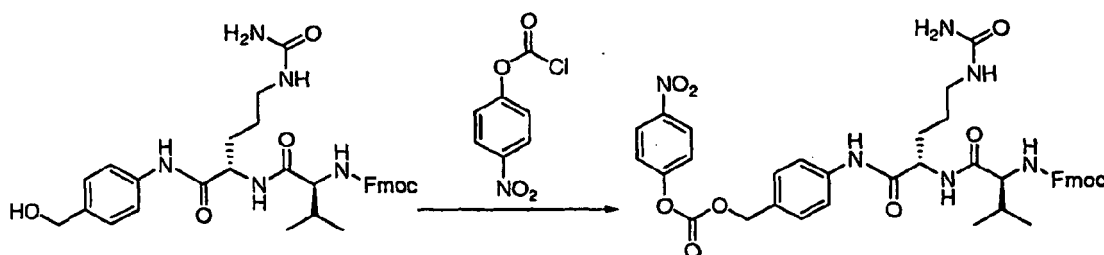
Synthesis of compound 8

[0132] 5-(2-(tert-butoxycarbonyl)ethoxy)benzofuran-2-carboxylic acid (3, 24.4 mg, 0.076 mMoles) was dissolved in 1 mL DMF, TBTU (25 mg, 0.076 mMoles) was added followed by the addition of compound 6 (25 mg, 0.058 mMoles) and finally DIPEA (37 μ L, 0.21 mMoles) and allowed to stir for 9 hours. The solvent was evaporated and the crude was purified by reverse phase HPLC to give 15 mgs of compound 7, 30 % yield after lyophilization. Mass Spec: $M^{[+]}$ = 663.4

[0133] Boc group from compound 7 was removed using freshly prepared solution of HCl in ethyl acetate to give compound 8 as its HCl salt.

Synthesis of Fmoc-Val-Cit-PABA**[0134]**

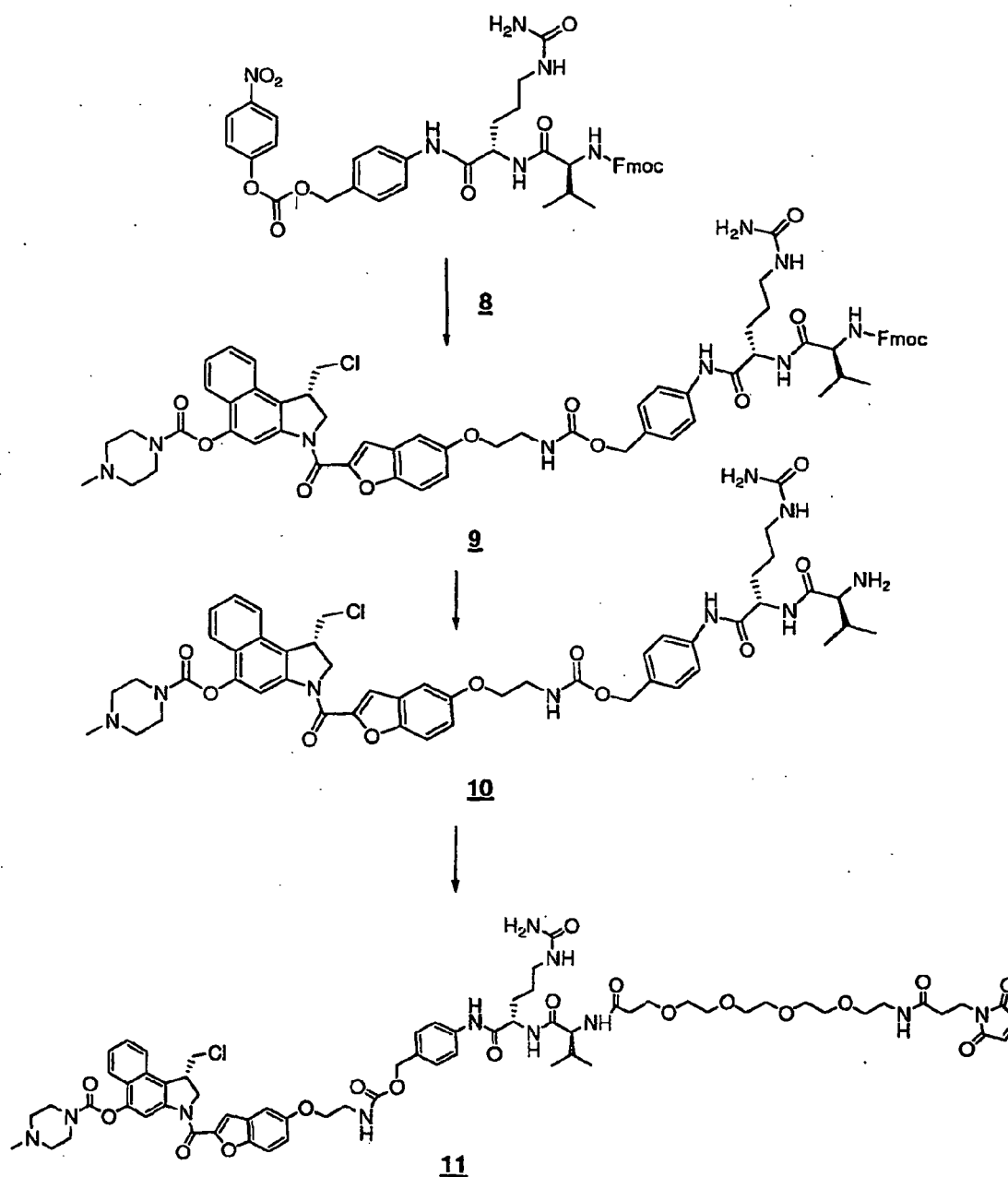
[0135] Fmoc-Val-Citrulline (1.5 g, 3.02 mMoles) was dissolved in a mixture of DCM 14 mL and MeOH 7 mL. 4-amino benzylalcohol (445.2 mg, 3.62 mMoles) was added followed by 2-ethoxy-1-ethoxycarbonyl-1,2-dihydroquinoline (EEDQ) (1.5g, 6.0 mMoles) and the reaction mixture was stirred for overnight. The solvent was removed and to the residue was added diethyl ether and sonicated for 5-10 minutes. The solid residue was allowed to settle down and the solvent decanted. This was repeated 2 more times to give 1.5 grams of Fmoc-Val-Cit-PABA (82 % yield). $M^{[+1]} = 602.6$, $M^{[1+Na]} = 624.8$, $M^{[+K]} = 640.6$

Synthesis of Fmoc-Val-Cit-PABA-PNP**[0136]**

[0137] Fmoc-Val-Cit-PABA (65 mg, 0.11 mMoles) was dissolved in 2mL DMF followed by addition of pyridine (36 μ L, 0.44 mMoles). *p*-Nitrophenol chloroformate (66 mg, 0.33 mMoles) dissolved in THF (2 mL) was added dropwise. The reaction was completed in less than an hour. The solvent was evaporated and the crude purified by silica gel column using 5 % MeOH in DCM to give 43 mg of desired product. 51% yield. Mass Spec: $M^{[+1]} 768$.

Synthesis of compound 11**[0138]**

Scheme 3



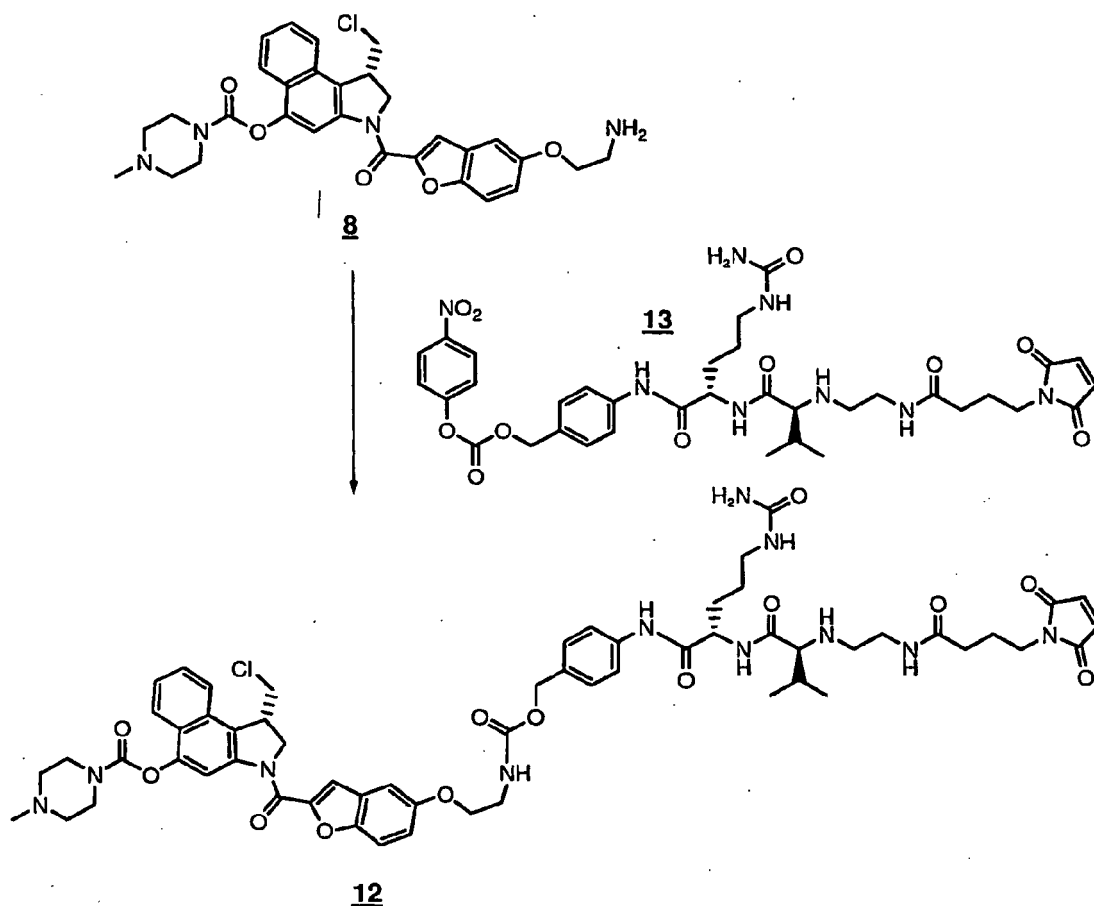
[0139] To a flask containing Fmoc-Val-Cit-PABA-PNP carbonate (13 mg; 0.017 moles) was added a solution of compound 8 (9.5 mg, 0.015 mmoles) in DMF 1mL followed by the addition of DIPEA (15 μ L). The reaction was over in less than 30 minutes. The solvent was evaporated and the crude purified by Reverse phase HPLC to give 9.0 mg of compound 9. Mass Spec: $M^{[+1]} = 1191$, $M^{[+Na]} = 1213$, $M^{[+K]} = 1229$

[0140] Fmoc protecting group of compound 9 (9 mg, 0.0076 mmoles) was removed using 5 % piperidine in DMF 3 mL. The solvent was evaporated and the crude residue was rinsed with hexanes and diethyl ether. Compound 10 was dried overnight under high vacuum and used in the next step without any further treatment/purification. Mass Spec $M^{[+1]} = 969$, $M^{[+Na]} = 991$, $M^{[+K]} = 1007$. Compound 10 was reacted with Maleimide-TEG-NHS ester in DMF the reaction mixture was allowed to stir for 1 hour the solvent was evaporated and purified by Reverse Phase HPLC on a C-18 column to give 5 mg (48% yield) of compound 11. $M^{[+1]} = 1367$

Synthesis of compound 12

[0141]

Scheme 4

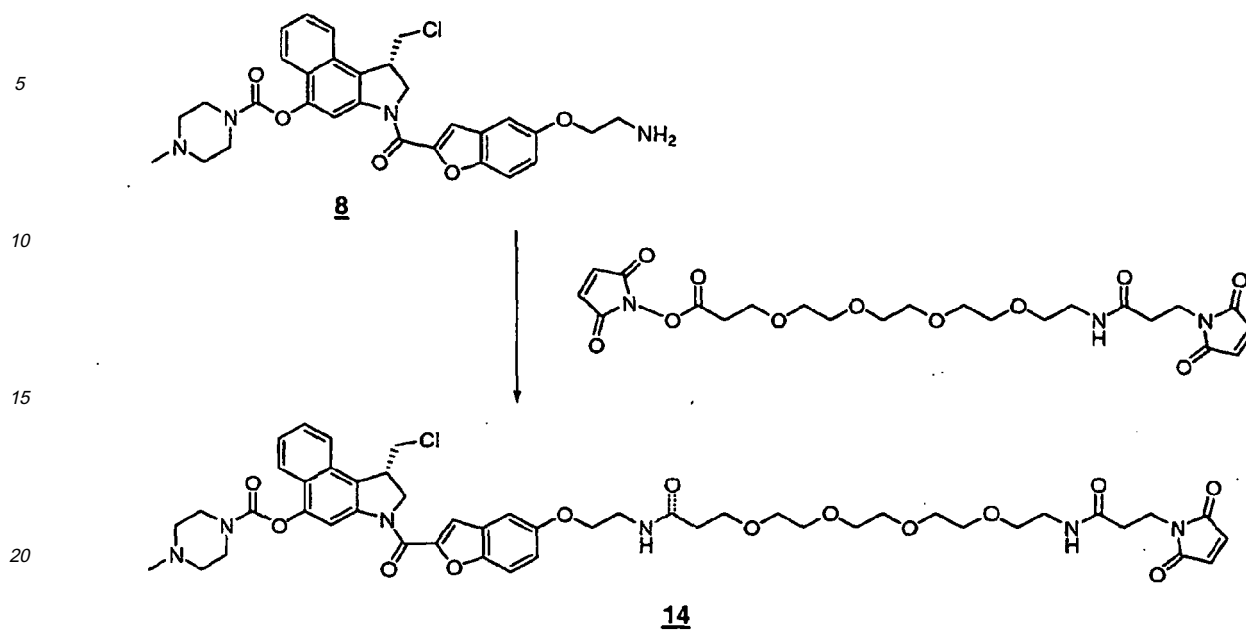


[0142] Compound 8 (8.5 mg, 0.013 mMoles) and Compound 13 (10 mg, 0.013 mMoles) were dissolved in DMF 1.5 mL followed by addition of DIPEA (7 μ L, 0.039 mMoles) the reaction was completed in 50 minutes, the solvent was evaporated and purified by reverse Phase HPLC on a Gemini C-18 column (Phenomenex Inc., Torrence, CA) to give 10 mg of compound 12 after lyophilization 65 % yield.

Synthesis of compound 14

[0143]

Scheme 5



25 **[0144]** Compound **8** (4.8 mg, 0.0076 mmoles) was dissolved in DMF 1 mL followed by the addition of Mal-TEG-NHS ester (8 mg, 0.015 mmoles) as a solution in DCM (0.5 mL). 25-40 μ L of DIPEA was added. The reaction was stirred for 30 minutes the solvent was evaporated and purified by reverse phase HPLC to give 4 mg of compound **14** (55 % yield). Mass Spec: $M^{[+1]}$ 962, $M^{[+Na]}$ = 984, $M^{[+M]}$

30 **Synthesis of compound 17**

[0145]

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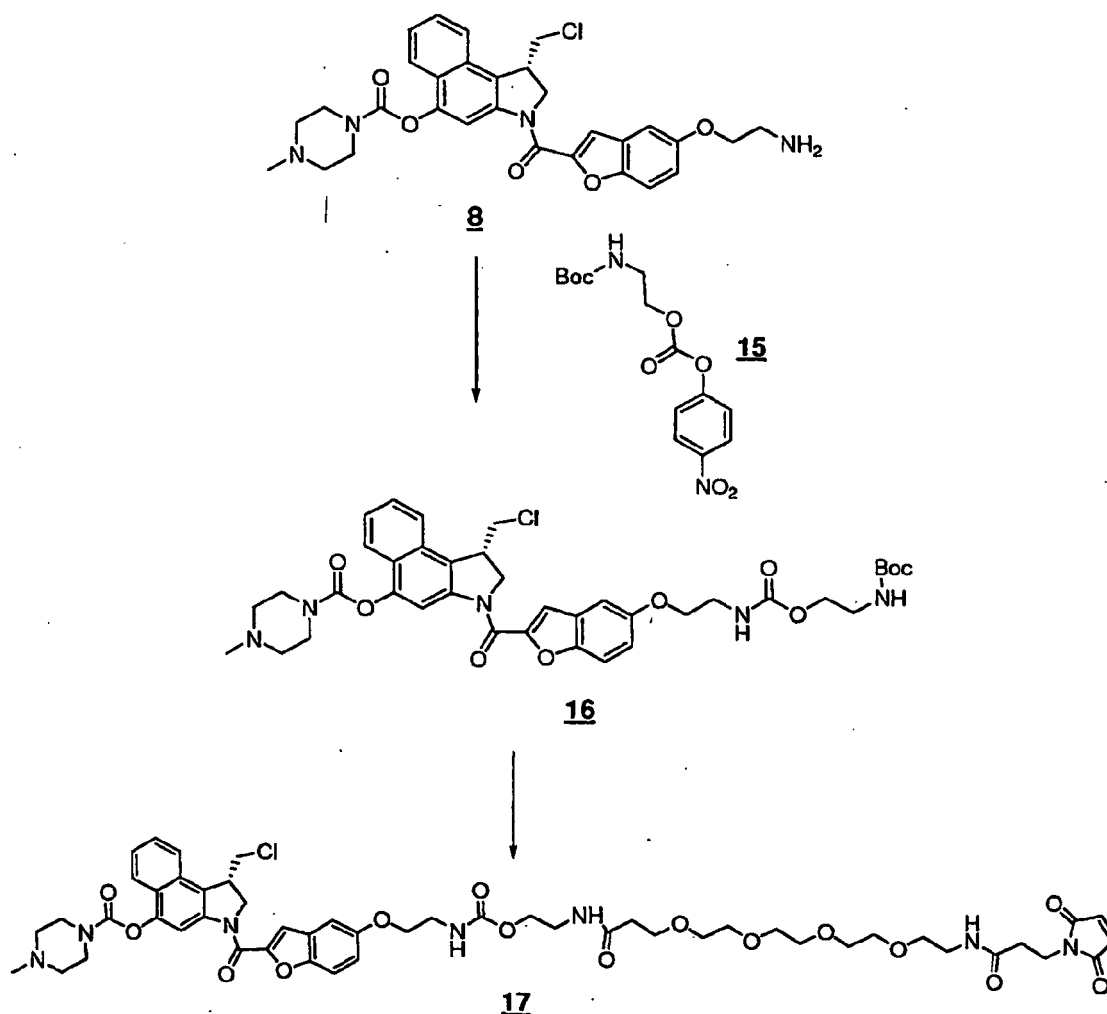
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Scheme 6

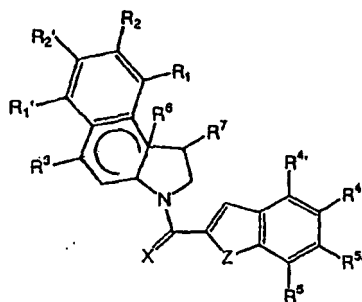


[0146] Tert-butyl 2-hydroxyethylcarbamate (270 mg, 1.675 mmoles) was dissolved in THF 10 mL. 4-Nitrophenyl chloroformate (674 mg, 3.35 mmoles) was added followed by dropwise addition of pyridine (400 μ L, 5 mmoles). The reaction mixture was allowed to stir for 2 hours. The solvent was evaporated and crude purified by Silica Gel Flash Chromatography using DCM as eluent, giving 500 mg of compound 15 (92 % yield). ^1H NMR, CDCl_3 , 1.45 (s, 9H), 3.45 (m, 2H), 4.34 (m, 2H), 7.38 (d, 2H), 8.27 (d, 2H)

[0147] Compound 8 (0.018 mmoles) was dissolved in DMF 2 mL and compound 15 (11.6 mg, 0.035 mmoles) was added followed by the addition of 10- 20 μ L DIPEA. The reaction mixture was stirred for 6 hours the solvent was evaporated the purified with reverse phase HPLC to give 7 mg (52 % yield) of compound 16. Mass Spec: $M^{[+1]}$ 750, $M^{[+Na]}$ = 772, $M^{[+K]}$ = 788. Compound 16 was deprotected using HCl-ethyl acetate and the solvent was evaporated and the product was dried overnight and used in the next reaction without any further purification. Mass Spec: $M^{[+1]}$ 651, $M^{[+Na]}$ = 673, $M^{[+K]}$ = 688. Crude product (0.009 mmoles) was dissolved in DMF 1mL followed by addition of Mal-TEG-NHS ester (18 mg, 0.035 mmoles) as a solution in 0.5 mL DCM followed by DIPEA (10-20 μ L). The reaction mixture was stirred for 15 minutes and the solvent was evaporated and purified by reverse phase HPLC to give 4.5 mg of compound 17 (48 % yield). Mass Spec: $M^{[+1]}$ = 1049, $M^{[+Na]}$ = 1071, $M^{[+K]}$ = 1087

Claims

1. A compound of the formula



wherein X is selected from O, S and NR²³ wherein R²³ is a member selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, and acyl; Z is O;

R¹ is H, substituted or unsubstituted C₁₋₆ alkyl, C(O)R⁸, or CO₂R⁸,

R^{1'} is H, substituted or unsubstituted C₁₋₆ alkyl or C(O)R⁸,

each R⁸ is a member independently selected from NR⁹R¹⁰ and OR⁹ and R⁹ and R¹⁰ are members independently selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl;

R² is H, substituted or unsubstituted C₁₋₆ alkyl, unsubstituted heteroalkyl, cyano, or alkoxy;

R² is H, substituted or unsubstituted C₁₋₆ alkyl, or unsubstituted heteroalkyl,

R³ is a member selected from the group consisting of SR¹¹, NHR¹¹ and OR¹¹, wherein R¹¹ is a member selected from the group consisting of H, substituted alkyl, unsubstituted alkyl, substituted heteroalkyl, unsubstituted heteroalkyl, diphosphates, triphosphates, acyl, C(O)R¹²R¹³, C(O)OR¹², C(O)NR¹²R¹³, P(O)(OR¹²)₂, C(O)CHR¹²R¹³, SR¹² and SiR¹²R¹³R¹⁴, in which R¹², R¹³ and R¹⁴ are members independently selected from H, substituted or unsubstituted alkyl substituted or unsubstituted heteroalkyl and substituted or unsubstituted aryl, or R¹² and R¹³ together with the nitrogen or carbon atom to which they are attached are joined to form a substituted or unsubstituted heterocycloalkyl ring system having from 4 to 6 members;

R⁶ is a single bond which is either present or absent and when present R⁶ and R⁷ are joined to form a cyclopropyl ring; and

R⁷ is CH₂-X¹ or -CH₂- joined in said cyclopropyl ring with R⁶, wherein X¹ is a leaving group,

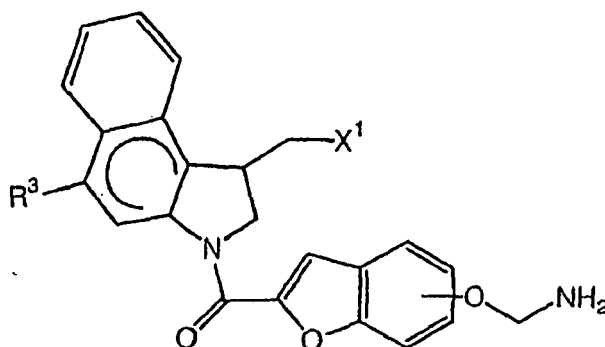
R⁴, R^{4'}, R⁵ and R^{5'} are members independently selected from the group consisting of H, substituted alkyl, unsubstituted alkyl, substituted aryl, unsubstituted aryl, substituted heteroaryl, unsubstituted heteroaryl, substituted heterocycloalkyl, unsubstituted heterocycloalkyl, halogen, NO₂, NR¹⁵R¹⁶, NC(O)R¹⁵, OC(O)NR¹⁵R¹⁶, OC(O)OR¹⁵, C(O)R¹⁵, SR¹⁵, OR¹⁵, CR¹⁵=NR¹⁶, and O(CH₂)_nNR²⁴R²⁵ wherein n is an integer from 1 to 20;

R¹⁵ and R¹⁶ are independently selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, substituted or unsubstituted heterocycloalkyl, and substituted or unsubstituted peptidyl wherein R¹⁵ and R¹⁶ together with the nitrogen atom to which they are attached are optionally joined to form a substituted or unsubstituted heterocycloalkyl ring system having from 4 to 6 members, optionally containing two or more heteroatoms;

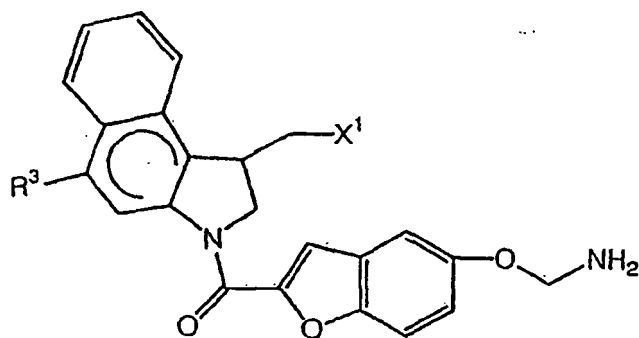
and R²⁴ and R²⁵ are independently selected from hydrogen and unsubstituted alkyl, wherein at least one of R²⁴ and R²⁵ is hydrogen, and

wherein at least one of R⁴, R^{4'}, R⁵ and R^{5'} is O(CH₂)_nNR²⁴R²⁵.

2. The compound of claim 1, wherein the compound has the following formula:



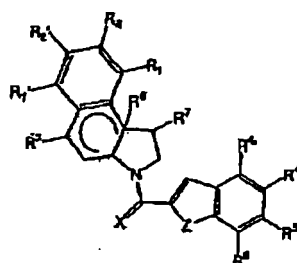
3. The compound of claim 1, wherein the compound has the following formula:



4. The compound of claim 1, wherein X is O.
5. A pharmaceutical formulation comprising a compound according to claim 1 and a pharmaceutically acceptable carrier.
6. A compound according to claim 1 for use in killing a cell.
7. The compound of claim 6, wherein the cell is a tumor cell.
8. A compound according to claim 1 for retarding or stopping the growth of a tumor in a mammalian subject.

Patentansprüche

1. Verbindung der Formel



wobei X aus O, S und NR²³ ausgewählt ist, wobei R²³ ein Element ist, ausgewählt aus H, substituiertem oder unsubstituiertem Alkyl, substituiertem oder unsubstituiertem Heteroalkyl und Acyl;

Z O ist;

R¹ H, substituiertes oder unsubstituiertes C₁₋₆-Alkyl, C(O)R⁸ oder CO₂R⁸ ist,

R¹ H, substituiertes oder unsubstituiertes C₁₋₆-Alkyl oder C(O)R⁸ ist,

jedes R⁸ ein Element ist, unabhängig ausgewählt aus NR⁹R¹⁰ und OR⁹, und R⁹ und R¹⁰ Elemente sind, unabhängig ausgewählt aus H, substituiertem oder unsubstituiertem Alkyl und substituiertem oder unsubstituiertem Heteroalkyl;

R² H, substituiertes oder unsubstituiertes C₁₋₆-Alkyl, unsubstituiertes Heteroalkyl, Cyano oder Alkoxy ist;

R² H, substituiertes oder unsubstituiertes C₁₋₆-Alkyl oder unsubstituiertes Heteroalkyl ist,

R³ ein Element ist, ausgewählt aus der Gruppe, bestehend aus SR¹¹, NHR¹¹ und OR¹¹, wobei R¹¹ ein Element ist, ausgewählt aus H, substituiertem Alkyl, unsubstituiertem Alkyl, substituiertem Heteroalkyl, unsubstituiertem Heteroalkyl, Diphosphaten, Triphosphaten, Acyl, C(O)R¹²R¹³, C(O)OR¹², C(O)NR¹²R¹³, P(O)(OR¹²)₂, C(O)CHR¹²R¹³, SR¹² und SiR¹²R¹³R¹⁴, in welchen R¹², R¹³ und R¹⁴ Elemente sind, unabhängig ausgewählt aus H, substituiertem oder unsubstituiertem Alkyl, substituiertem oder unsubstituiertem Heteroalkyl und substituiertem oder unsubstituiertem Aryl, oder R¹² und R¹³ zusammen mit dem Stickstoff- oder Kohlenstoffatom, an welches sie gebunden sind, verknüpft sind, um ein substituiertes oder unsubstituiertes Heterocycloalkylringsystem mit von 4 bis 6 Elementen

zu bilden;

R^6 eine einfache Bindung ist, welche entweder vorhanden oder nicht vorhanden ist und, wenn vorhanden, R^6 und R^7 verknüpft sind, um einen Cyclopropylring zu bilden; und

R^7 $\text{CH}_2\text{-X}^1$ oder $\text{-CH}_2\text{-}$, verknüpft in dem Cyclopropylring mit R^6 , ist, wobei X^1 eine Abgangs-Gruppe ist,

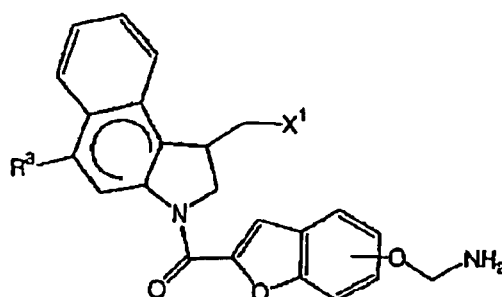
R^4 , R^4' , R^5 und R^5' Elemente sind, unabhängig ausgewählt aus H, substituiertem Alkyl, unsubstituiertem Alkyl, substituiertem Aryl, unsubstituiertem Aryl, substituiertem Heteroaryl, unsubstituiertem Heteroaryl, substituiertem Heterocycloalkyl, unsubstituiertem Heterocycloalkyl, Halogen, NO_2 , $\text{NR}^{15}\text{R}^{16}$, NC(O)R^{15} , $\text{OC(O)NR}^{15}\text{R}^{16}$, OC(O)OR^{15} , C(O)R^{15} , SR^{15} , OR^{15} , $\text{CR}^{15}=\text{NR}^{16}$ und $\text{O(CH}_2)_n\text{NR}^{24}\text{R}^{25}$, wobei n eine ganze Zahl von 1 bis 20 ist;

R^{15} und R^{16} unabhängig aus H, substituiertem oder unsubstituiertem Alkyl, substituiertem oder unsubstituiertem Heteroalkyl, substituiertem oder unsubstituiertem Aryl, substituiertem oder unsubstituiertem Heteroaryl, substituiertem oder unsubstituiertem Heterocycloalkyl und substituiertem oder unsubstituiertem Peptidyl ausgewählt sind, wobei R^{15} und R^{16} zusammen mit dem Stickstoffatom, an welches sie gebunden sind, gegebenenfalls verknüpft sind, um ein substituiertes oder unsubstituiertes Heterocycloalkylringsystem mit von 4 bis 6 Elementen, gegebenenfalls enthaltend zwei oder mehrere Heteroatome, zu bilden;

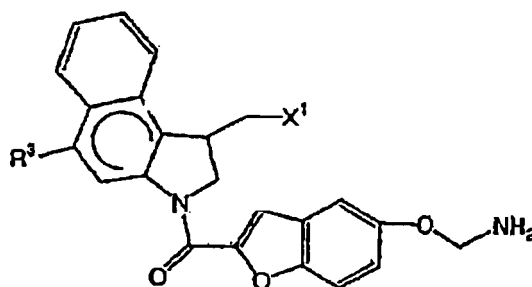
und R^{24} und R^{25} unabhängig aus Wasserstoff und unsubstituiertem Alkyl ausgewählt sind, wobei mindestens eines von R^{24} und R^{25} Wasserstoff ist und

wobei mindestens eines von R^4 , R^4' , R^5 und R^5' $\text{O(CH}_2)_n\text{NR}^{24}\text{R}^{25}$ ist.

2. Verbindung nach Anspruch 1, wobei die Verbindung die folgende Formel hat:



3. Verbindung nach Anspruch 1, wobei die Verbindung die folgende Formel hat:



4. Verbindung nach Anspruch 1, wobei X O ist.

5. Pharmazeutische Formulierung, umfassend eine Verbindung gemäß Anspruch 1 und einen pharmazeutisch verträglichen Träger.

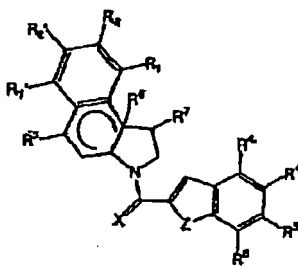
6. Verbindung gemäß Anspruch 1 zur Verwendung beim Abtöten einer Zelle.

7. Verbindung nach Anspruch 6, wobei die Zelle eine Tumorzelle ist.

8. Verbindung gemäß Anspruch 1 zum Verzögern oder Stoppen des Wachstums eines Tumors bei einem Säuger.

Revendications

1. Composé selon la formule



dans laquelle X est choisi parmi O, S et NR²³, R²³ étant un élément choisi parmi H, un groupe alkyle substitué ou non substitué, hétéroalkyle substitué ou non substitué, et acyle; Z est O;

R¹ est H, un groupe alkyle en C₁₋₆ substitué ou non substitué, C(O)R⁸, ou CO₂R⁸;

R^{1'} est H, un groupe alkyle en C₁₋₆ substitué ou non substitué, ou C(O)R⁸;

chaque R⁸ est un élément indépendamment choisi parmi NR⁹R¹⁰ et OR⁹, et R⁹ et R¹⁰ sont des éléments indépendamment choisis parmi H, un groupe alkyle substitué ou non substitué, et hétéroalkyle substitué ou non substitué;

R² est H, un groupe alkyle en C₁₋₆ substitué ou non substitué, hétéroalkyle non substitué, cyano, ou alcoxy;

R² est H, un groupe alkyle en C₁₋₆ substitué ou non substitué, ou hétéroalkyle non substitué;

R³ est un élément du groupe constitué de SR¹¹, NHR¹¹ et OR¹¹, R¹¹ étant un élément du groupe constitué de H, des groupes alkyle substitués, alkyle non substitués, hétéroalkyle substitués, hétéroalkyle non substitués, diphosphates, triphosphates, acyle, C(O)R¹²R¹³, C(O)OR¹², C(O)NR¹²R¹³, P(O)(OR¹²)₂, C(O)CHR¹²R¹³, SR¹² et SiR¹²R¹³R¹⁴, où R¹², R¹³, et R¹⁴ sont des éléments indépendamment choisis parmi H, un groupe alkyle substitué ou non substitué, hétéroalkyle substitué ou non substitué, et aryle substitué ou non substitué, ou R¹² et R¹³ conjointement avec l'atome d'azote ou de carbone auquel ils sont attachés sont réunis pour former une structure cyclique hétérocycloalkyle substituée ou non substituée ayant 4 à 6 chaînons;

R⁶ est une liaison simple qui est soit présente soit absente et, lorsqu'elle est présente, R⁶ et R⁷ sont réunis pour former un cycle cyclopropyle; et

R⁷ est CH₂-X¹ ou -CH₂- réuni dans ledit cycle cyclopropyle avec R⁶, X¹ étant un groupe partant;

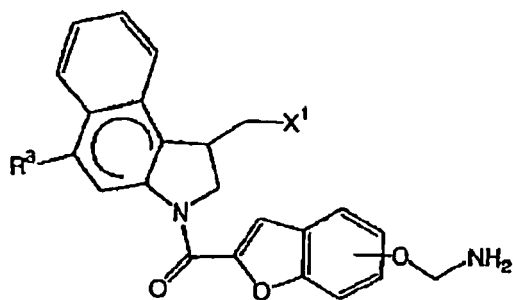
R⁴, R^{4'}, R⁵ et R^{5'} sont des éléments indépendamment choisis parmi H, un groupe alkyle substitué, alkyle non substitué, aryle substitué, aryle non substitué, hétéroaryle substitué, hétéroaryle non substitué, hétérocycloalkyle substitué, hétérocycloalkyle non substitué, halogène, NO₂, NR¹⁵R¹⁶, NC(O)R¹⁵, OC(O)NR¹⁵SR¹⁶, OC(O)OR¹⁵, C(O)R¹⁵, SR¹⁵, OR¹⁵, CR¹⁵=NR¹⁶, et O(CH₂)_nNR²⁴R²⁵, n étant un entier de 1 à 20;

R¹⁵ et R¹⁶ sont indépendamment choisis parmi H, un groupe alkyle substitué ou non substitué, hétéroalkyle substitué ou non substitué, aryle substitué ou non substitué, hétéroaryle substitué ou non substitué, hétérocycloalkyle substitué ou non substitué, et peptidyle substitué ou non substitué, où R¹⁵ et R¹⁶ conjointement avec l'atome d'azote auquel ils sont attachés sont optionnellement réunis pour former une structure cyclique hétérocycloalkyle substituée ou non substituée ayant 4 à 6 chaînons, contenant optionnellement au moins deux hétéroatomes;

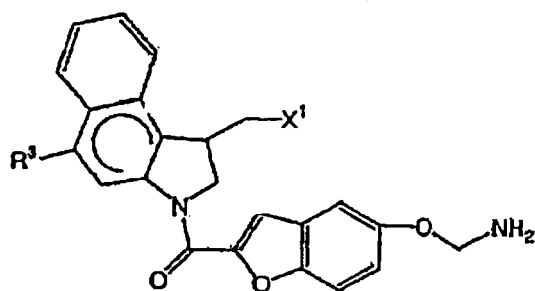
et R²⁴ et R²⁵ sont indépendamment choisis parmi un hydrogène et un groupe alkyle non substitué, au moins un desdits R²⁴ et R²⁵ étant un hydrogène, et

au moins un desdits R⁴, R^{4'}, R⁵ et R^{5'} étant O(CH₂)_nNR²⁴R²⁵.

2. Composé selon la revendication 1, ledit composé répondant à la formule suivante:



3. Composé selon la revendication 1, ledit composé répondant à la formule suivante:



4. Composé selon la revendication 1, dans lequel X est O.

5. Formulation pharmaceutique comprenant un composé selon la revendication 1 et un véhicule pharmaceutiquement acceptable.

6. Composé selon la revendication 1 destiné à être utilisé pour tuer une cellule.

7. Composé selon la revendication 6, ladite cellule étant une cellule tumorale.

8. Composé selon la revendication 1 destiné à retarder ou à arrêter la croissance d'une tumeur chez un sujet mammifère.

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