

ANTIVIRAL THERAPEUTIC AGENTS

Background of the Invention

Viral diseases are a major cause of death and economic loss in the world. The
5 *Flaviviridae* family of viruses consists of three genera: the flaviviruses (including dengue, West Nile, and yellow fever viruses), hepatitis virus (HCV), and the pestiviruses (including bovine viral diarrhea virus, BVDV). The disease states and conditions caused by members of this family include yellow fever, dengue, Japanese encephalitis, St. Louis encephalitis, Hepatitis B and C, West Nile disease, and AIDS. Currently, human immunodeficiency virus (HIV),
10 hepatitis B virus (HBV) and hepatitis C virus (HCV) infections are responsible for the largest number of viral related deaths worldwide. Although there are some drugs useful for treating HIV, there are only a few drugs useful for treating HBV, and no drugs that are broadly useful for treating HCV.

Ribavirin (1- β -D-ribofuranosyl-1-1,2,4-triazole-3-carboxamide) is a synthetic, non-
15 interferon-inducing, broad spectrum antiviral nucleoside. Ribavirin is structurally similar to guanosine, and has in vitro activity against several DNA and RNA viruses including *Flaviviridae* (Davis. Gastroenterology 118:S104-S114, 2000). Ribavirin reduces serum amino transferase levels to normal in 40% of patients, but it does not lower serum levels of HCV-RNA (Davis. Gastroenterology 118:S104-S114, 2000). Thus, ribavirin alone is not effective in
20 reducing viral RNA levels. Additionally, ribavirin has significant toxicity and is known to induce anemia.

Interferons (IFNs) are compounds which have been commercially available for the treatment of chronic hepatitis for nearly a decade. IFNs are glycoproteins produced by immune cells in response to viral infection. IFNs inhibit viral replication of many viruses, including
25 HCV. When used as the sole treatment for hepatitis C infection, IFN suppresses serum HCV-RNA to undetectable levels. Additionally, IFN normalizes serum amino transferase levels. Unfortunately, the effects of IFN are temporary and a sustained response occurs in only 8%-9% of patients chronically infected with HCV (Davis. Gastroenterology 118:S104-S114, 2000).

HCV is a positive stranded ss RNA virus with a well characterized RNA-dependent
30 RNA polymerase (RdRp) and a well characterized disease progression. HCV has infected an estimated 170 million people worldwide, leading to a major health crisis as a result of the disease. Indeed, during the next few years the number of deaths from HCV-related liver disease and hepatocellular carcinoma may overtake those caused by AIDS. Egypt is the hardest hit country in the world, with 23% of the population estimated to be carrying the virus; whereas, in
35 the USA the prevalence of chronic infections has recently been determined to be around 1.87%

(2.7 million persons). HCV infections become chronic in about 50% of cases. Of these, about 20% develop liver cirrhosis that can lead to liver failure, including hepatocellular carcinoma.

The NS5B region of HCV encodes a 65 KDa RdRp thought to be responsible for viral genome replication. RdRps function as the catalytic subunit of the viral replicase required for the replication of all positive-strand viruses. The NS5B protein has been well characterized, shown to possess the conserved GDD motif of RdRps and *in vitro* assay systems have been reported. Cellular localization studies revealed that NS5B is membrane-associated in the endoplasmic reticulum like NS5A, suggesting that those two proteins may remain associated with one another after proteolytic processing. Additional evidence suggests that NS3, NS4A and NS5B interact with each other to form a complex that functions as part of the replication machinery of HCV.

The X-ray crystal structure of NS5B apoenzyme has been determined and three very recent publications describe the unusual shape of the molecule. This unique shape for a polymerase, resembling a flat sphere, is attributed to extensive interactions between the fingers and thumb subdomains in such a way that the active site is completely encircled, forming a cavity 15 Å across and 20 Å deep. Modeling studies showed that the NS5B apoenzyme can accommodate the template-primer without large movement of the subdomains, suggesting that the structure is preserved during the polymerization reaction. The RdRp polypeptides from various members of the *Flaviviridae* family and other viral families have been shown to be conserved (J.A. Bruenn, Nucleic Acids Research, Vol. 19, No. 2 p. 217, 1991).

Currently, there are no safe and effective therapeutic agents on the market that target HCV polymerase. There is currently a need for therapeutic agents and therapeutic methods that are useful for treating viral infections, such as HCV, HIV, and HBV.

In addition, there is also a current need for therapeutic agents and therapeutic methods that are useful for treating cancer. Even though significant advances have occurred in the treatment of cancer, it still remains a major health concern. It has been reported that cancer is the cause of death of up to one of every four Americans. Notwithstanding the advances in treatments for cancer and other diseases there is still a need for novel drugs that are effective to treat cancer.

Summary of the Invention

The present invention provides compounds that are inhibitors of viral RNA and DNA polymerases (e.g. polymerases from hepatitis B, hepatitis C, human immunodeficiency virus, Polio, Cocksackie A and B, Rhino, Echo, small pox, Ebola, and West Nile virus) and that are useful for treating HCV, as well as other viral infections (e.g. flaviviral infections), and cancer.

Accordingly, the invention provides a novel compound of Formula I as described herebelow, or a pharmaceutically acceptable salt or prodrug thereof.

The invention also provides a pharmaceutical composition comprising a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof, and a pharmaceutically acceptable carrier. The composition can optionally comprise one or more additional anti-viral or anti-cancer agents.

5 The invention also provides a method for treating a viral infection in an animal comprising administering to the animal an effective amount of a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof.

The invention also provides a method for inhibiting a viral RNA or DNA polymerase comprising contacting the polymerase (*in vitro* or *in vivo*) with an effective inhibitory amount of
10 a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof.

The invention also provides a method for treating cancer in an animal comprising administering to the animal an effective amount of a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof.

The invention also provides a compound of Formula I, or a pharmaceutically acceptable
15 salt or prodrug thereof, for use in medical therapy (e.g. for use in treating a viral infection or for use in treating cancer).

The invention also provides the use of a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof, to prepare a medicament useful for treating a viral infection in an animal (e.g. a human).

20 The invention also provides the use of a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof, to prepare a medicament useful for treating cancer in an animal (e.g. a human).

The invention also provides a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof, for the prophylactic or therapeutic treatment of a viral infection.

25 The invention also provides a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof, for the prophylactic or therapeutic treatment of cancer.

The invention also provides novel synthetic intermediates and synthetic methods that are disclosed herein as being useful for preparing compounds of Formula I, or a salt or prodrug thereof. Some compounds of Formula I may be useful as synthetic intermediates for preparing
30 other compounds of Formula I.

Detailed Description of the Invention

Definitions

The term "pharmaceutically acceptable salt" as used herein refers to a compound of the present disclosure derived from pharmaceutically acceptable bases, inorganic or organic acids.

35 Examples of suitable acids include, but are not limited to, hydrochloric, hydrobromic, sulfuric,

nitric, perchloric, fumaric, maleic, phosphoric, glycollic, lactic, salicylic, succinic, toluene-p-sulfonic, tartaric, acetic, citric, methanesulfonic, formic, benzoic, malonic, naphthalene-2-sulfonic, trifluoroacetic and benzenesulfonic acids. Salts derived from appropriate bases include, but are not limited to, alkali such as sodium and ammonia.

5 The terms "treat", "treating" and "treatment" as used herein include administering a compound prior to the onset of clinical symptoms of a disease state/condition so as to prevent any symptom, as well as administering a compound after the onset of clinical symptoms of a disease state/condition so as to reduce or eliminate any symptom, aspect or characteristic of the disease state/condition. Such treating need not be absolute to be useful.

10 The term "animal" as used herein refers to any animal, including mammals, such as, but not limited to, mice, rats, other rodents, rabbits, dogs, cats, swine, cattle, sheep, horses, and primates. In one specific embodiment of the invention the animal is a human.

The term "therapeutically effective amount", in reference to treating a disease state/condition, refers to an amount of a compound either alone or as contained in a
15 pharmaceutical composition that is capable of having any detectable, positive effect on any symptom, aspect, or characteristics of a disease state/condition when administered as a single dose or in multiple doses. Such effect need not be absolute to be beneficial.

The term "alkyl" as used herein refers to alkyl groups having from 1 to 6 carbon atoms. This term is exemplified by groups such as methyl, ethyl, n-propyl, iso-propyl, n-butyl, t-butyl,
20 n-pentyl and the like. In a specific embodiment, the alkyl groups have from 1-4 carbon atoms and are referred to as lower alkyl.

The term "substituted alkyl" as used herein refers to an alkyl group having from 1 to 3 substituents, said substituents being selected from the group consisting of alkoxy, alkoxyalkyl, tri(C₁-C₄alkyl)silyl, substituted alkoxy, acyl, substituted acyl, acylamino, acyloxy, oxyacyl,
25 amino, substituted amino, aminoacyl, aryl, substituted aryl, aryloxy, substituted aryloxy, cyano, halogen, hydroxyl, nitro, N₃, carboxyl, carboxyl esters, thiol, thioalkyl, substituted thioalkyl, thioaryl, substituted thioaryl, thioheteroaryl, substituted thioheteroaryl, thiocycloalkyl, substituted thiocycloalkyl, thioheterocyclic, substituted thioheterocyclic, cycloalkyl, substituted cycloalkyl, heteroaryl, substituted heteroaryl, heterocyclic, and substituted heterocyclic. In one
30 specific embodiment of the invention, the term "substituted alkyl" refers to an alkyl group substituted with 1 to 3 substituents, said substituents being selected from the group consisting of alkoxy, alkoxyalkyl, tri(C₁-C₄alkyl)silyl, acyl, acylamino, acyloxy, oxyacyl, amino, aminoacyl, aryl, aryloxy, cyano, halogen, hydroxyl, nitro, N₃, carboxyl, carboxyl esters, thiol, thioalkyl, thioaryl, thioheteroaryl, thiocycloalkyl, thioheterocyclic, cycloalkyl, heteroaryl, and
35 heterocyclic.

The terms "alkenyl" or "alkene" as used herein refers to an alkenyl group having from 2 to 10 carbon atoms and having at least 1 site of alkenyl unsaturation. Such groups are exemplified by vinyl(ethen-1-yl), allyl, but-3-en-1-yl, and the like.

5 The term "substituted alkenyl" as used herein refers to alkenyl groups having from 1 to 3 substituents, said substituents being selected from those describe above for a substituted alkyl.

The term "alkynyl" or "alkyne" as used herein refers to an alkynyl group having from 2-10 carbon atoms and having at least 1 site of alkynyl unsaturation. Such groups are exemplified by, but not limited to, ethyn-1-yl, propyn-1-yl, propyn-2-yl, 1-methylprop-2-yn-1-yl, butyn-1-yl, butyn-2-yl, butyn-3-yl, and the like.

10 The term "substituted alkynyl" as used herein refers to alkynyl groups having from 1 to 3 substituents, said substituents being selected those describe above for a substituted alkyl.

The term "alkoxy" refers to the group alkyl-O-.

The term "substituted alkoxy" as used herein refers to the group substituted alkyl-O-.

15 The term "acyl" as used herein refers to the groups alkyl-C(O) -, alkenyl-C(O) -, alkynyl-C(O) -, cycloalkyl-C(O) -, aryl-C(O) -, heteroaryl-C(O) -, and heterocyclic-C(O) -.

The term " substituted acyl" as used herein refers to the groups substituted alkyl-C(O)-, substituted alkenyl-C(O) -, substituted alkynyl-C(O) -, substituted cycloalkyl-C(O) -, substituted aryl-C (O)-, substituted heteroaryl-C(O), and substituted heterocyclic-C(O) -.

20 The term "acylamino" as used herein refers to the group-C(O)NZ₁Z₂ where each Z₁ and Z₂ are independently selected from the group consisting of hydrogen, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl and substituted alkynyl, and the substituents described above in the definition of substituted alkyl.

25 The term "acyloxy" as used herein refers to the groups alkyl-C(O)O-, substituted alkyl-C(O)O-, alkenyl-C(O)O-, substituted alkenyl-C(O)O-, alkynyl-C(O)O-, substituted alkynyl-C(O)O-, aryl-C(O)O-, substituted aryl-C(O)O-, cycloalkyl-C(O)O-, substituted cycloalkyl-C(O)O-, heteroaryl-C(O)O-, substituted heteroaryl-C(O)O-, heterocyclic-C(O)O-, and substituted heterocyclic-C(O)O-.

30 The term "oxyacyl" as used herein refers to the groups alkyl-OC(O) -, substituted alkyl-OC(O)-, alkenyl-OC(O)-, substituted alkenyl-OC(O) -, alkynyl-OC(O) -, substituted alkynyl-OC(O)-, aryl-OC(O)-, substituted aryl-OC(O)-, cycloalkyl-OC(O)-, substituted cycloalkyl-OC(O)-, heteroaryl-OC(O) -, substituted heteroaryl-OC(O) -, heterocyclic- OC(O)-, and substituted heterocyclic-OC(O)-.

The term "amino" as used herein refers to the group -NH₂.

The term "substituted amino" as used herein refers to the group-N Z_1Z_2 where Z_1 and Z_2 are as described above in the definition of acylamino, provided that Z_1 and Z_2 are both not hydrogen.

The term "aminoacyl" as used herein refers to the groups - $NZ_3C(O)$ alkyl, -
5 $NZ_3C(O)$ substituted alkyl, - $NZ_3C(O)$ cycloalkyl, - $NZ_3C(O)$ substituted cycloalkyl, -
 $NZ_3C(O)$ alkenyl, - $NZ_3C(O)$ substituted alkenyl, - $NZ_3C(O)$ alkynyl, - $NZ_3C(O)$ substituted alkynyl,
- $NZ_3C(O)$ aryl, - $NZ_3C(O)$ substituted aryl, - $NZ_3C(O)$ heteroaryl, - $NZ_3C(O)$ substituted heteroaryl,
- $NZ_3C(O)$ heterocyclic, and - $NZ_3C(O)$ substituted heterocyclic, where Z_3 is hydrogen or alkyl.

The term "aryl" as used herein refers to a monovalent aromatic cyclic group of from 6 to
10 14 carbon atoms having a single ring (e.g., phenyl) or multiple condensed rings (e.g., naphthyl
or anthryl) which condensed rings may or may not be aromatic. Exemplary aryls include, but are
not limited to, phenyl and naphthyl.

The term "substituted aryl" as used herein refers to aryl groups which are substituted
with from 1 to 3 substituents selected from alkyl, substituted alkyl, alkenyl, substituted alkenyl,
15 alkynyl and substituted alkynyl, and those substituents described above in the definition of
substituted alkyl.

The term "aryloxy" as used herein refers to the group aryl-O- that includes, by way of
example but not limitation, phenoxy, naphthoxy, and the like.

The term "substituted aryloxy" as used herein refers to substituted aryl-O-groups.

20 The term "carboxyl" as used herein refers to -COOH or salts thereof.

The term "carboxyl esters" as used herein refers to the groups-C(O)O-alkyl, -C(O)O-
substituted alkyl, -C(O)O-aryl, and-C(O)O-substituted aryl.

The term "cycloalkyl" as used herein refers to a saturated or unsaturated cyclic
hydrocarbon ring systems, such as those containing 1 to 3 rings and 3 to 7 carbons per ring.
25 Exemplary groups include but are not limited to cyclopropyl, cyclobutyl, cyclopentyl,
cyclohexyl, cycloheptyl, and adamantyl.

The term "substituted cycloalkyl" as used herein refers to a cycloalkyl having from 1 to 5
substituents selected from the group consisting of oxo (=O), thioxo (=S), alkyl, substituted alkyl,
and those substituents described in the definition of substituted alkyl.

30 The term "cycloalkoxy" as used herein refers to -O-cycloalkyl groups.

The term "substituted cycloalkoxy" as used herein refers to-O-substituted cycloalkyl
groups.

The term "formyl" as used herein refers to HC(O)-.

The term "halogen" as used herein refers to fluoro, chloro, bromo and iodo.

35 The term "heteroaryl" as used herein refers to an aromatic group of from 1 to 10 carbon

atoms and 1 to 4 heteroatoms selected from the group consisting of oxygen, nitrogen, sulfur in the ring. The sulfur and nitrogen heteroatoms atoms may also be present in their oxidized forms. Such heteroaryl groups can have a single ring (e. g. , pyridyl or furyl) or multiple condensed rings (e. g. , indolizinyl or benzothienyl) wherein the condensed rings may or may not be aromatic and/or contain a heteroatom. Exemplary heteroaryl groups include, but are not limited to, heteroaryls include pyridyl, pyrrolyl, thienyl, indolyl, thiophenyl, and furyl.

The term "substituted heteroaryl" as used herein refers to heteroaryl groups that are substituted with from 1 to 3 substituents selected from the same group of substituents defined for substituted aryl.

The term "heteroaryloxy" as used herein refers to the group -O-heteroaryl.

The term "substituted heteroaryloxy" as used herein refers to the group -O-substituted heteroaryl.

The term "heterocycle" or "heterocyclic" or "heterocycloalkyl" refers to a saturated or unsaturated group (but not heteroaryl) having a single ring or multiple condensed rings, from 1 to 10 carbon atoms and from 1 to 4 hetero atoms selected from the group consisting of nitrogen, oxygen, sulfur, within the ring wherein, in fused ring systems, one or more the rings can be cycloalkyl, aryl or heteroaryl provided that the point of attachment is through the heterocyclic ring. The sulfur and nitrogen heteroatoms atoms may also be present in their oxidized forms.

The term "substituted heterocycle" or "substituted heterocyclic" or "substituted heterocycloalkyl" refers to heterocycle groups that are substituted with from 1 to 3 of the same substituents as defined for substituted aryl.

Examples of heterocycles and heteroaryls include, but are not limited to, azetidine, pyrrole, imidazole, pyrazole, pyridine, pyrazine, pyrimidine, pyridazine, indolizine, isoindole, indole, dihydroindole, indazole, purine, quinolizine, isoquinoline, quinoline, phthalazine, naphthylpyridine, quinoxaline, quinazoline, cinnoline, pteridine, carbazole, carboline, phenanthridine, acridine, phenanthroline, isothiazole, phenazine, isoxazole, phenoxazine, phenothiazine, imidazolidine, imidazoline, piperidine, piperazine, indoline, phthalimide, 1,2, 3,4-tetrahydroisoquinoline, 4,5, 6,7-tetrahydrobenzo [b] thiophene, thiazole, thiazolidine, thiophene, benzo [b] thiophene, morpholinyl, thiomorpholinyl (also referred to as thiamorpholinyl), piperidinyl, pyrrolidine, tetrahydrofuranyl, and the like.

The term "heterocyclyloxy" as used herein refers to the group -O-heterocyclic.

The term "substituted heterocyclyloxy" as used herein refers to the group-O-substituted heterocyclic.

The term "phosphate" as used herein refers to the groups- OP(O)(OH)_2 (monophosphate or phospho), $-\text{OP(O)(OH)OP(O)(OH)}_2$ (diphosphate or diphospho) and -

OP(O)(OH)OP(O)(OH)OP(O)(OH)₂ (triphosphate or triphospho) or salts thereof including partial salts thereof. It is understood that the initial oxygen of the mono-, di-, and triphosphate may include the oxygen atom of a sugar.

The term "phosphate esters" as used herein refers to the mono-, di- and tri-phosphate groups described above wherein one or more of the hydroxyl groups is replaced by an alkoxy group.

The term "phosphonate" refers to the groups -OP(O)(Z₄)(OH) or -OP(O)(Z₄)(OZ₄) or salts thereof including partial salts thereof, wherein each Z₄ is independently selected from hydrogen, alkyl, substituted alkyl, carboxylic acid, and carboxyl ester. It is understood that the initial oxygen of the phosphonate may include the oxygen of a sugar.

The term "thiol" as used herein refers to the group -SH.

The term "thioalkyl" or "alkylthioether" or "thioalkoxy" refers to the group -S-alkyl.

The term "substituted thioalkyl" or "substituted alkylthioether" or "substituted thioalkoxy" refers to the group -S-substituted alkyl.

The term "thiocycloalkyl" as used herein refers to the group -S-cycloalkyl.

The term "substituted thiocycloalkyl" as used herein refers to the group -S-substituted cycloalkyl.

The term "thioaryl" as used herein refers to the group -S-aryl.

The term "substituted thioaryl" as used herein refers to the group -S-substituted aryl.

The term "thioheteroaryl" as used herein refers to the group -S-heteroaryl.

The term "substituted thioheteroaryl" as used herein refers to the group -S-substituted heteroaryl.

The term "thioheterocyclic" as used herein refers to the group -S-heterocyclic.

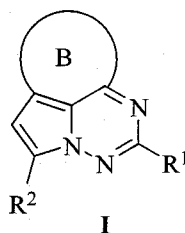
The term "substituted thioheterocyclic" as used herein refers to the group -S-substituted heterocyclic.

The term "amino acid sidechain" refers to the Z₇ substituent of α-amino acids of the formula Z₆NHCH(Z₇)COOH where Z₇ is selected from the group consisting of hydrogen, alkyl, substituted alkyl and aryl and Z₆ is hydrogen or together with Z₇ and the nitrogen and carbon atoms bound thereto respectively form a heterocyclic ring. In one embodiment, the α-amino acid sidechain is the sidechain of one of the twenty naturally occurring L amino acids.

Sugars described herein may either be in D or L configuration.

Compounds of Formula I

Compounds of the invention include compounds of formula I:



wherein;

- 5 B represents a 5, 6, 7 or 8 membered carbocyclic or heterocyclic ring comprising one or more double bonds, wherein B is optionally substituted with one or more oxo, thioxo, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R';

wherein:

R is H, alkyl or aryl;

- 10 R' is OH, NH₂ or alkyl;

R¹ is H, NR_aR_b, Cl, F, OR_a, SR_a, NHCOR_a, NHSO₂R_a, NHCONHR_a, CN, alkyl, aryl, ONR_aR_b, or NR_aC(O)OR_b;

R² is a nucleoside sugar group;

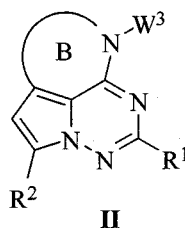
W³ is absent, alkyl, or H;

- 15 R_a and R_b are independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, heterocyclic, aryl, substituted aryl, acyl, substituted acyl, SO₂-alkyl, amino, substituted amino, and NO; or R_a and R_b together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring;

- 20 R_c and R_d are independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, acyl, substituted acyl and SO₂-alkyl; or R_c and R_d together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring; and

- 25 each R_z is independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, acyl and substituted acyl; or a pharmaceutically acceptable salt or prodrug thereof.

In one embodiment of the invention the compound of formula I is a compound of formula II:



wherein;

B represents a 5, 6, 7 or 8 membered ring comprising one or more heteratoms and one or more double bonds, wherein B is optionally substituted with one or more oxo, thioxo, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R';

wherein:

R is H, alkyl or aryl;

R' is OH, NH₂ or alkyl;

R¹ is H, NR_aR_b, Cl, F, OR_a, SR_a, NHCOR_a, NHSO₂R_a, NHCONHR_a, CN, alkyl, aryl,

10 ONR_aR_b, or NR_aC(O)OR_b;

R² is a nucleoside sugar group;

W³ is absent, alkyl, or H;

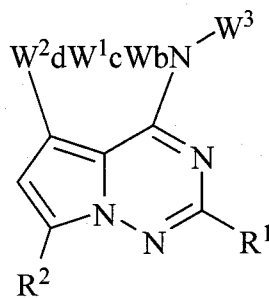
R_a and R_b are independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, heterocyclic, aryl, substituted aryl, acyl, substituted acyl, SO₂-alkyl, amino, substituted amino, and NO; or R_a and R_b together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring;

R_c and R_d are independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, acyl, substituted acyl and SO₂-alkyl; or R_c and R_d together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring; and

each R_z is independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, acyl and substituted acyl; or a pharmaceutically acceptable salt or prodrug thereof.

25 In one embodiment of the invention the compound of formula I is a compound of formula II wherein W³ is absent or H.

In one embodiment of the invention the compound of formula I is a compound of formula III:



(III)

wherein:

each b, c and d is independently selected from a single and double bond provided that
 5 when b is a double bond, c is single bond, when c is a double bond, b and d are single bonds and
 when d is a double bond c is a single bond; or d is absent when W² is absent; and W² and d are
 not absent, when bNW³ is absent;

W is C=R_e, CH₂, CR_g or O, provided that when W is C=R_e, CH₂ or O, b and c are single
 bonds, or c is a single bond and bNW³ is absent; and provided when W is CR_g, one of b or c is a
 10 double bond, or bNW³ is absent and c is a double bond;

R_e is O or S;

R_g is H, NR_cR_d, OR_z or SR_z;

W¹ is C=R_h, CR_iR_{i'}, N, NR_n, CR_j or O provided that when W¹ is C=R_h, CR_iR_{i'}, NR_n or
 O, c and d are single bonds or c is a single bond and W²d is absent; and provided when W¹ is
 15 CR_j or N one of c or d is a double bond or W²d is absent and c is a double bond;

R_h is O or S;

R_i and R_{i'} are H, CH₃, NH₂ or Br;

R_j is CH₃, NH₂, or H;

W² is C=R_k, (CR_lR_{l'})_{p'}, CR_m, O, NR_s, absent or N provided that when W² is C=R_k,
 20 CR_lR_{l'}, O, or NR_s d is a single bond; when W² is N or CR_m d is a double bond; and provided
 when W² is absent, d is absent;

R_k is O or S;

R_l and R_{l'} are H, CH₃, OCH₃, NH₂ or SCH₃;

p' is 1 or 2;

R_m is H, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R';

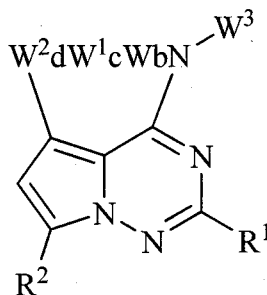
R_n is H, alkyl, or NR_qR_r wherein each R_q and R_r is H or alkyl;

R_s is H, CH₃, or NH₂; and

W³ is absent, H or alkyl; provided that when W³ is absent b is a double bond;
 or a pharmaceutically acceptable salt or prodrug thereof.

30 In one embodiment of the invention the compound of formula I is a compound of

formula IV:



(IV)

wherein:

- 5 each b, c and d is independently selected from a single or double bond provided that when b is a double bond, c is single bond, when c is a double bond, b and d are single bonds and when d is a double bond c is a single bond; or d is absent when W² is absent;
- W is C=R_e, CR_fR_f, CR_g or O, provided that when W is C=R_e, CR_fR_f or O, b and c are single bonds and when W is CR_g, one of b or c is a double bond;
- 10 R_e is O or S;
R_f is H;
R_g is H, NR_cR_d, OR_z or SR_z;
- W¹ is C=R_h, CR_iR_i, NH, CR_j or O provided that when W¹ is C=R_h, CR_iR_i, or O, c and d are single bonds; when W¹ is CR_j, one of c or d is a double bond; and when W¹ is NH, W is not
- 15 O and W² is not O, NH, or N;
- R_h is O or S;
R_i and R_i' are H, CH₃ or Br;
R_j is CH₃ or H;
- W² is C=R_k, (CR_lR_l)_p, CR_m, O, NH, absent, or N provided that when W² is C=R_k, CR_lR_l, CR_m, O, or NH d is a single bond; when W² is N or CR_m d is a double bond; or when
- 20 W² is absent, d is absent;
- R_k is O or S;
R_l and R_l' are H, CH₃, OCH₃ or SCH₃;
p' is 1 or 2;
- 25 R_m is H, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R'; and
W³ is absent, H or alkyl; provided that when W³ is absent b is a double bond;
or a pharmaceutically acceptable salt or prodrug thereof.

In one embodiment of the invention the compound of formula I is a compound of formula IV wherein:

each b, c and d is independently selected from a single or double bond provided that when b is a double bond, c is single bond, when c is a double bond, b and d are single bonds and when d is a double bond c is a single bond;

W is C=R_e, CR_fR_f, CR_g or O, provided that when W is C=R_e, CR_fR_f or O, b and c are single bonds and when W is CR_g, one of b or c is a double bond;

R_e is O or S;

R_f is H;

R_g is H, NR_cR_d, OR_z or SR_z;

W¹ is C=R_h, CR_iR_i, CR_j or O provided that when W¹ is C=R_h, CR_iR_i, or O, c and d are single bonds and when W¹ is CR_j, one of c or d is a double bond;

R_h is O or S;

R_i and R_i' are H, CH₃ or Br;

R_j is CH₃ or H;

W² is C=R_k, (CR_lR_l)_p, CR_m, O, NH or N provided that when W² is C=R_k, CR_lR_l, CR_m, O, or NH d is a single bond and when W² is N or CR_m d is a double bond;

R_k is O or S;

R_l and R_l' are H, CH₃, OCH₃ or SCH₃;

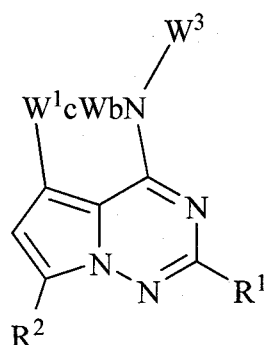
p' is 1 or 2;

R_m is H, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R'; and

W³ is absent or H, provided that when W³ is absent b is a double bond;

or a pharmaceutically acceptable salt or prodrug thereof.

In one embodiment of the invention the compound of formula I is a compound of formula V:



(V)

wherein:

each of b and c is independently selected from a single or double bond provided that when b is a double bond, c is single bond and when c is a double bond b is a single bond;

W is C=R_e, CR_fR_f, CR_g or O, provided that when W is C=R_e, CR_fR_f or O, b and c are single bonds and when W is CR_g, one of b or c is a double bond;

R_e is O or S;

R_f is H;

5 R_g is H, NR_cR_d, OR_z or SR_z;

W¹ is C=R_h, CR_iR_i, NH, CR_j or O provided that when W¹ is C=R_h, CR_iR_i, or O, c is a single bond; when W¹ is CR_j, c is a double bond; and when W¹ is NH, W is not O;

R_h is O or S;

R_i and R_i are each independently H, CH₃ or Br;

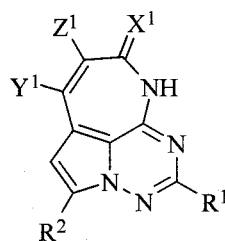
10 R_j is CH₃ or H; and

W³ is absent, H, or alkyl, provided that when W³ is absent b is a double bond; or a pharmaceutically acceptable salt or prodrug thereof.

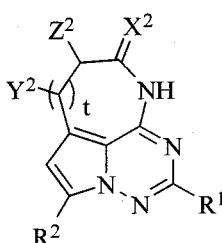
In one embodiment of the invention the compound of formula I is a compound of formula V wherein W³ is absent, H, or methyl.

15 In one embodiment of the invention the compound of formula I is a compound of formula V wherein W³ is methyl.

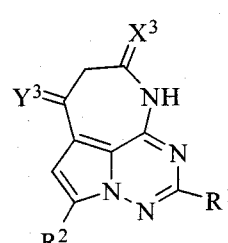
In another embodiment of the invention provides compounds of formula I that are compounds of formula 1-9:



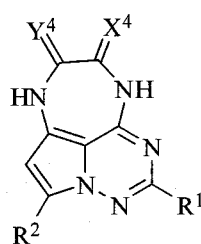
1



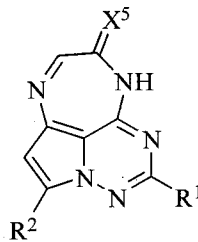
2



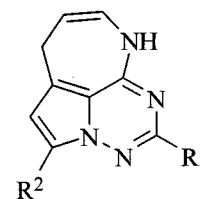
3



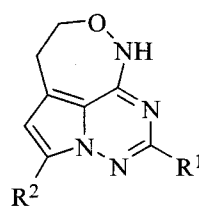
4



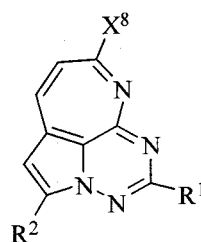
5



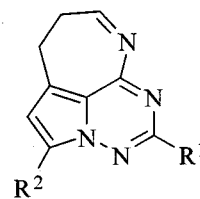
6



7



8



9

wherein:

X^1 is O, S, or two hydrogens;

X^2 is O, S, or two hydrogens;

X^3 is O or S;

5 X^4 is O, S, or two hydrogens;

X^5 is O, S, or two hydrogens;

X^8 is NH_2 , OCH_3 or SCH_3 ;

Y^1 is H, OH, NH_2 , $NHCH_3$, $N(CH_3)_2$, F, Cl, Br, I, OCH_3 , Oalkyl, alkyl SCH_3 , CH_3 , $C\equiv N$, $C\equiv C-R$, N_3 or SO_2R' ;

10 Y^2 is H, CH_3 , OCH_3 or SCH_3 ;

Y^3 is O or S;

Y^4 is O, S, or two hydrogens;

Z^1 is H or CH_3 ;

Z^2 is H, CH_3 or Br; and

15 t is 1 or 2;

or a pharmaceutically acceptable salt or prodrug thereof.

In another embodiment the invention provides a compound of Formula I as described above, wherein R^1 is H or NR_aR_b ; or a pharmaceutically acceptable salt or prodrug thereof.

In another embodiment the invention provides a compound of Formula I as described above, wherein R^2 is a nucleoside sugar group of Group A, B, C, D, E, or F described
20 hereinbelow; or a pharmaceutically acceptable salt or prodrug thereof.

In another embodiment the invention provides a compound of Formula I as described above, wherein R^2 is ribose, 2-methylribose, 2-deoxyribose; 2-deoxy-2-fluororibose; arabinose; 2-deoxy-2-fluoroarabinose; 2,3-dideoxyribose; 2,3-dideoxy-2-fluoroarabinose; 2,3-dideoxy-3-
25 fluororibose; 2,3-dideoxy-2,3-didehydroribose; 2,3-dideoxy-3-azidoribose; 2,3-dideoxy-3-thiaribose; or 2,3-dideoxy-3-oxaribose; or a pharmaceutically acceptable salt or prodrug thereof.

In another embodiment the invention provides a compound of Formula I as described above, wherein R^2 is thioribose, 2-deoxythioribose; 2-deoxy-2-fluorothioribose; thioarabinose; 2-deoxy-2-fluorothioarabinose; 2,3-dideoxythioribose; 2,3-dideoxy-2-fluorothioarabinose; 2,3-
30 dideoxy-3-fluorothioribose; 2,3-dideoxy-2,3-didehydrothioribose; or 2,3-dideoxy-3-azidothioribose; or a pharmaceutically acceptable salt or prodrug thereof.

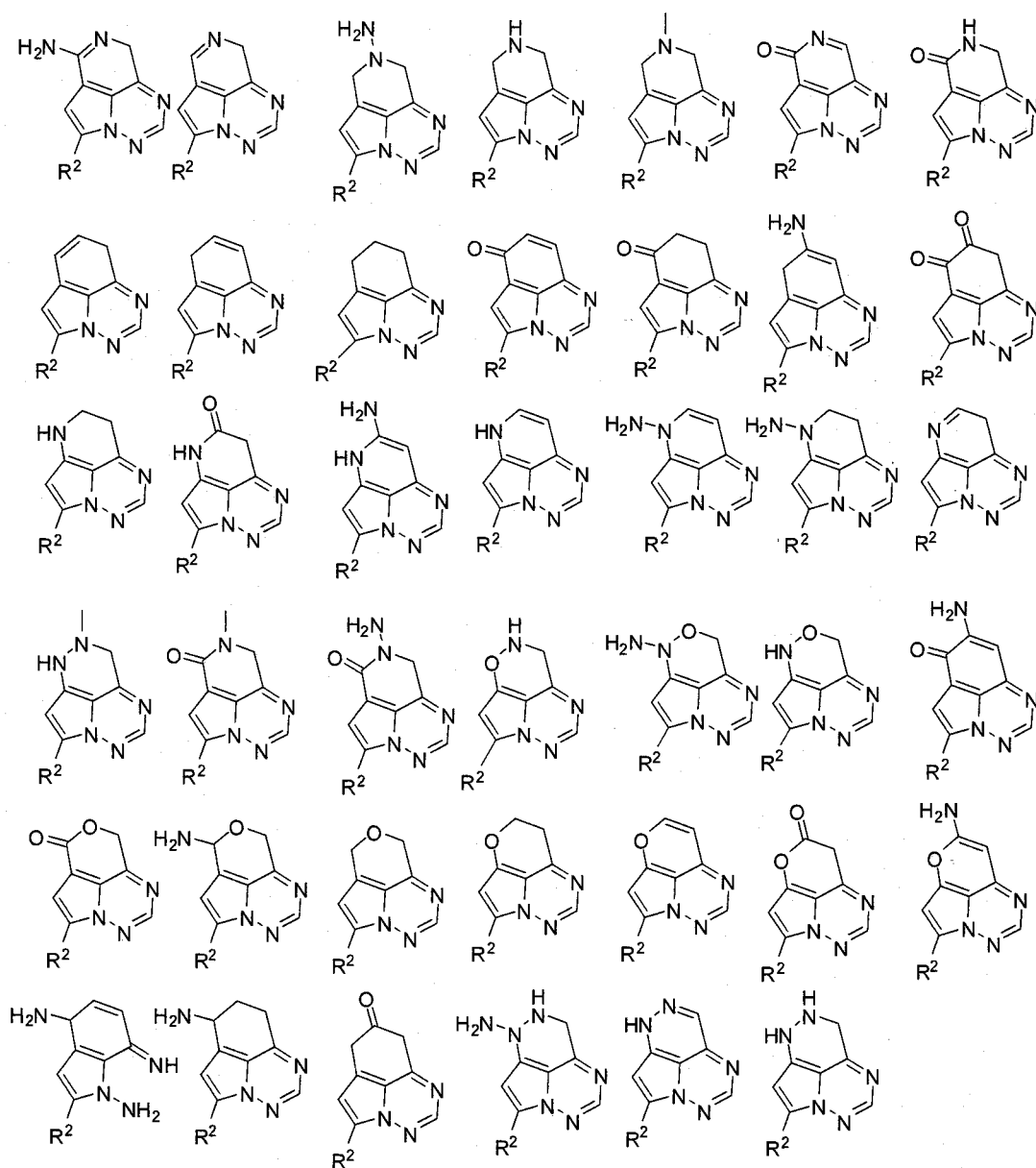
In another embodiment the invention provides a compound of Formula I as described above, wherein R^2 is 4-hydroxymethylcyclopent-2-ene; 2,3-dihydroxy-4-
hydroxymethylcyclopent-4-ene; 3-hydroxy-4-hydroxymethylcyclopentane; 2-hydroxy-4-
35 hydroxymethylcyclopentene; 2-fluoro-3-hydroxy-4-hydroxymethylcyclopentane; 2,3-dihydroxy-

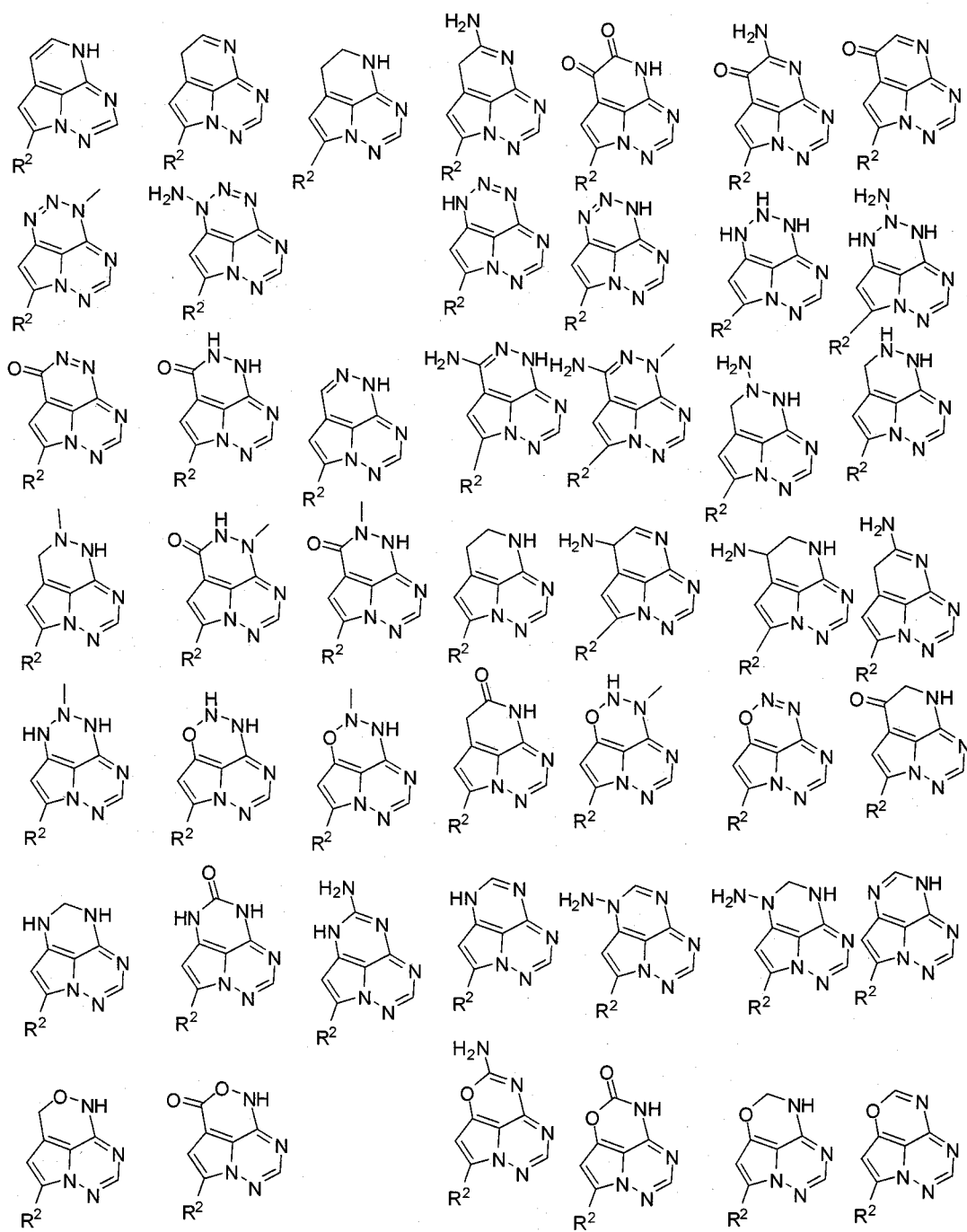
4-hydroxymethyl-5-methylenecyclopentane; 4-hydroxymethylcyclopentane, 2,3-dihydroxy-4-hydroxymethylcyclopentane; or 2,3-dihydroxymethylcyclobutane; or a pharmaceutically acceptable salt or prodrug thereof.

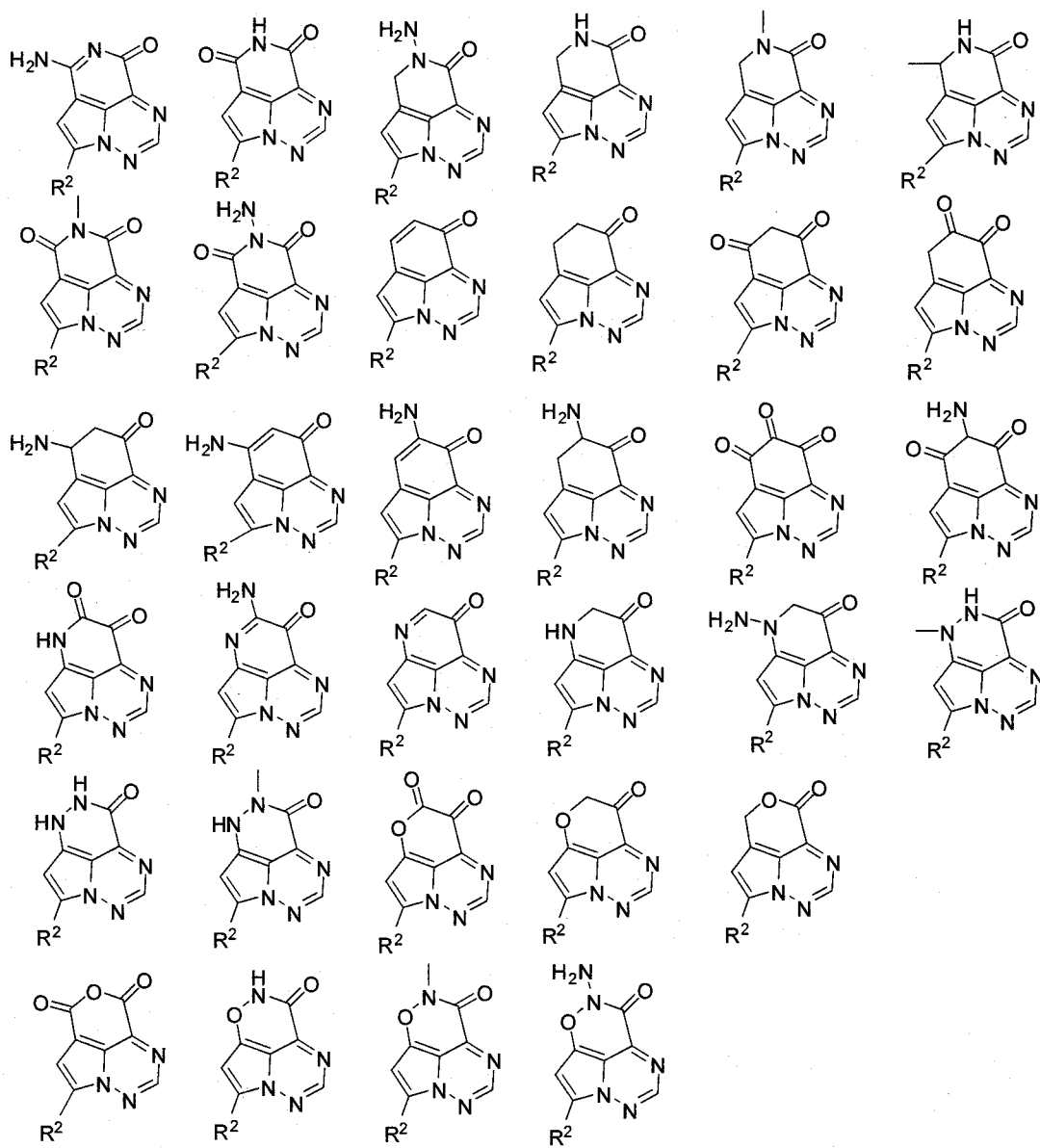
In another embodiment the invention provides a compound of Formula I as described above, wherein R² is 4-hydroxymethylpyrrolidine; 2,3-dihydroxy-4-hydroxymethylpyrrolidine; 2/3-hydroxy-4-hydroxymethylpyrrolidine; 2-fluoro-3-hydroxy-4-hydroxymethylpyrrolidine; or 3-fluoro-2-hydroxy-4-hydroxymethyl-pyrrolidine; or a pharmaceutically acceptable salt or prodrug thereof.

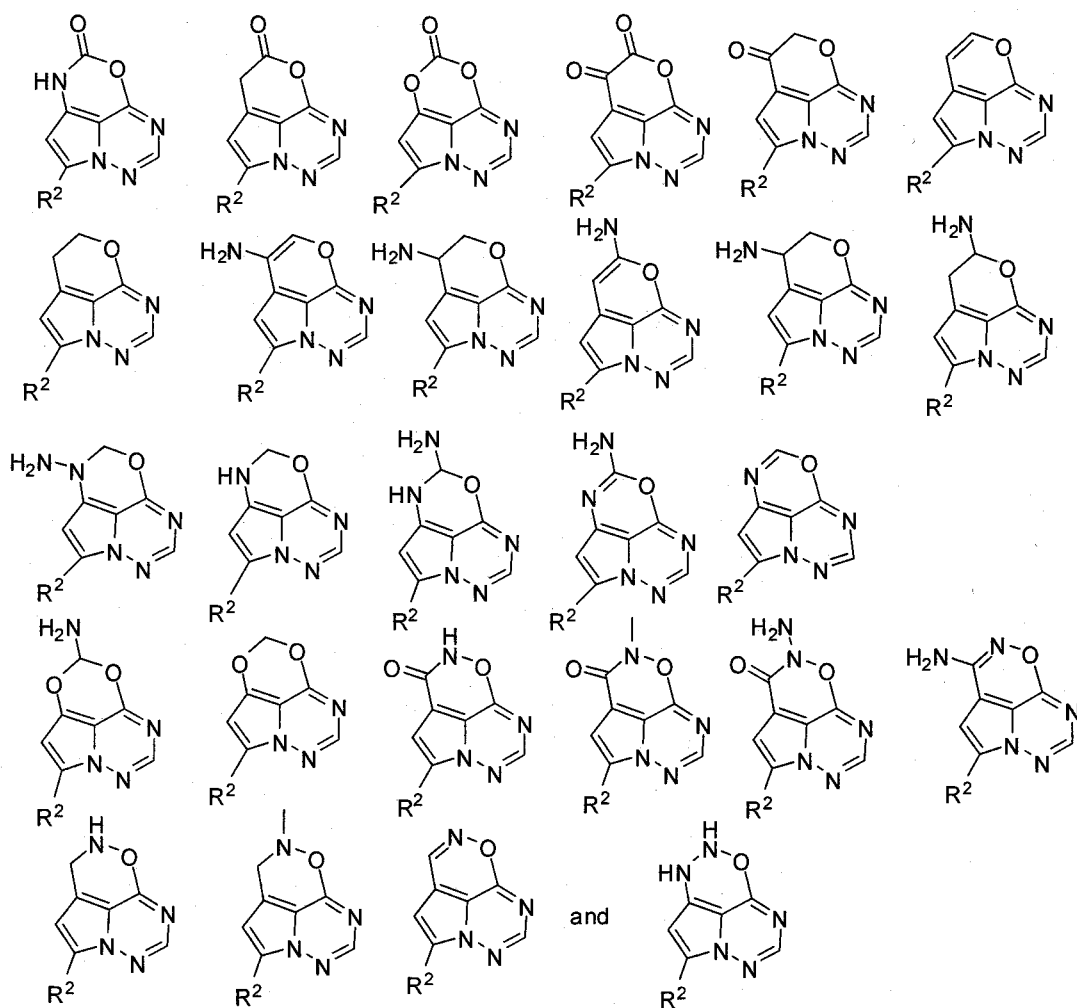
In another embodiment the invention provides a compound of Formula I as described above, wherein R_a, R_b, R_c, and R_d are independently selected from the group consisting of H, alkyl, and substituted alkyl; or R_a and R_b together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring; or R_b and R_c together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring.

In another embodiment the invention provides a compound selected from,



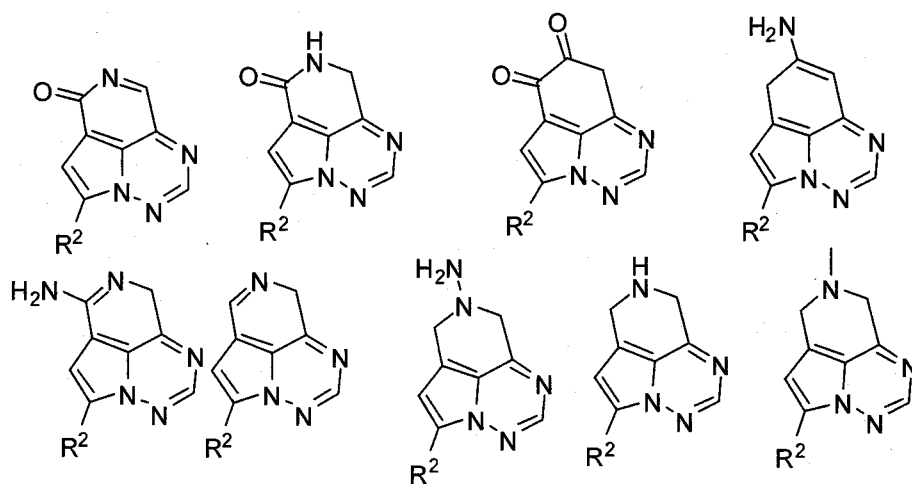


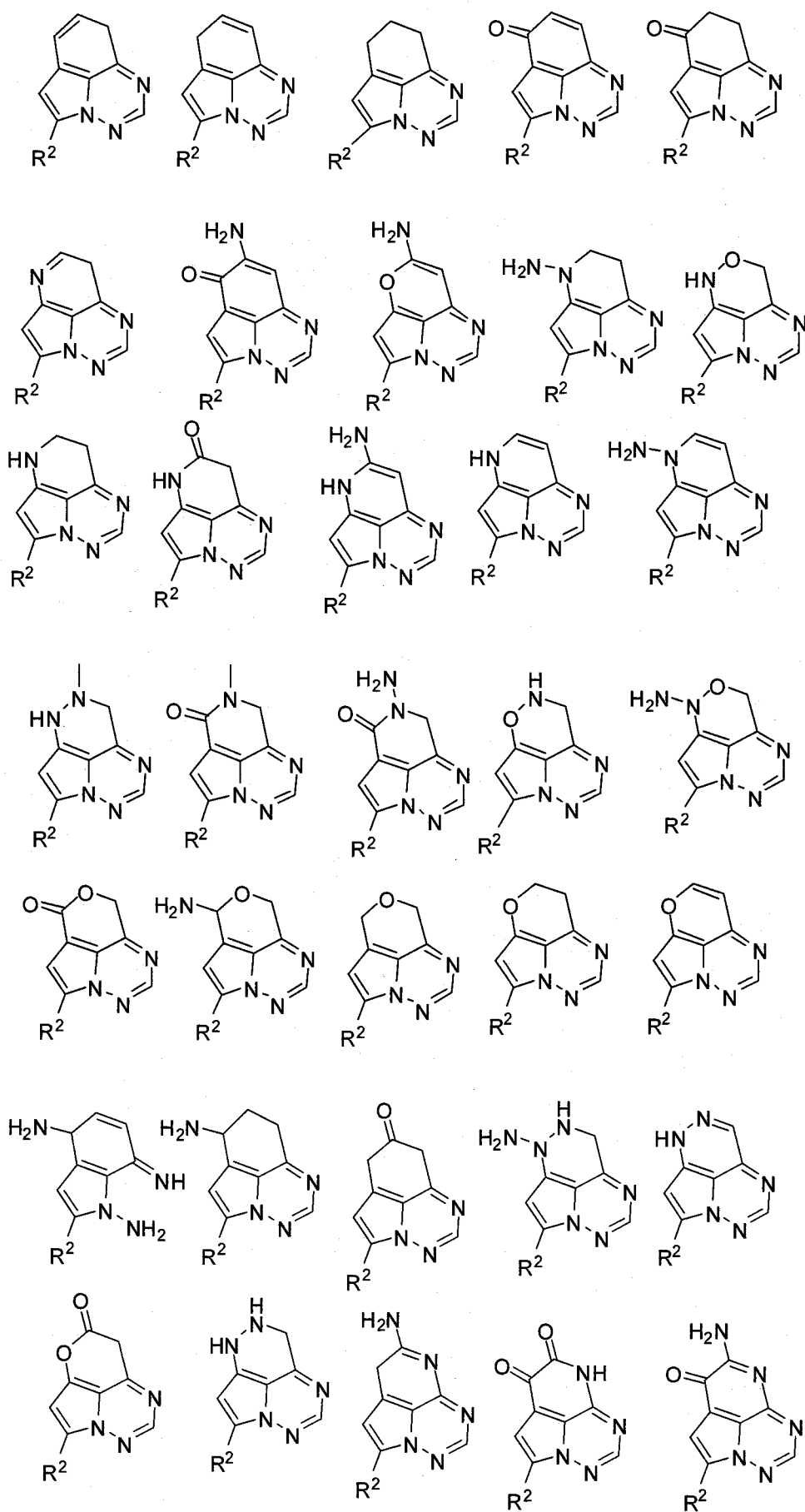


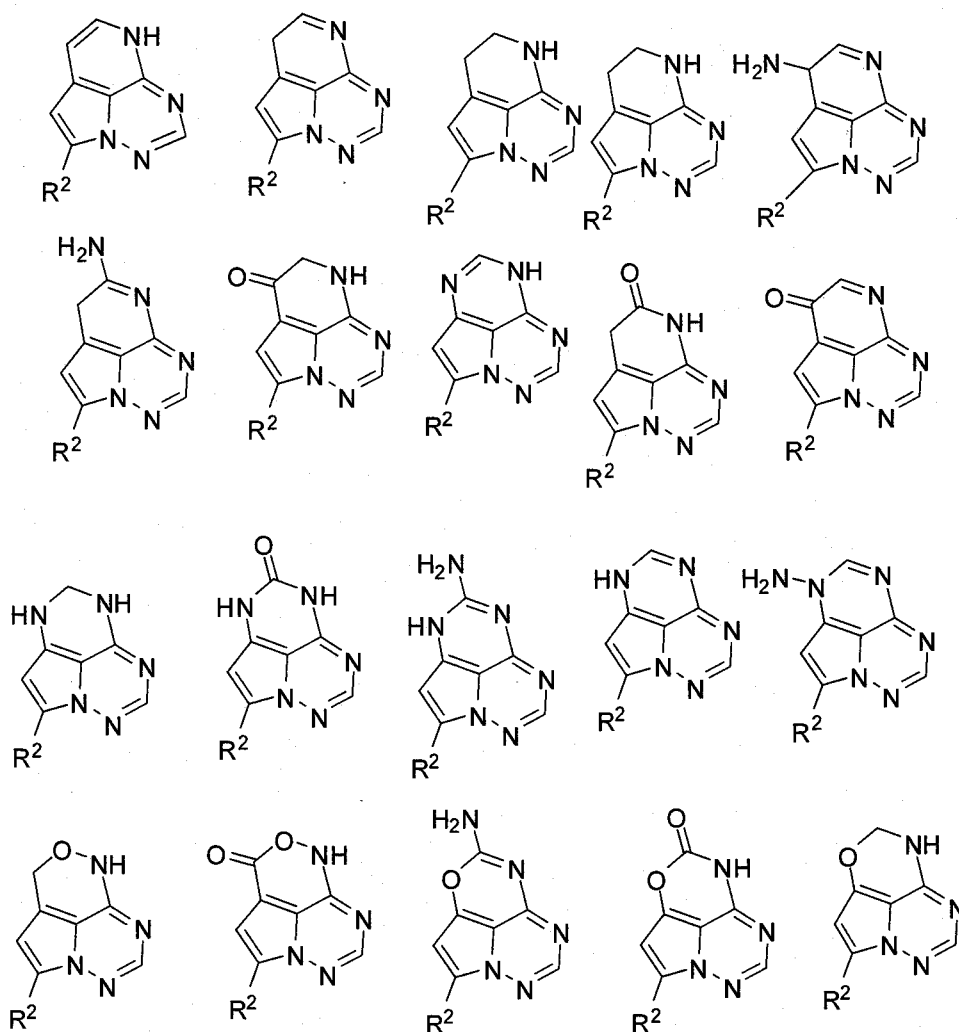


or a pharmaceutically acceptable salt or prodrug thereof.

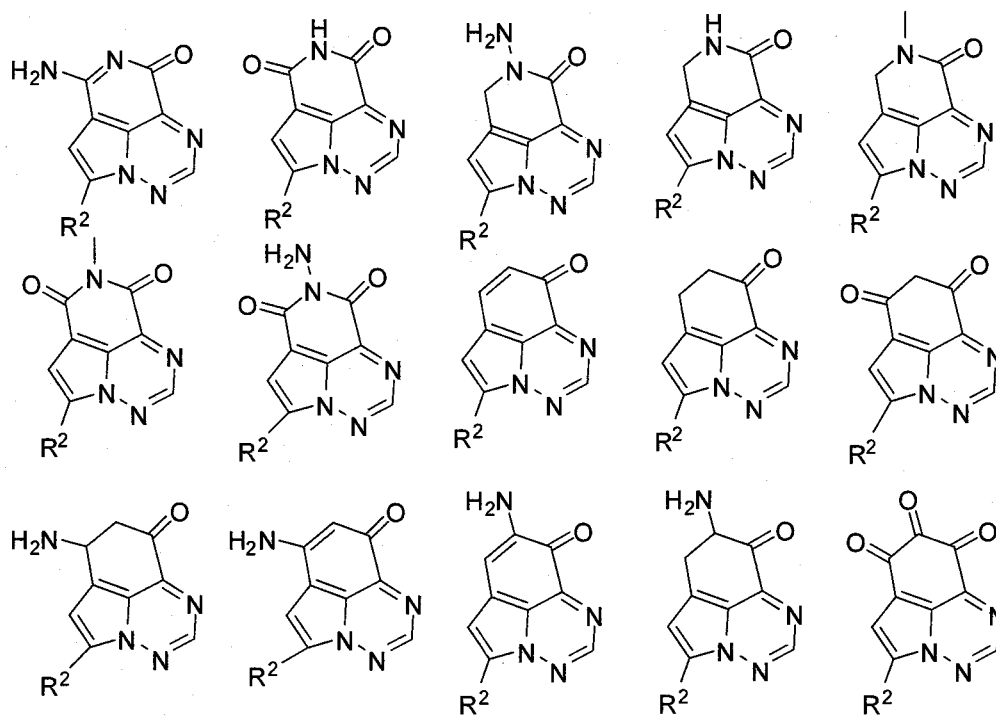
In one embodiment the invention provides a compound of formula I selected from:

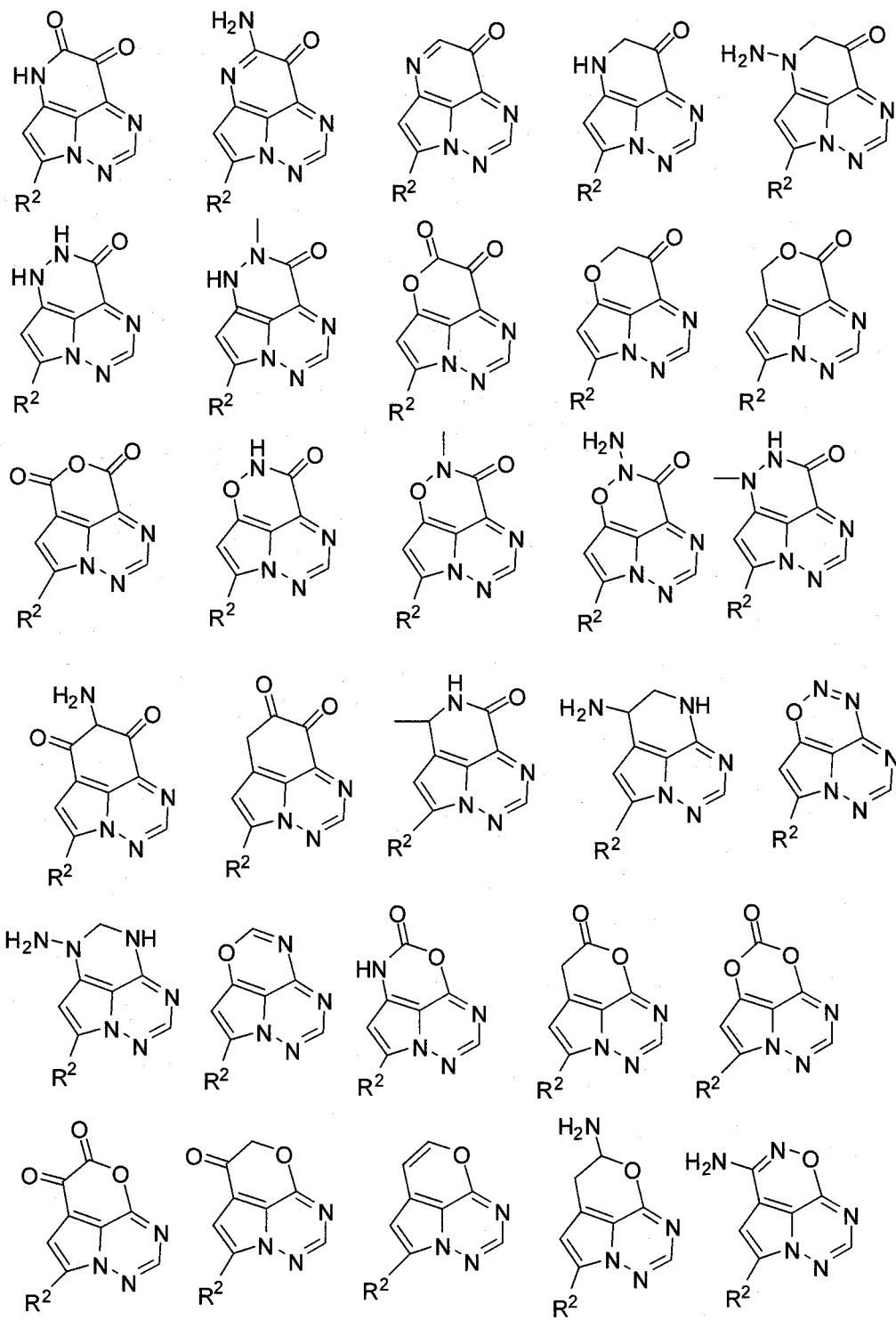


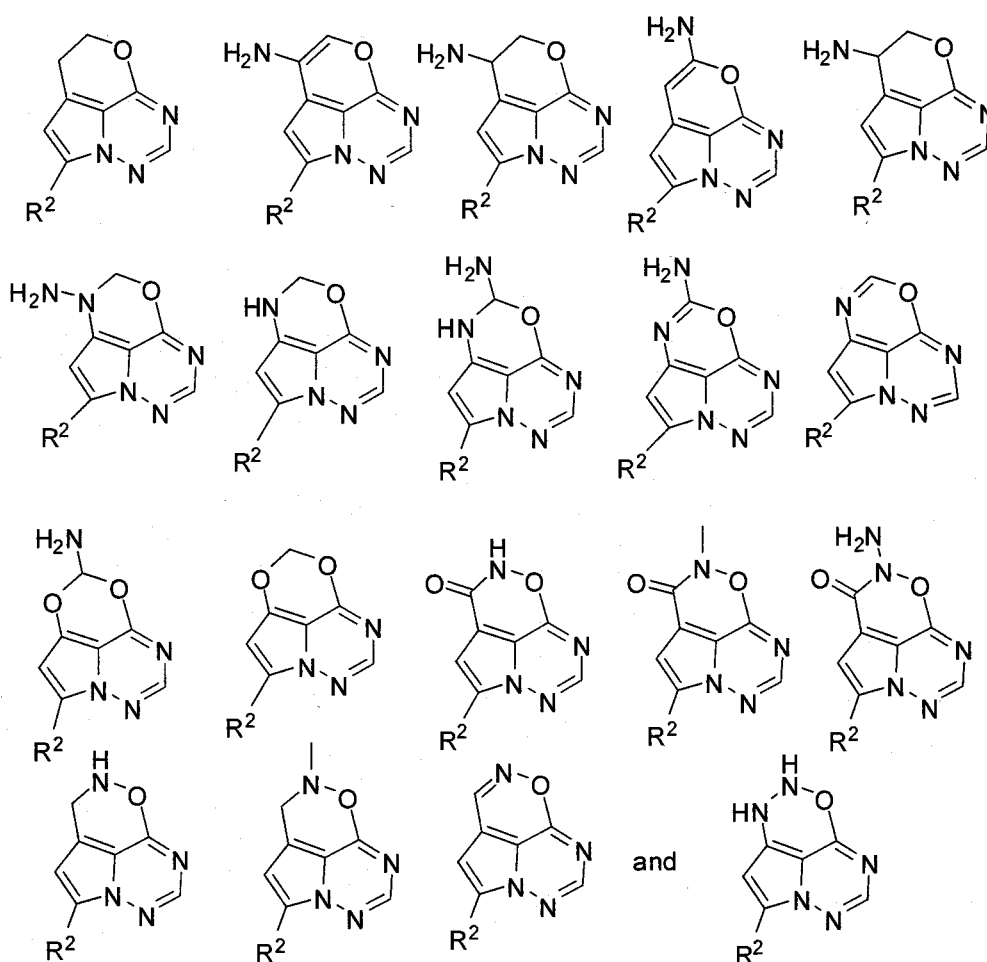




5

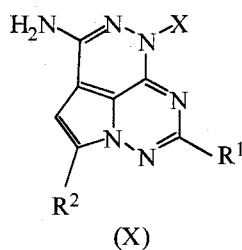






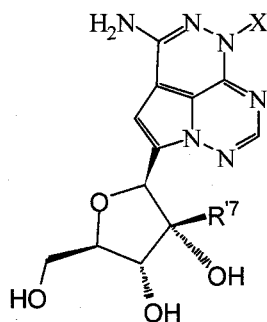
5 or a pharmaceutically acceptable salt or prodrug thereof.

In another embodiment the invention the compound of formula (I) is not a compound of the following formula (X):



or a pharmaceutically acceptable salt or prodrug thereof; wherein X is H or alkyl.

10 In another embodiment the invention the compound of formula (I) is not a compound of the following formula:

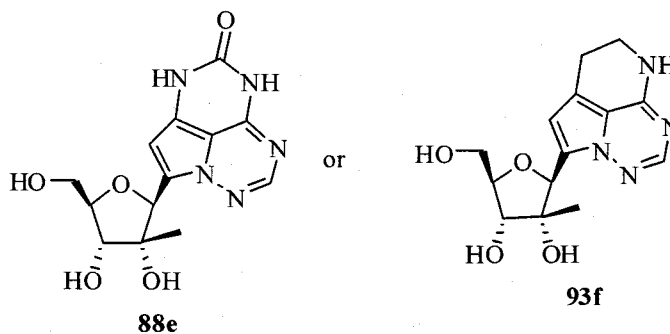


or a pharmaceutically acceptable salt or prodrug thereof; wherein X is H or methyl ; and R'⁷ is H or methyl.

In another embodiment the invention B is not a 6 membered ring comprising two nitrogens and one double bond, wherein B is substituted with NR_cR_d.

In another embodiment the invention B represents a 5, 7, or 8 membered ring comprising one or more heteratoms and one or more double bonds, wherein B is optionally substituted with one or more oxo, thioxo, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R'.

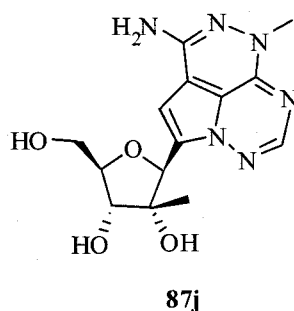
In another embodiment the invention the compound of formula (I) is:



10

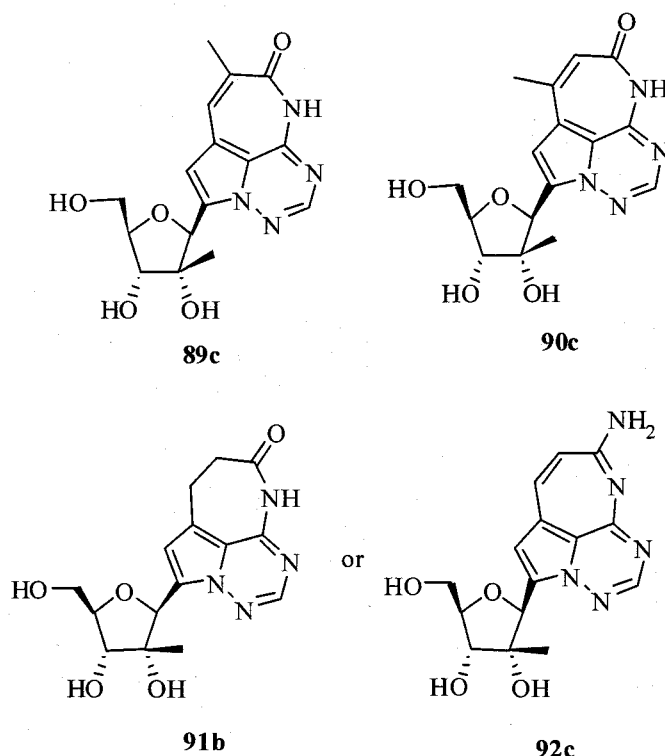
or a pharmaceutically acceptable salt or prodrug thereof.

In another embodiment the invention the compound of formula (I) is:



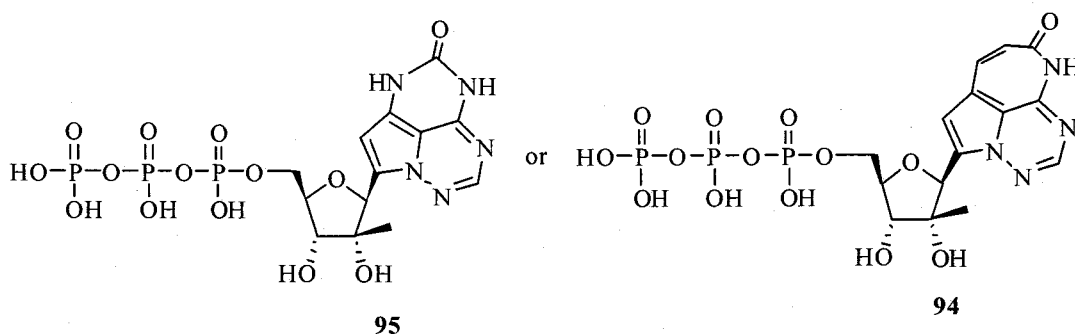
15 or a pharmaceutically acceptable salt or prodrug thereof.

In another embodiment the invention the compound of formula (I) is:



or a pharmaceutically acceptable salt or prodrug thereof.

In another embodiment the invention the compound of formula (I) is:



or a pharmaceutically acceptable salt or prodrug thereof.

- 5 In another embodiment the invention B represents a 5 membered ring comprising one or more heteratoms (e.g. 1, 2, or 3) and one or more double bonds (e.g. 1, 2, or 3), wherein B is optionally substituted with one or more (e.g. 1, 2, or 3) oxo, thioxo, NR_cR_d , F, Cl, Br, I, OR_z , SR_z , alkyl, $\text{C}\equiv\text{N}$, $\text{C}\equiv\text{C-R}$, N_3 or $\text{SO}_2\text{R}'$.

- 10 In another embodiment the invention B represents a 6 membered ring comprising one or more heteratoms (e.g. 1, 2, or 3) and one or more double bonds (e.g. 1, 2, or 3), wherein B is optionally substituted with one or more (e.g. 1, 2, or 3) oxo, thioxo, NR_cR_d , F, Cl, Br, I, OR_z , SR_z , alkyl, $\text{C}\equiv\text{N}$, $\text{C}\equiv\text{C-R}$, N_3 or $\text{SO}_2\text{R}'$.

In another embodiment the invention B represents a 7 membered ring comprising one or more heteratoms (e.g. 1, 2, or 3) and one or more double bonds (e.g. 1, 2, or 3), wherein B is

optionally substituted with one or more (e.g. 1, 2, or 3) oxo, thioxo, NR_dR_d , F, Cl, Br, I, OR_z , SR_z , alkyl, $\text{C}\equiv\text{N}$, $\text{C}\equiv\text{C-R}$, N_3 or $\text{SO}_2\text{R}'$.

In another embodiment the invention B represents an 8 membered ring comprising one or more heteratoms (e.g. 1, 2, or 3) and one or more double bonds (e.g. 1, 2, or 3), wherein B is optionally substituted with one or more (e.g. 1, 2, or 3) oxo, thioxo, NR_dR_d , F, Cl, Br, I, OR_z , SR_z , alkyl, $\text{C}\equiv\text{N}$, $\text{C}\equiv\text{C-R}$, N_3 or $\text{SO}_2\text{R}'$.

Prodrugs

The term "prodrug" as used herein refers to a compound that can be metabolized *in vivo* to provide a compound of Formula I. Thus prodrugs include compounds that can be prepared by modifying one or more functional groups in a compound of Formula I to provide a corresponding compound that can be metabolized *in vivo* to provide a compound of Formula I. Such modifications are known in the art. For example, one or more hydroxy groups or amine groups in a compound of Formula I can be acylated with alkyl-C(=O)-groups or with residues from amino acids to provide a prodrug. Alternatively, one or more pendent hydroxyl groups from a mono-, di-, or tri-phosphate functionality in a compound of Formula I can be converted to an alkoxy, substituted alkoxy, aryloxy, or substituted aryloxy group.

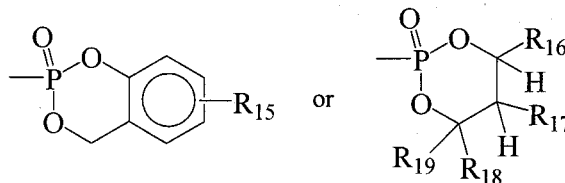
In one embodiment, the term prodrug includes a compound wherein one or more hydroxy groups on a nucleoside sugar group (e.g. a 2', 3', or 5' hydroxy group) have been converted to a group that can be metabolized *in vivo* to provide a compound of Formula I. For example, the invention provides a compound wherein one or more hydroxy groups on a nucleoside sugar group (e.g. a 2', 3', or 5' hydroxy group) have been converted to an acyloxy, acylamino or R-O group, wherein R is a carboxy-linked amino acid.

In one embodiment, the term prodrug includes a compound wherein one or more pendent hydroxyl groups from a mono-, di-, or tri-phosphate functionality in a compound of Formula I is converted to a group $\text{R}_y\text{-O-}$; wherein each R_y is independently a 1-20 carbon branched or unbranched, saturated or unsaturated chain, wherein one or more (e.g. 1, 2, 3, or 4) of the carbon atoms is optionally replaced with -O- or -S- and wherein one or more of the carbon atoms is optionally substituted with oxo (=O) or thioxo (=S) (See Lefebvre et al., J. Med. Chem. 1995, 38, 3941-50).

In another embodiment, the term prodrug includes a compound wherein one or more pendent hydroxyl groups from a mono-, di-, or tri-phosphate functionality in a compound of Formula I is converted to a group $\text{R}_z\text{-N-}$; wherein each R_z is a residue of an amino acid. Thus, in the methods of treatment of the present invention, the term "administering" includes administration of a compound of Formula I, as well as administration of a prodrug which converts to a compound of Formula I or a salt thereof *in vivo*. Conventional procedures for the

selection and preparation of prodrug derivatives are described, for example, in "Design of Prodrugs", ed. H. Bundgaard, Elsevier, 1985; and in International Patent Application Publication Number WO 2005/084192. A variety of prodrugs are also described in International Patent Application Number PCT US2004/013063, which was published as International Publication Number WO 2004/096286.

In another embodiment the prodrug comprises one of more groups of formula:



wherein:

R_{15} is H, alkyl, substituted alkyl, aryl, substituted aryl, cycloalkyl, substituted cycloalkyl, heteroaryl, substituted heteroaryl, heterocyclic, substituted heterocyclic, and an amino acid;

R_{16} is H, optionally substituted monocyclic aryl, or optionally substituted monocyclic heteroaryl; and R_{17} is H, halogen, CN, $-\text{CO}-R_{20}$, $-\text{CON}(\text{R}_{21})_2$, $-\text{CO}_2\text{R}_{20}$, $-\text{SO}_2\text{R}_{20}$, $-\text{SO}_2\text{N}(\text{R}_{21})_2$, $-\text{OR}_{21}$, $-\text{SR}_{21}$, $-\text{R}_{21}$, $-\text{N}(\text{R}_{21})_2$, $-\text{O}-\text{COR}_{20}$, $-\text{O}-\text{CO}_2\text{R}_{20}$, $-\text{SCOR}_{20}$, $-\text{S}-\text{CO}_2\text{R}_{20}$, $-\text{NHCOR}_{21}$, $-\text{NHCO}_2\text{R}_{21}$, $-(\text{CH}_2)_p-\text{OR}_{22}$, or $-(\text{CH}_2)_p-\text{SR}_{22}$; or R_{16} and R_{17} are connected via an additional 3-5 atoms to form a cyclic group, optionally containing one heteroatom, that is fused to an aryl group at the beta and gamma position to the O attached to the phosphorus; or R_{17} and R_{18} are connected as described below;

R_{18} and R_{19} are each independently H, alkyl, aryl, heterocycloalkyl, aralkyl, optionally substituted monocyclic aryl or optionally substituted monocyclic heteroaryl; or R_{18} and R_{19} are connected via an additional 2-5 atoms to form a cyclic group, optionally containing 0-2 heteroatoms; or R_{17} and R_{18} are connected via an additional 3-5 atoms to form a cyclic group, optionally containing one heteroatom and R_{19} is H, alkyl, aryl, heterocycloalkyl, aralkyl, optionally substituted monocyclic aryl or optionally substituted monocyclic heteroaryl; and

R_{20} is alkyl, aryl, heterocycloalkyl, or arylalkyl;

R_{21} is H, alkyl, aryl, heterocycloalkyl, or arylalkyl;

R_{22} is H or lower acyl;

n is an integer from 2-5;

m is an integer from 10-20; and

p is an integer from 2-3.

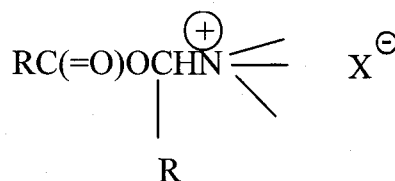
Prodrug forms of a compound bearing various nitrogen functions (amino, hydroxyamino, amide, etc.) may include the following types of derivatives where each R_p group individually

may be hydrogen, substituted or unsubstituted alkyl, aryl, alkenyl, alkynyl, heterocycle, alkylaryl, aralkyl, aralkenyl, aralkynyl, cycloalkyl or cycloalkenyl groups as defined earlier.

- (a) Carboxamides, represented as -NHC(O)R_p
- (b) Carbamates, represented as -NHC(O)OR_p
- 5 (c) (Acyloxy)alkyl Carbamates, represented as NHC(O)OROC(O)R_p
- (d) Enamines, represented as $\text{-NHCR(=CHCO}_2\text{R}_p\text{)}$ or $\text{-NHCR(=CHCONR}_p\text{R}_p\text{)}$
- (e) Schiff Bases, represented as $\text{-N=CR}_p\text{R}_p$
- (f) Mannich Bases (from carboximide compounds), represented as $\text{RCONHCH}_2\text{NR}_p\text{R}_p$

10 Preparations of such prodrug derivatives are discussed in various literature sources (examples are: Alexander *et al.*, J. Med. Chem. 1988, 31, 318; Aligas-Martin *et al.*, PCT WO0041531, p.30).

Prodrug forms of carboxyl-bearing compounds include esters ($\text{-CO}_2\text{R}_m$) where the R_m group corresponds to any alcohol whose release in the body through enzymatic or hydrolytic
15 processes would be at pharmaceutically acceptable levels. Another prodrug derived from a carboxylic acid form of the disclosure may be a quaternary salt type of structure described by Bodor *et al.*, J. Med. Chem. 1980, 23, 469.



25

Nucleoside Sugar Groups

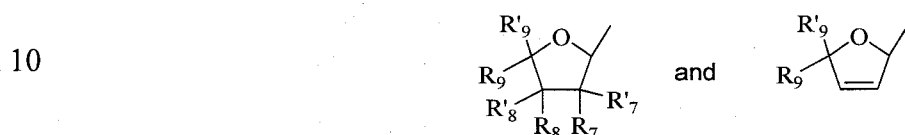
The term “nucleoside sugar group” as used herein includes cyclic and acyclic groups that can be included as the sugar portion of a nucleoside analog of Formula I. Many examples of such groups are known in the field of nucleoside chemistry (See for example Antiviral Drugs
30 by John S. Driscoll (2002) published by Ashgate Publishing Ltd.).

The term nucleoside sugar group includes substituted and unsubstituted tetrahydrofuranyl and dihydrofuranyl compounds including those set forth in group (A) below, substituted and unsubstituted tetrahydrothiophenyl and dihydrothiophenyl compounds including those set forth in group (B) below, substituted and unsubstituted alkyl compounds including
35 those set forth in group (C) below, substituted and unsubstituted cycloalkyl and cycloalkenyl compounds including those set forth in group (D) below, substituted and unsubstituted dihydropyrrolidinyl and tetrahydropyrrolidinyl compounds including those set forth in group (E) below, and substituted and unsubstituted dioxolane, substituted and unsubstituted thioxolane,

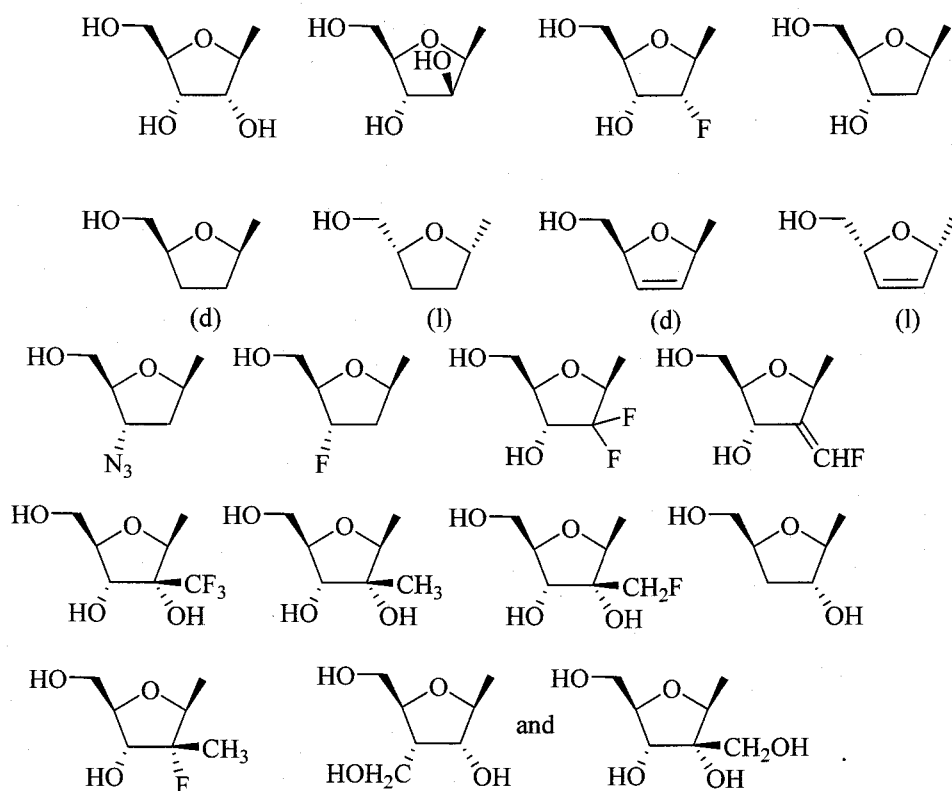
and substituted and unsubstituted dithiolane compounds including those set forth in group (F) below.

Group A

- 5 Examples of substituted tetrahydro and dihydrofuranyl compounds include those compounds represented by the general structures:



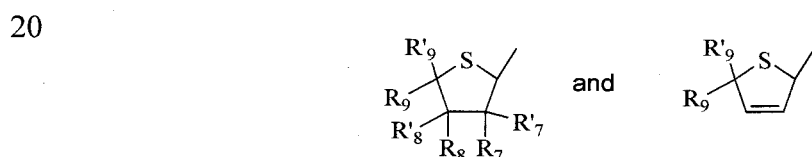
Specific examples include, but are not limited to, the following compounds:



15

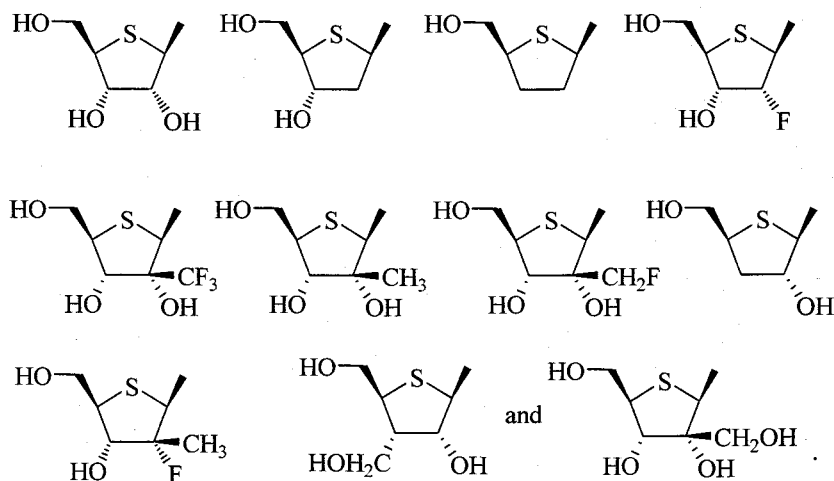
Group B

Examples of substituted tetrahydrothiophenyl and dihydrothiophenyl compounds include those compounds represented by the general structures:



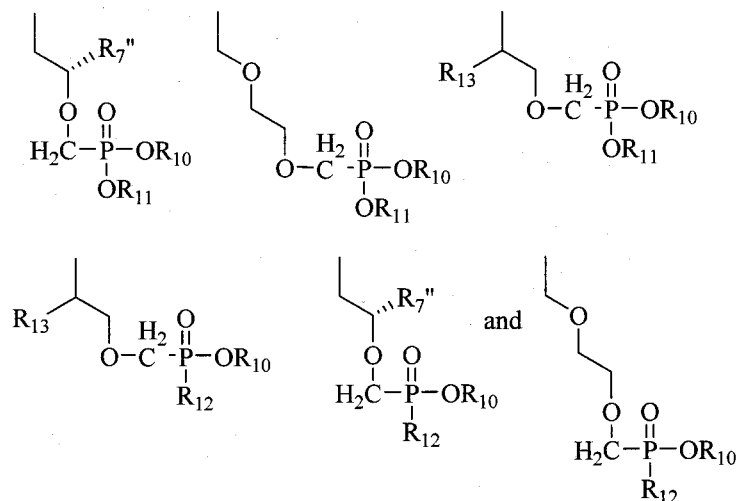
- 25 Specific examples include, but are not limited to, the following compounds:

10

Group C

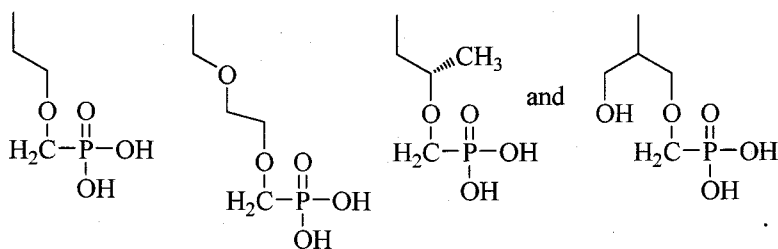
20

Examples of substituted alkyl compounds include those compounds represented by:



Specific examples include, but are not limited to, the following compounds:

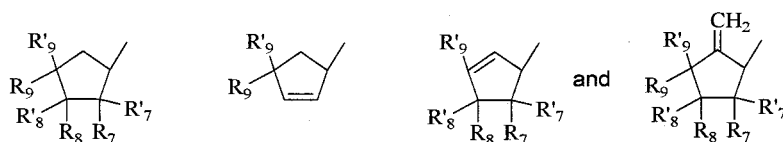
25



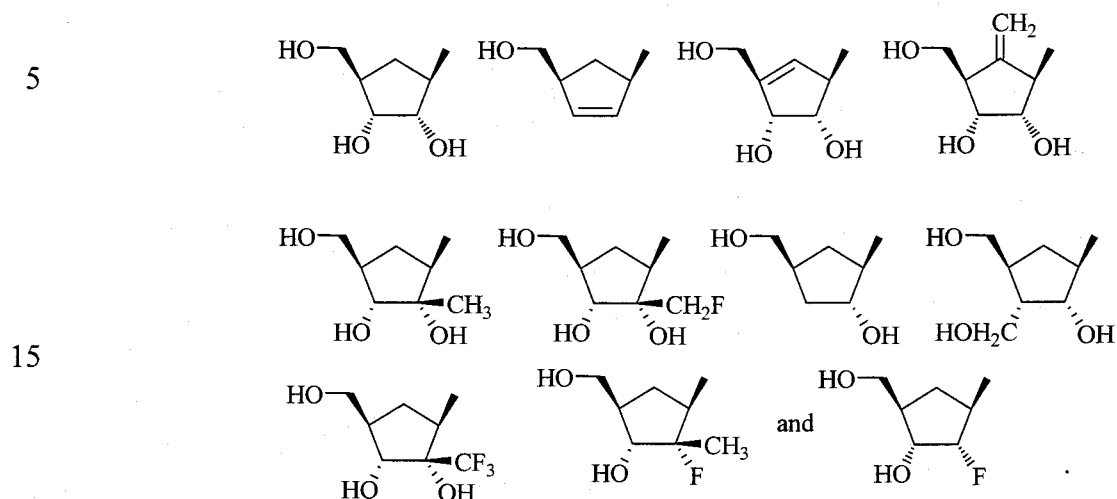
35

Group D

Examples of substituted cycloalkyl and cycloalkenyl compounds include those compounds represented by the general structures:

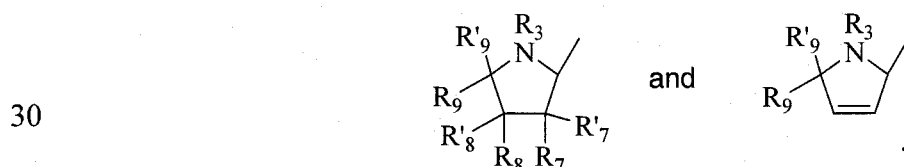


Specific examples include, but are not limited to, the following compounds:

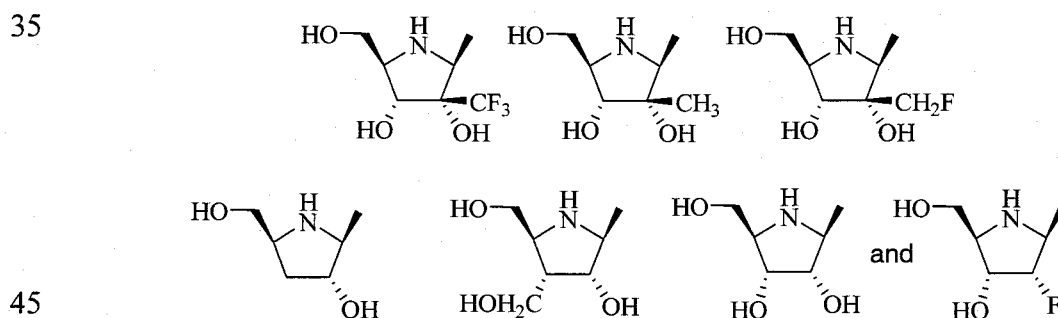


Group E

Examples of substituted dihydropyrrolidinyl and tetrahydropyrrolidinyl compounds include those compounds represented by the general structures:



Specific examples include, but are not limited to, the following compounds:



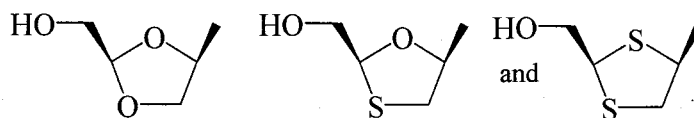
Group F

Examples of substituted dioxolane, substituted thioxolane and substituted dithiolane compounds include those compounds represented by the general structures:



Specific examples include, but are not limited to, the following compounds:

5

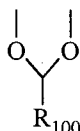


For the structures in Groups A-F, the following definitions apply:

10 R_7 is H, OR_{14} , N_3 , NH_2 , or F; and R'_7 is H, F, OH, O-alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_7 and R'_7 together may be $=CH_2$, $=CHF$; wherein both R_7 and R'_7 are not OH; and when one of R_7 and R'_7 is NH_2 , the other is not OH; and when one of R_7 and R'_7 is N_3 , the other is not OH;

15 R_8 is H, OR_{14} , N_3 , NH_2 , or F; and R'_8 is H, F, OH, O alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_8 and R'_8 together may be $=CH_2$, $=CHF$; wherein both R_8 and R'_8 are not OH; and when one of R_8 and R'_8 is NH_2 , the other is not OH; and when one of R_8 and R'_8 is N_3 , the other is not OH;

or R_7 and R_8 together can form

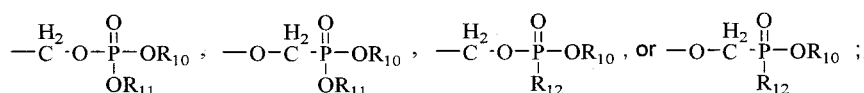


25 wherein: R_{100} is C_{1-12} alkyl C_{3-8} cycloalkyl, aryl or heteroaryl; wherein any C_{1-12} alkyl and C_{3-8} cycloalkyl of R_{100} is unsubstituted or is substituted with 1-3 substituents selected from halogen, hydroxy, carboxy, and C_{1-4} alkoxy; and wherein any aryl or heteroaryl of R_{100} is unsubstituted or is substituted with 1-5 substituents independently selected from R_{101} ;

30 each R_{101} is independently halo, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} alkylthio, C_{1-4} alkylsulfoyl, cyano, nitro, amino, phenyl, carboxy, trifluoromethyl, trifluoromethoxy, C_{1-4} alkylamino, di(C_{1-4} alkyl) amino, C_{1-4} alkanoyl, C_{1-4} alkanoyloxy, or C_{1-4} alkyloxycarbonyl;

R_9 is H, CH_3 , C_2H_5 , or N_3 ;

R'_9 is CH_2OR_{14} , CH_2F , CH_2SH , $CHFOH$, CF_2OH , CH_2 -diphosphate, CH_2 -triphosphate,



35

R_{10} and R_{11} are each independently H, alkyl, aryl, substituted aryl, acyloxyalkyl, or $(CH_2)_n-O-(CH_2)_mCH_3$;

R_{12} is an N-linked amino acid residue (e.g. $-NH-CH(CH_3)CO_2$ alkyl or $-NH-CH(isopropyl)-CO_2$ alkyl); and

40 R_{14} is H;

n is 2-5; and

m is 10-20.

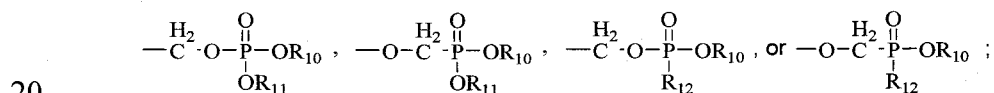
In one specific embodiment of the invention for the structures in Groups A-F:

5 R₇ is H, OR₁₄, N₃, NH₂, or F; and R'₇ is H, F, OH, O-alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R₇ and R'₇ together may be =CH₂, =CHF; wherein both R₇ and R'₇ are not OH; and when one of R₇ and R'₇ is NH₂, the other is not OH; and when one of R₇ and R'₇ is N₃, the other is not OH; R'₇ is alkyl or substituted alkyl.

10 R₈ is H, OR₁₄, N₃, NH₂, or F; and R'₈ is H, F, OH, O alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R₈ and R'₈ together may be =CH₂, =CHF; wherein both R₈ and R'₈ are not OH; and when one of R₈ and R'₈ is NH₂, the other is not OH; and when one of R₈ and R'₈ is N₃, the other is not OH;

R₉ is H, CH₃, C₂H₅, or N₃;

R'₉ is CH₂OR₁₄, CH₂F, CH₂SH, CHFOH, CF₂OH,



R₁₀ and R₁₁ are each independently H, alkyl, aryl, substituted aryl, acyloxyalkyl, or (CH₂)_n-O-(CH₂)_mCH₃;

R₁₂ is an N-linked amino acid residue (e.g. -NH-CH(CH₃)CO₂alkyl or -NH-CH(isopropyl)-CO₂alkyl);

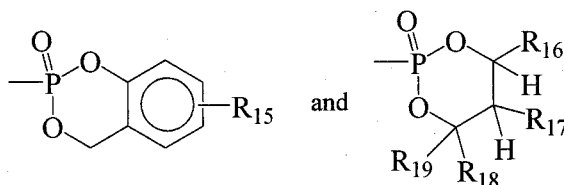
25 R₁₃ is H, CH₃, C₂H₅, CH₂F, CH₂OH, CH₂CH₂F, CH₂CH₂OH, CH₂N₃, CH₂CH₂N₃, CH₂NH₂, or CH₂CH₂NH₂;

R₁₄ is H;

n is 2-5; and

m is 10-20.

30 In one embodiment, for a compound of Formula I, R₁₄ is replaced to form a pharmaceutically acceptable prodrug, for example, a prodrug selected from the group consisting of: acyl, oxyacyl, phosphonate, phosphate, phosphate esters, phosphoramidate, phosphorodiamidate, phosphoramidate mono ester, cyclic phosphoramidate, cyclic phosphorodiamidate, phosphoramidate diester, C(O)CHR₁₅NH₂,



wherein:

R_{15} is H, alkyl, substituted alkyl, aryl, substituted aryl, cycloalkyl, substituted cycloalkyl, heteroaryl, substituted heteroaryl, heterocyclic, substituted heterocyclic, or an amino acid;

R_{16} is H, optionally substituted monocyclic aryl, or optionally substituted monocyclic heteroaryl; and R_{17} is H, halogen, CN, $-\text{CO}-R_{20}$, $-\text{CON}(\text{R}_{21})_2$, $-\text{CO}_2\text{R}_{20}$, $-\text{SO}_2\text{R}_{20}$, $-\text{SO}_2\text{N}(\text{R}_{21})_2$, $-\text{OR}_{21}$, $-\text{SR}_{21}$, $-\text{R}_{21}$, $-\text{N}(\text{R}_{21})_2$, $-\text{O}-\text{COR}_{20}$, $-\text{O}-\text{CO}_2\text{R}_{20}$, $-\text{SCOR}_{20}$, $-\text{S}-\text{CO}_2\text{R}_{20}$, $-\text{NHCOR}_{21}$, $-\text{NHCO}_2\text{R}_{21}$, $-(\text{CH}_2)_p-\text{OR}_{22}$, or $-(\text{CH}_2)_p-\text{SR}_{22}$; or R_{16} and R_{17} are connected via an additional 3-5 atoms to form a cyclic group, optionally containing one heteroatom, that is fused to an aryl group at the beta and gamma position to the O attached to the phosphorus; or R_{17} and R_{18} are connected as described below;

R_{18} and R_{19} are each independently H, alkyl, aryl, heterocycloalkyl, aralkyl, optionally substituted monocyclic aryl or optionally substituted monocyclic heteroaryl; or R_{18} and R_{19} are connected via an additional 2-5 atoms to form a cyclic group, optionally containing 0-2 heteroatoms; or R_{17} and R_{18} are connected via an additional 3-5 atoms to form a cyclic group, optionally containing one heteroatom and R_{19} is H, alkyl, aryl, heterocycloalkyl, aralkyl, optionally substituted monocyclic aryl or optionally substituted monocyclic heteroaryl; and

R_{20} is alkyl, aryl, heterocycloalkyl, or arylalkyl;

R_{21} is H, alkyl, aryl, heterocycloalkyl, or arylalkyl;

R_{22} is H or lower acyl; and

p is an integer from 2-3.

Synthetic Processes

Processes for preparing compounds of Formula I, or a pharmaceutically acceptable salts or prodrugs thereof, as well as processes for preparing intermediate compounds that can be used to prepare compounds of Formula I or pharmaceutically acceptable salts or prodrugs thereof are provided as further embodiments of the invention. For example in one embodiment the invention provides a method for preparing a pharmaceutically acceptable salt of compound of Formula I comprising converting a corresponding compound of Formula I to the salt.

In another embodiment the invention provides a method for preparing a prodrug of a compound of Formula I comprising converting a corresponding compound of Formula I to the prodrug.

In another embodiment the invention provides a method for preparing a compound of Formula I comprising deprotecting a corresponding compound of Formula I that comprises one or more protecting groups to provide the compound of Formula I.

Synthetic Intermediates

5 The invention also provides synthetic intermediates that are useful for preparing compounds of Formula I or a salt or prodrug thereof. For example, the invention provides novel synthetic intermediates such as those described in the Examples herein.

Isomers and Physical Forms

10 It will be appreciated by those skilled in the art that compounds of the invention having a chiral center may exist in and be isolated in optically active and racemic forms. Some compounds may exhibit polymorphism. It is to be understood that the present invention encompasses any racemic, optically-active, polymorphic, tautomeric, or stereoisomeric form, or mixtures thereof, of a compound of the invention (e.g. a compound of Formula I, which possess the useful properties described herein, it being well known in the art how to prepare optically
15 active forms (for example, by resolution of the racemic form by recrystallization techniques, by synthesis from optically-active starting materials, by chiral synthesis, or by chromatographic separation using a chiral stationary phase) and how to determine anti-viral or anti-cancer activity using the standard tests described herein, or using other similar tests which are well known in the art. Although the invention includes all isomeric forms of the compounds described herein,
20 one embodiment of the invention provides compounds having the absolute stereochemistry depicted in the Examples hereinbelow.

Pharmaceutical Compositions, Modes of Administration and Methods of Treatment

The present disclosure provides compounds of the general Formula I as detailed above which are inhibitors of DNA and/or RNA viral polymerases and anticancer agents. Various
25 forms of DNA and RNA viral polymerases are inhibited by the compounds disclosed, such as but not limited to viral RdRps. The compounds of the present disclosure therefore have utility in treating and/or preventing viral infections in a host and in treatment and/or preventing a variety of disease states and/or conditions caused by or related to such viral infections. In one embodiment, the compounds are useful in the above mentioned treating and/or preventing by
30 inhibiting a viral RNA and DNA polymerases. Such viral agents include, but are not limited to, hepatitis B, hepatitis C, human immunodeficiency virus, Polio, Coxsackie A and B, Rhino, Echo, small pox, Ebola, and West Nile virus. In a particular embodiment, the causative agent of the viral infection is a flavivirus.

The present disclosure provides for a compound of the general Formula I and a
35 pharmaceutical composition comprising a pharmaceutically effective amount of at least one

compound of general Formula I as described herein. Such compounds and/or pharmaceutical compositions may be used in the manufacture of a medicament for treating and/or preventing a disease or condition in which it is desirable to inhibit a viral RNA and DNA polymerases. Such pharmaceutical compositions may also comprise a pharmaceutically acceptable carrier and other ingredients known in the art, or may comprise solely a compound of the general Formula I.

The pharmaceutically acceptable carriers described herein, including, but not limited to, vehicles, adjuvants, excipients, or diluents, are well-known to those who are skilled in the art. Typically, the pharmaceutically acceptable carrier is chemically inert to the active compounds and has no detrimental side effects or toxicity under the conditions of use. The pharmaceutically acceptable carriers can include polymers and polymer matrices.

The compounds described in the instant disclosure can be administered by any conventional method available for use in conjunction with pharmaceuticals, either as individual therapeutic agents or in combination with additional therapeutic agents.

The compounds described are administered in a pharmaceutically effective amount. The pharmaceutically effective amount of the compound and the dosage of the pharmaceutical composition administered will, of course, vary depending upon known factors, such as the pharmacodynamic characteristics of the particular agent and its mode and route of administration; the age, health and weight of the recipient; the severity and stage of the disease state or condition; the kind of concurrent treatment; the frequency of treatment; and the effect desired.

A daily dosage of active ingredient can be expected to be about 0.001 to 1000 milligrams (mg) per kilogram (kg) of body weight per day. In one embodiment, the total amount is between about 0.1 mg/kg and about 100 mg/kg of body weight per day; in an alternate embodiment between about 1.1 mg/kg and about 50 mg/kg of body weight per day; in yet another alternate embodiment between 0.1 mg/kg and about 30 mg/kg of body weight per day. The above described amounts may be administered as a series of smaller doses over a period of time if desired. The pharmaceutically effective amount can be calculated based on the weight of the parent compound to be delivered. If the salt or prodrug exhibits activity in itself, the pharmaceutically effective amount can be estimated as above using the weight of the salt or prodrug, or by other means known to those skilled in the art. The dosage of active ingredient may be given other than daily if desired.

The total amount of the compound administered will also be determined by the route, timing and frequency of administration as well as the existence, nature, and extent of any adverse side effects that might accompany the administration of the compound and the desired physiological effect. It will be appreciated by one skilled in the art that various conditions or

disease states, in particular chronic conditions or disease states, may require prolonged treatment involving multiple administrations.

Dosage forms of the pharmaceutical compositions described herein (forms of the pharmaceutical compositions suitable for administration) contain from about 0.1 mg to about 3000 mg of active ingredient (i.e. the compounds disclosed) per unit. In these pharmaceutical compositions, the active ingredient will ordinarily be present in an amount of about 0.5-95% weight based on the total weight of the composition. Multiple dosage forms may be administered as part of a single treatment. The active ingredient may be administered to achieve peak plasma concentrations of the active ingredient of from about 0.2 to 70 μM , or from about 1.0 to 10 μM .

The active ingredient can be administered orally in solid dosage forms, such as capsules, tablets, and powders, or in liquid dosage forms, such as elixirs, syrups and suspensions. It can also be administered parenterally, in sterile liquid dosage forms. The active ingredient can also be administered intranasally (nose drops) or by inhalation via the pulmonary system, such as by propellant based metered dose inhalers or dry powders inhalation devices. Other dosage forms are potentially possible such as administration transdermally, via patch mechanisms or ointment.

Formulations suitable for oral administration can include (a) liquid solutions, such as a pharmaceutically effective amount of the compound dissolved in diluents, such as water, saline, or orange juice; (b) capsules, sachets, tablets, lozenges, and troches, each containing a predetermined pharmaceutically effective amount of the active ingredient, as solids or granules; (c) powders; (d) suspensions in an appropriate liquid; and (e) suitable emulsions. Liquid formulations may include diluents, such as water and alcohols, for example, ethanol, benzyl alcohol, propylene glycol, glycerin, and the polyethylene alcohols, either with or without the addition of a pharmaceutically acceptable surfactant, suspending agent, or emulsifying agent.

Capsule forms can be of the ordinary hard- or soft-shelled gelatin type containing, for example, surfactants, lubricants, and inert fillers, such as lactose, sucrose, calcium phosphate, and corn starch. Tablet forms can include one or more of the following: lactose, sucrose, mannitol, corn starch, potato starch, alginic acid, microcrystalline cellulose, acacia, gelatin, guar gum, colloidal silicon dioxide, croscarmellose sodium, talc, magnesium stearate, calcium stearate, zinc stearate, stearic acid, and other excipients, colorants, diluents, buffering agents, disintegrating agents, moistening agents, preservatives, flavoring agents, and pharmacologically compatible carriers. Lozenge forms can comprise the active ingredient in a flavor, usually sucrose and acacia or tragacanth, as well as pastilles comprising the active ingredient in an inert base, such as gelatin and glycerin, or sucrose and acacia, emulsions, and gels containing, in addition to the active ingredient, such carriers as are known in the art.

Formulations suitable for parenteral administration include aqueous and non-aqueous, isotonic sterile injection solutions, which can contain anti-oxidants, buffers, bacteriostats, and solutes that render the formulation isotonic with the blood of the patient, and aqueous and non-aqueous sterile suspensions that can include suspending agents, solubilizers, thickening agents, stabilizers, and preservatives.

The compound can be administered in a physiologically acceptable diluent in a pharmaceutically acceptable carrier, such as a sterile liquid or mixture of liquids, including water, saline, aqueous dextrose and related sugar solutions, an alcohol, such as ethanol, isopropanol, or hexadecyl alcohol, glycols, such as propylene glycol or polyethylene glycol such as poly(ethyleneglycol) 400, glycerol ketals, such as 2,2-dimethyl-1,3-dioxolane-4-methanol, ethers, an oil, a fatty acid, a fatty acid ester or glyceride, or an acetylated fatty acid glyceride with or without the addition of a pharmaceutically acceptable surfactant, such as a soap or a detergent, suspending agent, such as pectin, carbomers, methylcellulose, hydroxypropylmethylcellulose, or carboxymethylcellulose, or emulsifying agents and other pharmaceutical adjuvants.

Oils, which can be used in parenteral formulations, include petroleum, animal, vegetable, or synthetic oils. Specific examples of oils include peanut, soybean, sesame, cottonseed, corn, olive, petrolatum, and mineral. Suitable fatty acids for use in parenteral formulations include oleic acid, stearic acid, and isostearic acid. Ethyl oleate and isopropyl myristate are examples of suitable fatty acid esters. Suitable soaps for use in parenteral formulations include fatty alkali metal, ammonium, and triethanolamine salts, and suitable detergents include (a) cationic detergents such as, for example, dimethyldialkylammonium halides, and alkylpyridinium halides, (b) anionic detergents such as, for example, alkyl, aryl, and olefin sulfonates, alkyl, olefin, ether, and monoglyceride sulfates, and sulfosuccinates, (c) nonionic detergents such as, for example, fatty amine oxides, fatty acid alkanolamides, and polyoxyethylene polypropylene copolymers, (d) amphoteric detergents such as, for example, alkyl .beta.-aminopropionates, and 2-alkylimidazoline quaternary ammonium salts, and (e) mixtures thereof.

The parenteral formulations typically contain from about 0.5% to about 25% by weight of the active ingredient in solution. Suitable preservatives and buffers can be used in such formulations. In order to minimize or eliminate irritation at the site of injection, such compositions may contain one or more nonionic surfactants having a hydrophile-lipophile balance (HLB) of from about 12 to about 17. The quantity of surfactant in such formulations ranges from about 5% to about 15% by weight. Suitable surfactants include polyethylene sorbitan fatty acid esters, such as sorbitan monooleate and the high molecular weight adducts of

ethylene oxide with a hydrophobic base, formed by the condensation of propylene oxide with propylene glycol.

Pharmaceutically acceptable excipients are also well-known to those who are skilled in the art. The choice of excipient will be determined in part by the particular compound, as well as by the particular method used to administer the composition. Accordingly, there is a wide variety of suitable formulations of the pharmaceutical composition of the present invention. The following methods and excipients are merely exemplary and are in no way limiting. The pharmaceutically acceptable excipients preferably do not interfere with the action of the active ingredients and do not cause adverse side-effects. Suitable carriers and excipients include solvents such as water, alcohol, and propylene glycol, solid absorbants and diluents, surface active agents, suspending agent, tableting binders, lubricants, flavors, and coloring agents.

The compounds of the present invention, alone or in combination with other suitable components, can be made into aerosol formulations to be administered via inhalation. These aerosol formulations can be placed into pressurized acceptable propellants, such as dichlorodifluoromethane, propane, and nitrogen. Such aerosol formulations may be administered by metered dose inhalers. They also may be formulated as pharmaceuticals for non-pressured preparations, such as in a nebulizer or an atomizer.

The formulations can be presented in unit-dose or multi-dose sealed containers, such as ampules and vials, and can be stored in a freeze-dried (lyophilized) condition requiring only the addition of the sterile liquid excipient, for example, water, for injections, immediately prior to use. Extemporaneous injection solutions and suspensions can be prepared from sterile powders, granules, and tablets. The requirements for effective pharmaceutically acceptable carriers for injectable compositions are well known to those of ordinary skill in the art. See *Pharmaceutics and Pharmacy Practice*, J.B. Lippincott Co., Philadelphia, Pa., Banker and Chalmers, Eds., 238-250 (1982) and *ASHP Handbook on Injectable Drugs*, Toissel, 4th ed., 622-630 (1986).

Formulations suitable for topical administration include pastilles comprising the active ingredient in an inert base, such as gelatin and glycerin, or sucrose and acacia, as well as creams, emulsions, and gels containing, in addition to the active ingredient, such carriers as are known in the art. Furthermore, transdermal patches can be prepared using methods known in the art.

Additionally, formulations suitable for rectal administration may be presented as suppositories by mixing with a variety of bases such as emulsifying bases or water-soluble bases. Formulations suitable for vaginal administration may be presented as pessaries, tampons, creams, gels, pastes, foams, or spray formulas containing, in addition to the active ingredient, such carriers as are known in the art to be appropriate.

One skilled in the art will appreciate that suitable methods of administering a compound of the present invention to a patient are available, and, although more than one route can be used to administer a particular compound, a particular route can provide a more immediate and more effective reaction than another route.

5 Useful embodiments of pharmaceutical dosage forms for administration of the compounds according to the present invention can be illustrated as follows.

A large number of hard-shell capsules are prepared by filling standard two-piece hard gelatine capsules each with 100 mg of powdered active ingredient, 150 mg of lactose, 50 mg of cellulose and 6 mg of magnesium stearate.

10 A mixture of active ingredient in a digestible oil such as soybean oil, cottonseed oil or olive oil is prepared and injected by means of a positive displacement pump into molten gelatin to form soft gelatin capsules containing 100 mg of the active ingredient. The capsules are washed and dried. The active ingredient can be dissolved in a mixture of polyethylene glycol, glycerin and sorbitol to prepare a water miscible medicine mix.

15 A large number of tablets are prepared by conventional procedures so that the dosage unit is 100 mg of active ingredient, 0.2 mg of colloidal silicon dioxide, 5 mg of magnesium stearate, 275 mg of microcrystalline cellulose, 11 mg of starch, and 98.8 mg of lactose. Appropriate aqueous and non-aqueous coatings may be applied to increase palatability, improve elegance and stability or delay absorption.

20 Immediate release tablets/capsules are solid oral dosage forms made by conventional and novel processes. These units are taken orally without water for immediate dissolution and delivery of the medication. The active ingredient is mixed in a liquid containing ingredient such as sugar, gelatin, pectin and sweeteners. These liquids are solidified into solid tablets or caplets by freeze drying and solid state extraction techniques. The drug compounds may be compressed
25 with viscoelastic and thermoelastic sugars and polymers or effervescent components to produce porous matrices intended for immediate release, without the need of water.

Moreover, the compounds of the present invention can be administered in the form of nose drops, or metered dose and a nasal or buccal inhaler. The drug is delivered from a nasal solution as a fine mist or from a powder as an aerosol.

30 In one embodiment, the teachings of the present disclosure provide for the use of such pharmaceutical compositions and medicaments in a method of treating a viral infection or treating a disease state and/or condition caused by or related to such viral infection. In one embodiment, the treatment is the result of the inhibition of a viral RNA or DNA polymerase, such as but not limited to a RdRp. Such treatment or inhibition need not be complete to be
35 useful. The method of treatment comprises the steps of: (i) identifying a patient in need of such

treatment; (ii) providing such pharmaceutical composition containing at least one compound of the invention; and (iii) administering such pharmaceutical composition in a therapeutically effective amount to treat the viral infection in a patient in need of such treatment or to inhibit the activity of a viral RNA or DNA polymerase in a patient in need of such treatment.

5 In one embodiment, the teachings of the present disclosure provide for the use of such pharmaceutical compositions and medicaments in a method of preventing or suppressing a viral infection or preventing or suppressing a disease state and/or condition caused by or related to such viral infection. In one embodiment, the prevention or suppression is the result of the inhibition of a viral RNA or DNA polymerase, such as but not limited to a RdRp. Such
10 prevention, suppression or inhibition need not be complete to be useful. The method of preventing or suppressing can optionally comprises the steps of: (i) identifying a patient in need of such prevention; (ii) providing such pharmaceutical composition containing at least one compound of the general Formula I; and (iii) administering such pharmaceutical composition in a therapeutically effective amount to prevent or suppress the viral infection in a patient in need
15 of such treatment or to inhibit the activity of a viral RNA and DNA polymerase in a patient in need of such treatment.

The methods of the treating and preventing a viral infection or a disease state and/or condition caused by or related to said viral infection may further comprise administering a therapeutically effective amount of a compound of the present invention in combination with a
20 therapeutically effective amount of another anti-viral agent which, in particular, may be active against HCV. Agents active against HCV include, but are not limited to, ribavirin, levovirin, viramidine, thymosin alpha-1, an inhibitor of HCV NS3 serine protease, an inhibitor of inosine monophosphatedehydrognease, interferon- α , pegylated interferon- α (peginterferon- α), a combination of interferon- α and ribavirin, a combination of peginterferon- α and ribavirin, a
25 combination of interferon- α and levovirin, and a combination of peginterferon- α and levovirin. Interferon- α includes, but is not limited to, recombinant interferon- α 2a, interferon- α 2b, a consensus interferon, and a purified interferon- α product.

The compounds and pharmaceutical compositions of the present disclosure can be administered to patients to prevent and/or treat a number of cancers. Cancers include, but are
30 not limited to, leukemias and lymphomas such as acute lymphocytic leukemia, acute nonlymphocytic leukemias, chronic lymphocytic leukemia, chronic myelogenous leukemia, Hodgkin's Disease, non-Hodgkin's lymphomas, and multiple myeloma, childhood solid tumors such as brain tumors, neuroblastoma, retinoblastoma, Wilms Tumor, bone tumors, and soft-tissue sarcomas, common solid tumors of adults such as lung cancer, colon and rectum cancer,
35 breast cancer, prostate cancer, urinary cancers, uterine cancers, oral cancers, pancreatic cancer,

melanoma and other skin cancers, stomach cancer, ovarian cancer, brain tumors, liver cancer, laryngeal cancer, thyroid cancer, esophageal cancer, and testicular cancer. The cancer may be related to a viral infection or an activity of a viral DNA or RNA polymerase.

The methods of the treating and preventing cancer may also comprises further administering of a chemotherapeutic agent in combination with any of the compounds or pharmaceutical compositions of the present disclosure. Any suitable chemotherapeutic agent can be employed for this purpose. The chemotherapeutic agent is typically selected from the group consisting of alkylating agents, antimetabolites, natural products, hormonal agents, and miscellaneous agents.

Examples of alkylating chemotherapeutic agents include carmustine, chlorambucil, cisplatin, lomustine, cyclophosphamide, melphalan, mechlorethamine, procarbazine, thiotepa, uracil mustard, triethylenemelamine, busulfan, pipobroman, streptozocin, ifosfamide, dacarbazine, carboplatin, and hexamethylmelamine.

Examples of chemotherapeutic agents that are antimetabolites include cytosine arabinoside, fluorouracil, gemcitabine, hydroxyurea, mercaptopurine, methotrexate, azaserine, thioguanine, floxuridine, fludarabine, cladribine and L-asparaginase.

Examples of chemotherapeutic agents that are natural products include actinomycin D, bleomycin, camptothecins, daunomycin, doxorubicin, etoposide, mitomycin C, TAXOLTM (paclitaxel), taxotere, teniposide, vincristine, vinorelbine, mithramycin, idarubicin, MITHRACINTM. (plicamycin), and deoxycoformycin.

An example of a hormonal chemotherapeutic agent includes tamoxifen. Examples of the aforesaid miscellaneous chemotherapeutic agents include mitotane, mitoxantrone, vinblastine, and levamisole.

The ability of a compound to inhibit viral polymerases can be evaluated using known assays. The ability of a compound to inhibit HCV NS5B polymerase can be evaluated using the following assay.

HCV NS5B Polymerase Assay

Antiviral activity of the test compounds was assessed (Okuse *et al.*, Antiviral Res. 2005, 65, 23-34) in the stably HCV RNA-replicating cell line, AVA5, derived by transfection of the human hepatoblastoma cell line, Huh7 (Blight *et al.*, Sci. 2000, 290, 1972). Compounds were added to dividing cultures once daily for three days. Media was changed with each addition of compound. Cultures generally started the assay at 30-50% confluence and reached confluence during the last day of treatment. Intracellular HCV RNA levels and cytotoxicity were assessed 24 hours after the last dose of compound.

Triplicate cultures for HCV RNA levels (on 48-well and 96-well plates) and cytotoxicity (on 96-well plates) were used. A total of six untreated control cultures, and triplicate cultures treated with α -interferon and ribavirin served as positive antiviral and toxicity controls.

Intracellular HCV RNA levels were measured using a conventional blot hybridization method in which HCV RNA levels are normalized to the levels of B-actin RNA in each individual culture (Okuse *et al.*, Antivir. Res. 2005, **65**, 23-34). Cytotoxicity was measured using a neutral red dye uptake assay (Korba and Gerin, Antivir. Res. 1992, **19**, 55). HCV RNA levels in the treated cultures are expressed as a percentage of the mean levels of RNA detected in untreated cultures.

A representative compound of Formula I demonstrated significant activity in this assay.

Compound Synthesis

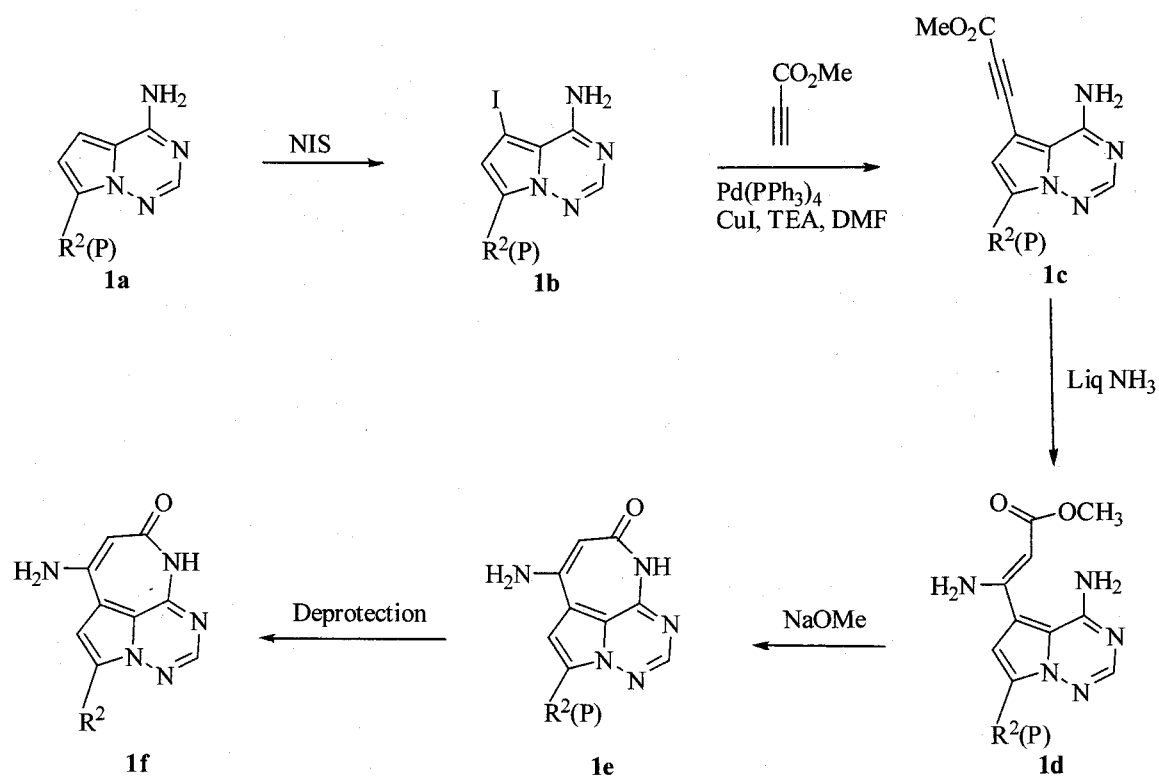
Compounds of Formula I can be prepared using synthetic intermediates and synthetic procedures that are known, or they can be prepared using the synthetic intermediates and synthetic procedures described herein, for example, as described in the following Schemes.

The following abbreviations are used herein.

Tr :	trityl
Bn:	benzyl
TBDPS:	<i>tert</i> -butyldiphenylsilyl
m-CPBA :	3-chloroperoxybenzoic acid
TFA :	trifluoroacetic acid
TBDMSCl :	<i>tert</i> -butyldimethylsilyl chloride
DMF:	dimethylformamide
THF:	tetrahydrofuran
LDA:	lithium diisopropylamine
TEAB:	triethylammonium bicarbonate
MmTrCl:	monomethoxytrityl chloride
MMTrCl:	monomethoxytrityl chloride
DMAP:	dimethylaminopyridine
DEAE :	diethylaminoethyl-sepharose
CMA-80 :	Chloroform 80:MeOH 18: NH ₄ OH :2
CMA-50 :	Chloroform 50:MeOH 40: NH ₄ OH :10
Bz:	benzoyl
BnBr:	benzyl bromide
LiHMDS :	lithium hexamethyldisilazane
TBDPSCl:	<i>tert</i> -butyldiphenylsilyl chloride
DMSO:	dimethylsulfoxide
RMgBr:	alkyl magnesium bromide
DIBAL:	diisobutylaluminum hydride
DBN:	1,5-diazabicyclo[4.3.0]non-5-ene
DBU:	1,8-diazabicyclo[5.4.0]undec-7-ene
MeMgBr :	methylmagnesium bromide
P:	Represents a suitable protecting group
R:	In Schemes 41-86 R can have any of the values defined for R ² herein

Scheme 1

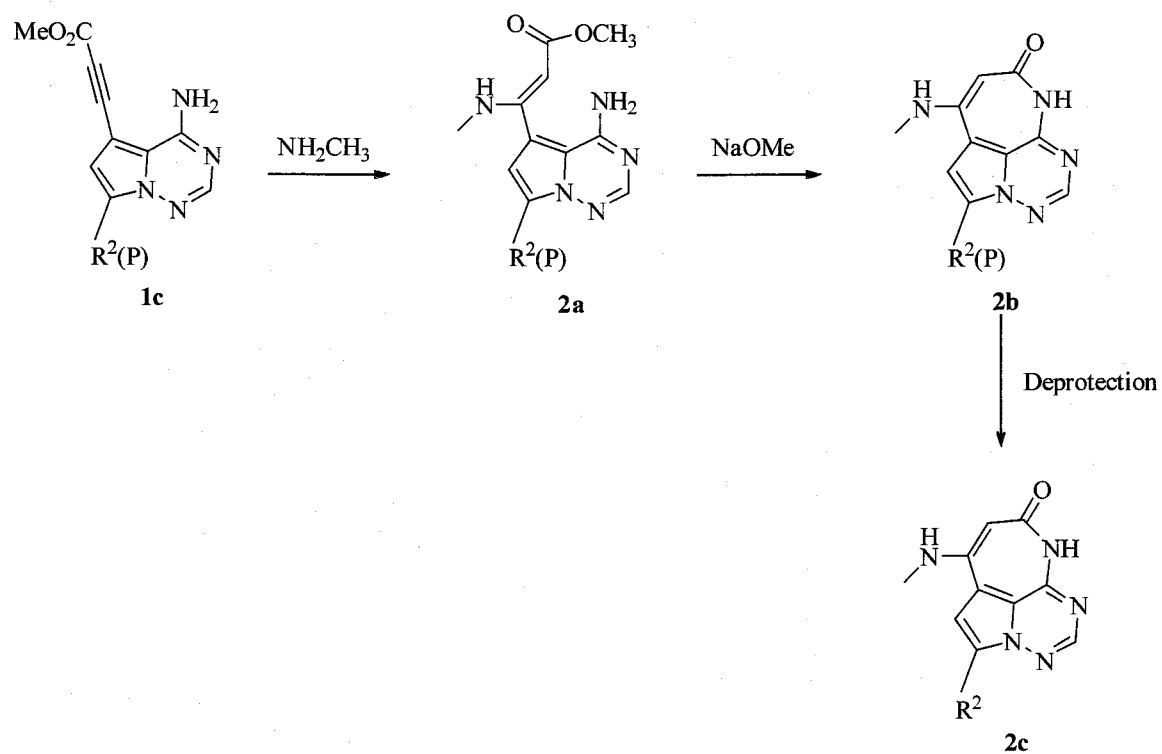
Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = NH_2$, $Z^1 = H$, $R^1 = H$ (**1f**)



5

Scheme 2

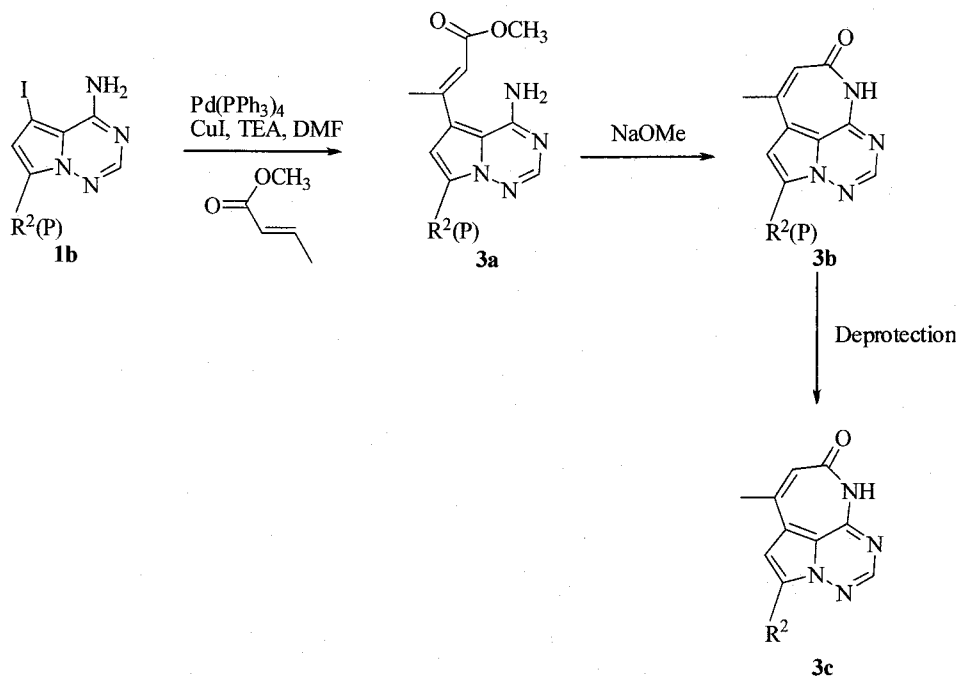
Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = NHCH_3$, $Z^1 = H$, $R^1 = H$ (**2c**)



10

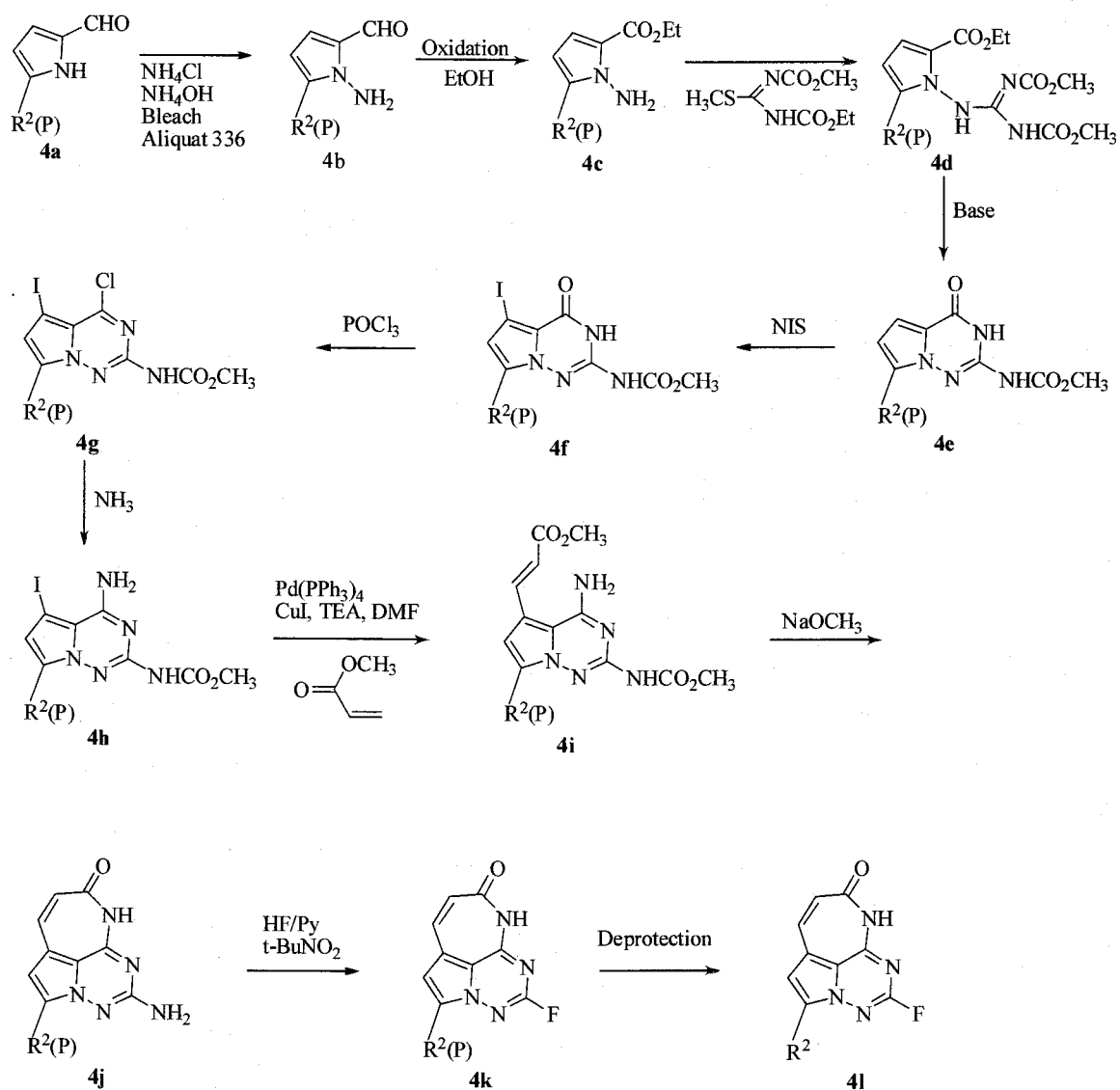
Scheme 3

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = CH_3$, $Z^1 = H$, $R^1 = H$ (**3c**)



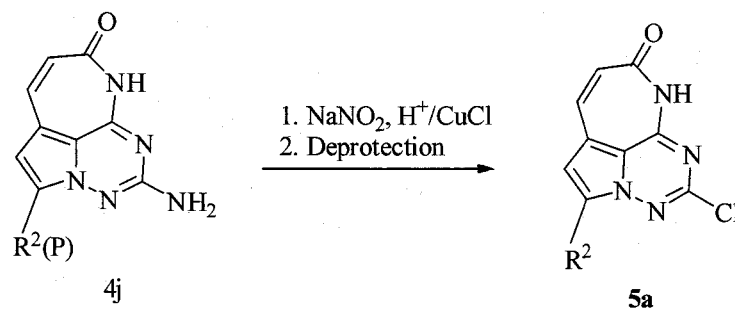
Scheme 4

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = Z^1 = H$, $R^1 = F$ (**4l**)



Scheme 5

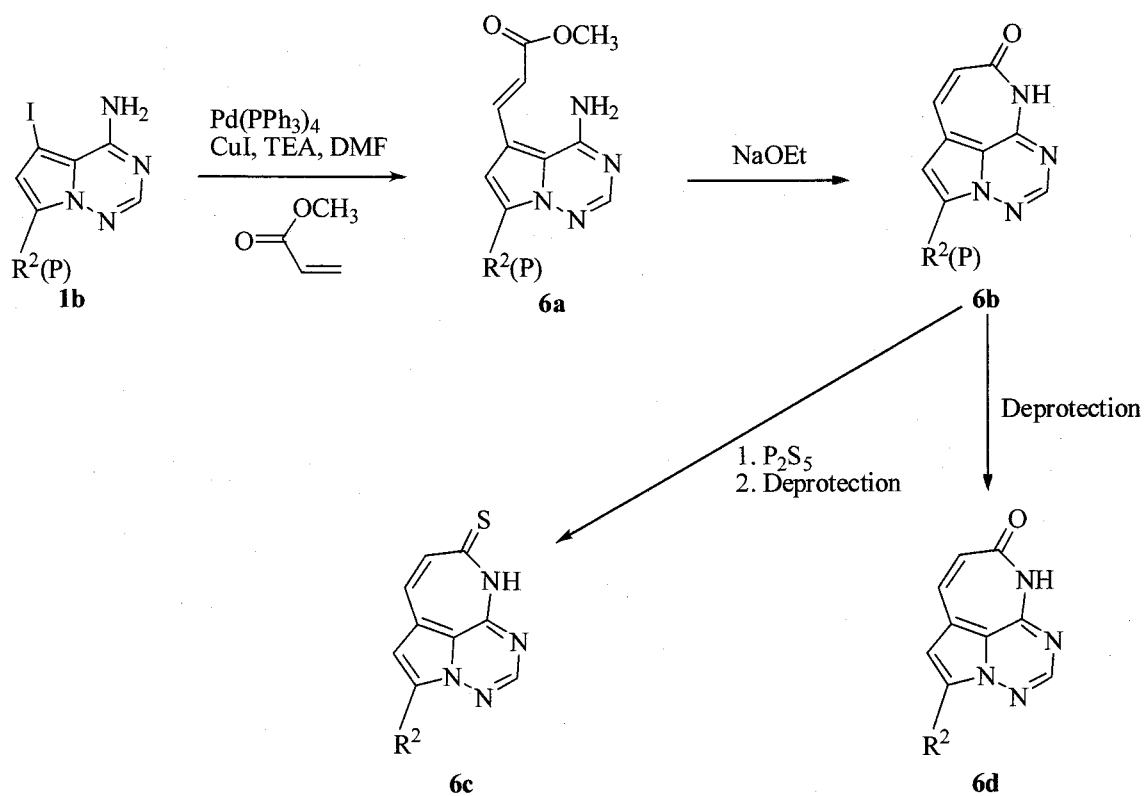
Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = Z^1 = H$, $R^1 = Cl$ (**5a**)



5

Scheme 6

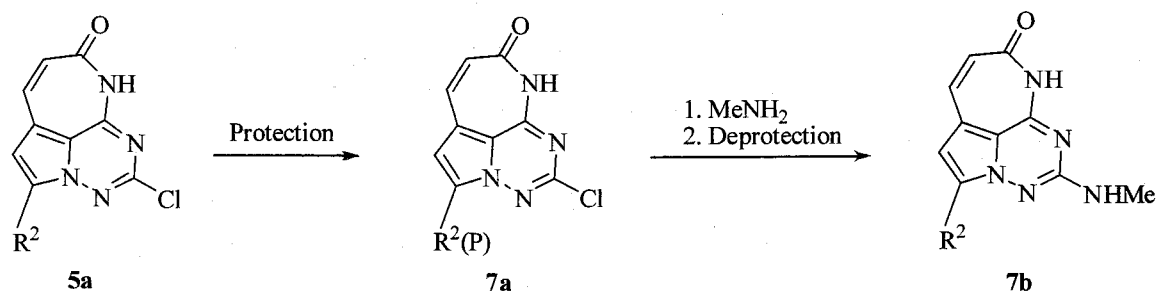
Synthesis of a compound of formula 1; where $X^1 = S$ or O , $Y^1 = Z^1 = H$, $R^1 = H$ (**6c** and **6d**)



10

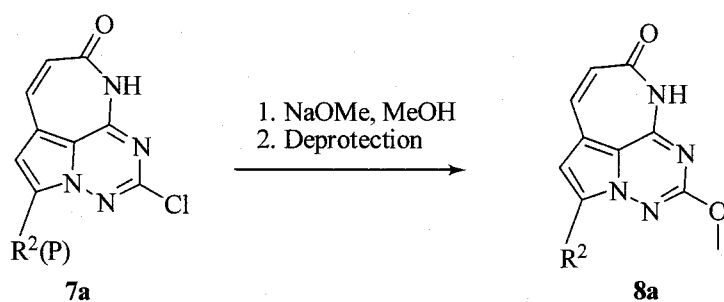
Scheme 7

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = Z^1 = H$, $R^1 = NHMe$ (7b)



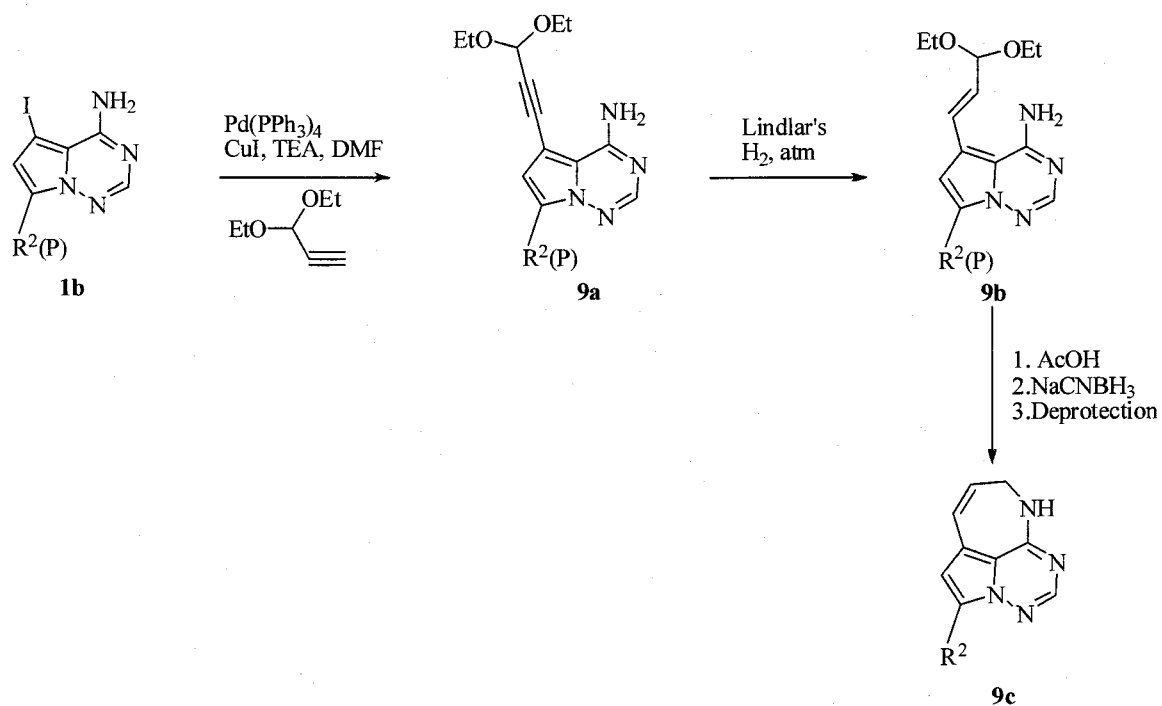
Scheme 8

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = Z^1 = H$, $R^1 = OCH_3$ (8a)



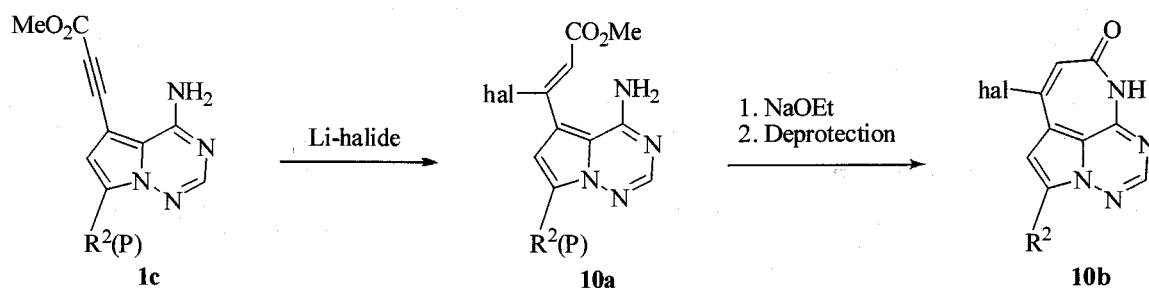
Scheme 9

Synthesis of a compound of formula 1; where $X^1 = \text{two hydrogens}$, $Y^1 = Z^1 = H$, $R^1 = H$ (9c)

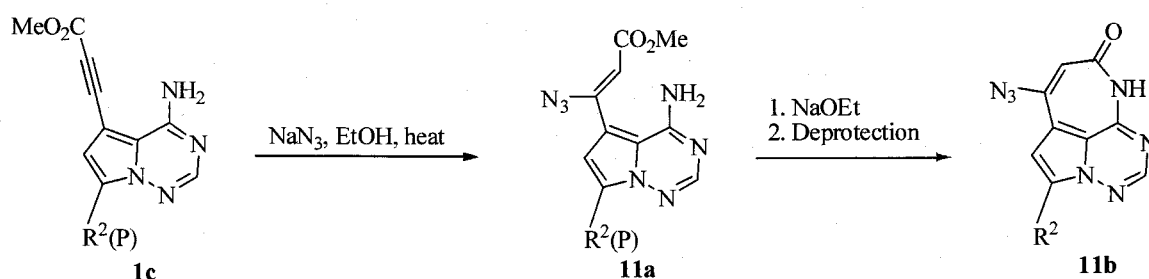


Scheme 10

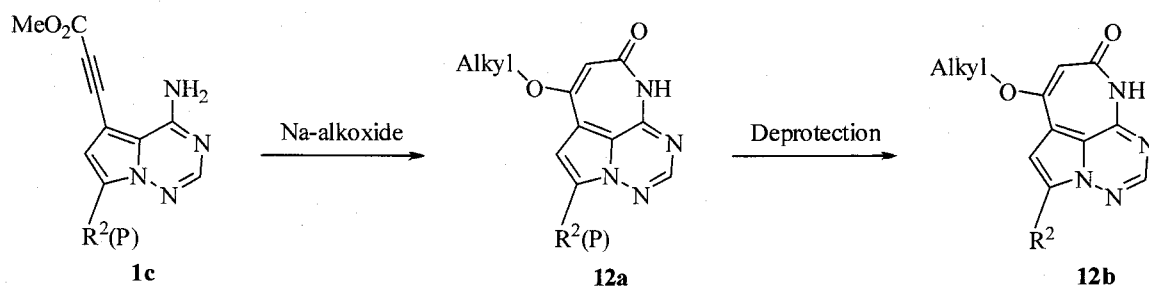
Synthesis of a compound of formula 1; where $X^1 = O$, $Z^1 = H$, $Y^1 = \text{hal} = \text{halogen}$, $R^1 = H$ (**10b**)

**Scheme 11**

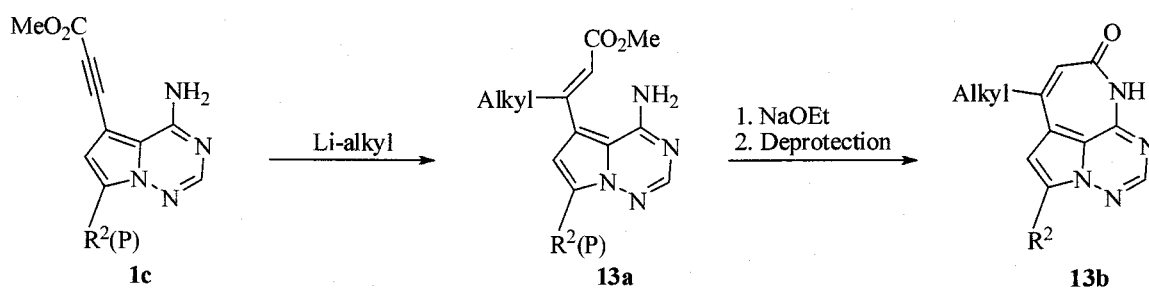
Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = N_3$, $Z^1 = H$, $R^1 = H$ (**11b**)

**Scheme 12**

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = O\text{-alkyl}$, $Z^1 = H$, $R^1 = H$ (**12b**)

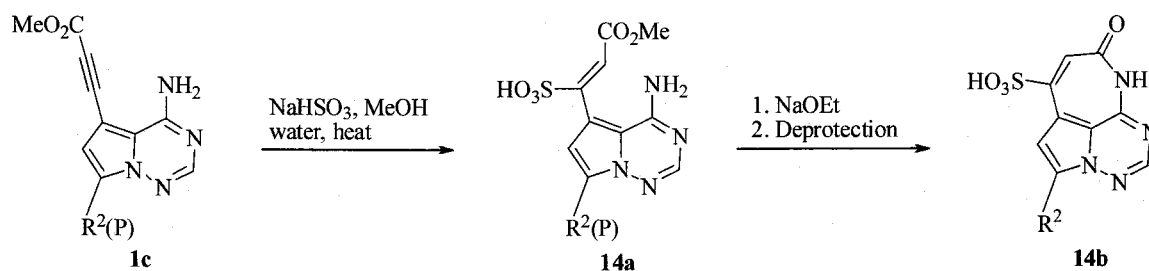
**Scheme 13**

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = \text{alkyl}$, $Z^1 = H$, $R^1 = H$ (**13b**)



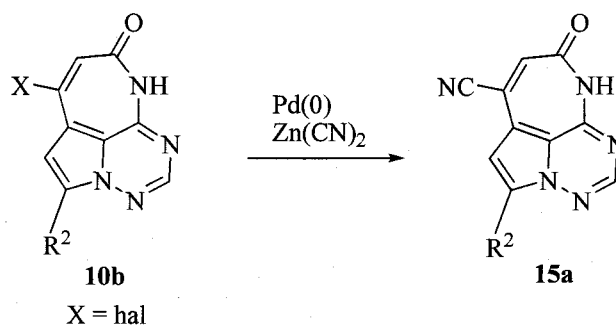
Scheme 14

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = SO_3H$, $Z^1 = H$, $R^1 = H$ (**14b**)



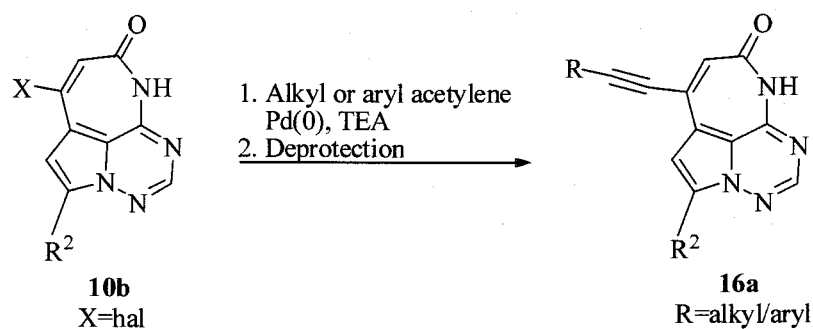
Scheme 15

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = CN$, $Z^1 = H$, $R^1 = H$ (**15a**)



Scheme 16

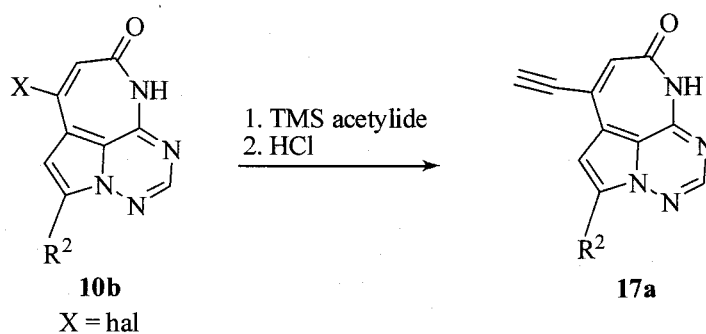
Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = C \equiv CR$, $Z^1 = H$, $R = \text{alkyl or aryl}$, $R^1 = H$ (**16a**)



Scheme 17

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = C \equiv CH$, $Z^1 = H$, $R^1 = H$ (**17a**)

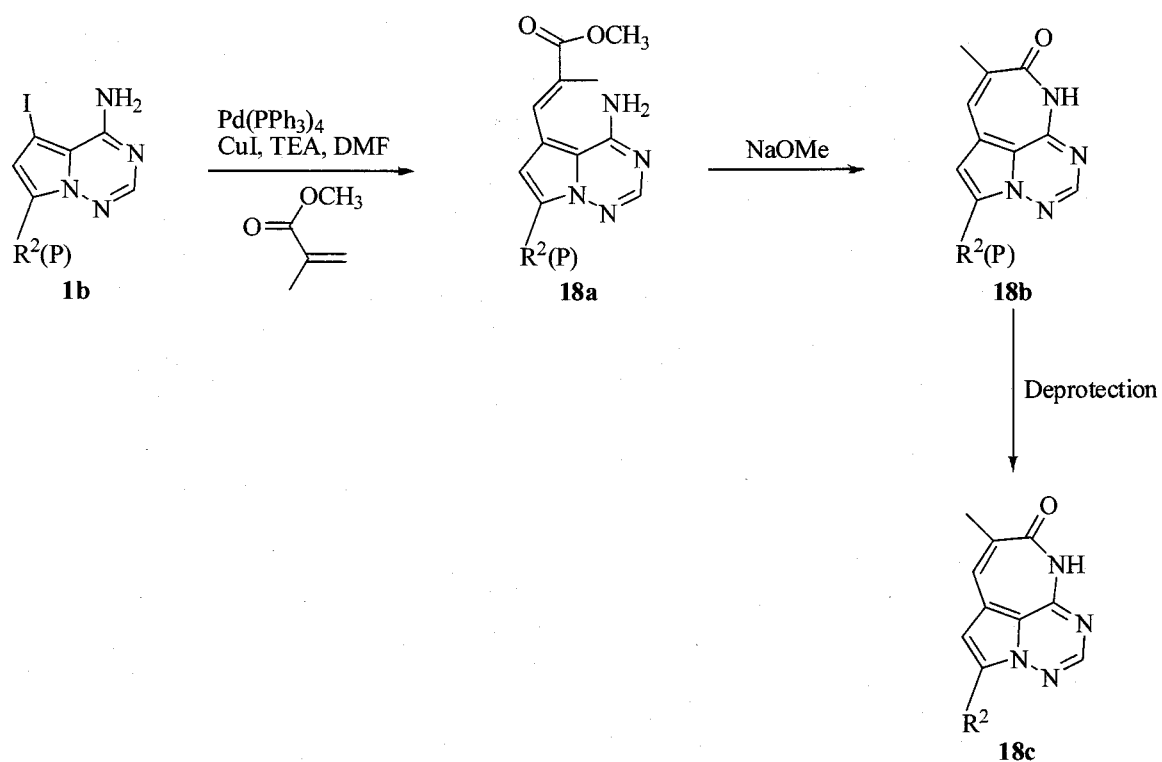
20



Scheme 18

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = H$, $Z^1 = CH_3$, $R^1 = H$ (**18c**)

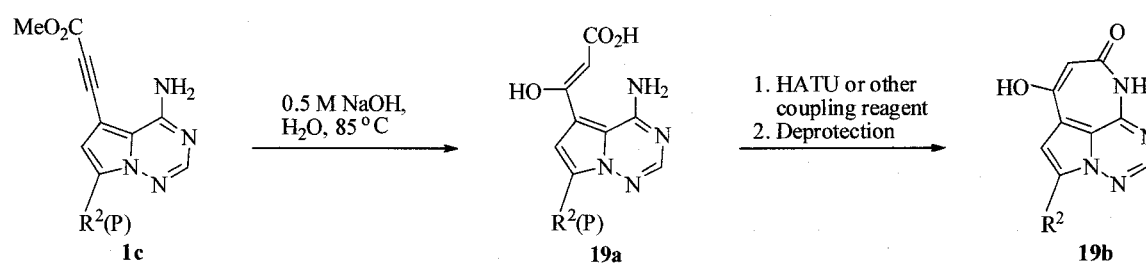
5



Scheme 19

Synthesis of a compound of formula 1; where $X^1 = O$, $Y^1 = OH$, $Z^1 = H$, $R^1 = H$ (**19b**)

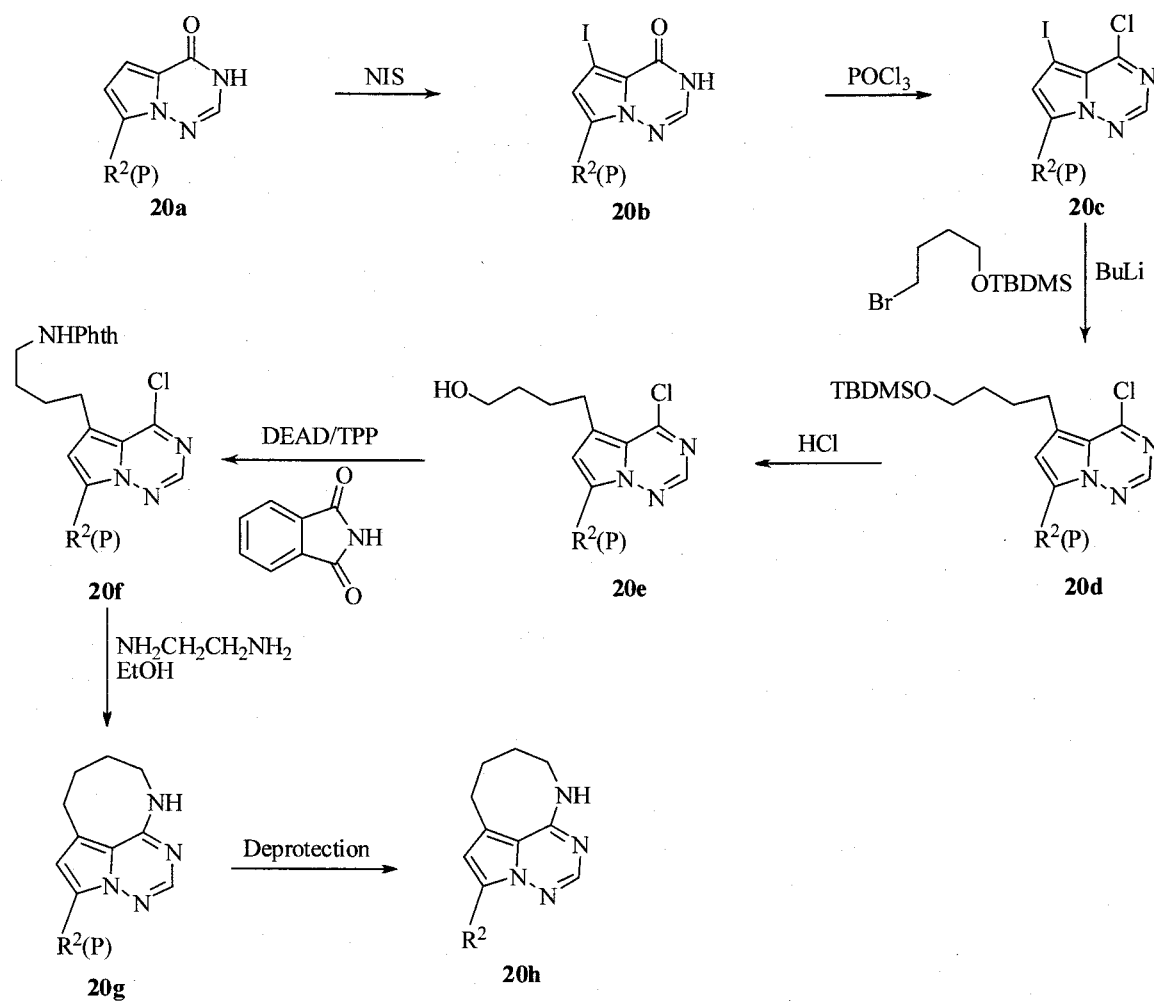
10



Scheme 20

Synthesis of a compound of formula 2; where X^2 = two hydrogens, $Y^2 = Z^2 = H$, $t = 2$, $R^1 = H$
(20h)

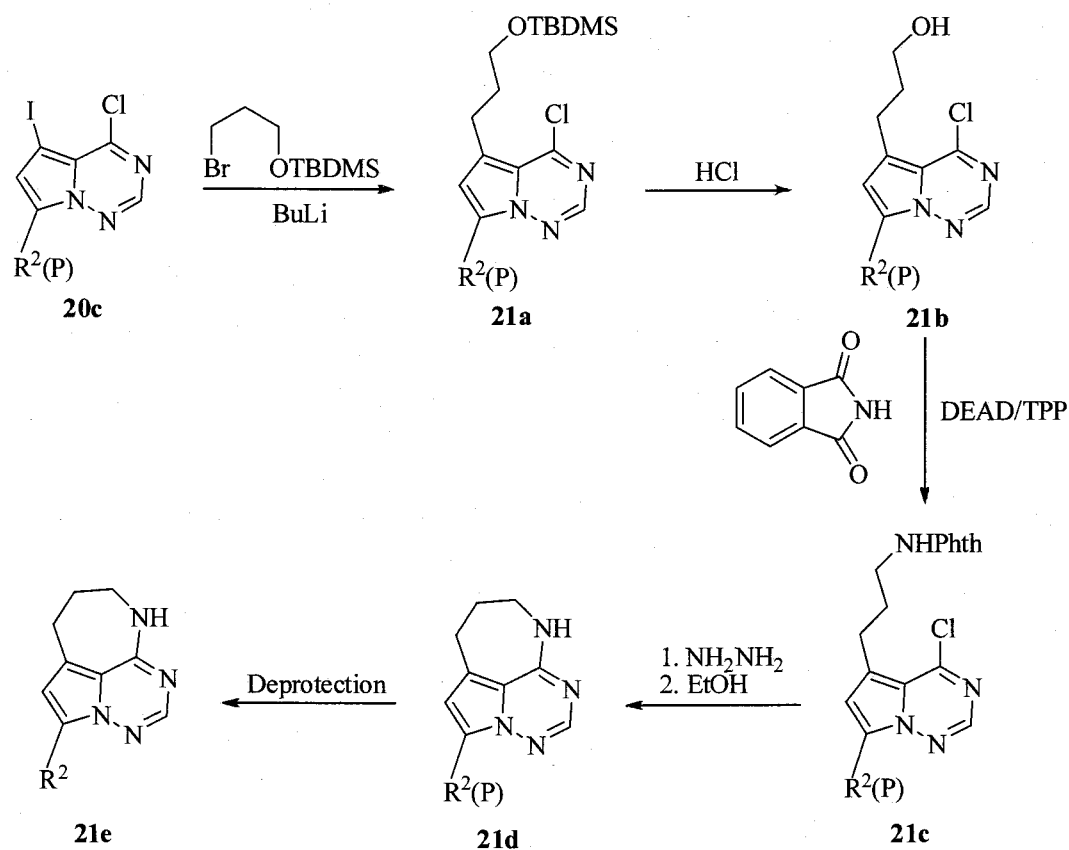
5



Scheme 21

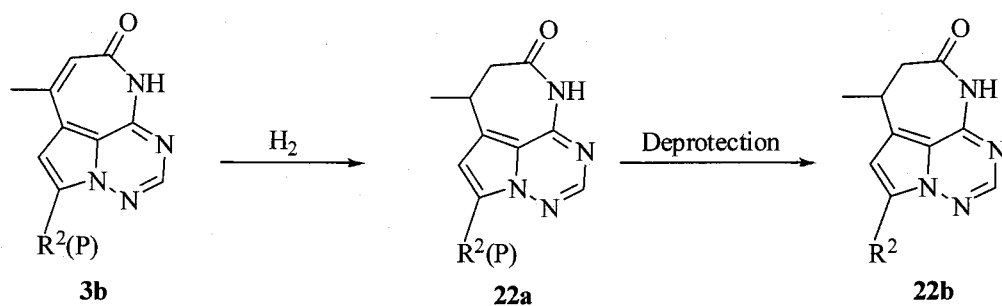
Synthesis of a compound of formula 2; where X^2 = two hydrogens, $Y^2 = Z^2 = H$, $t = 1$, $R^1 = H$
(21e)

10



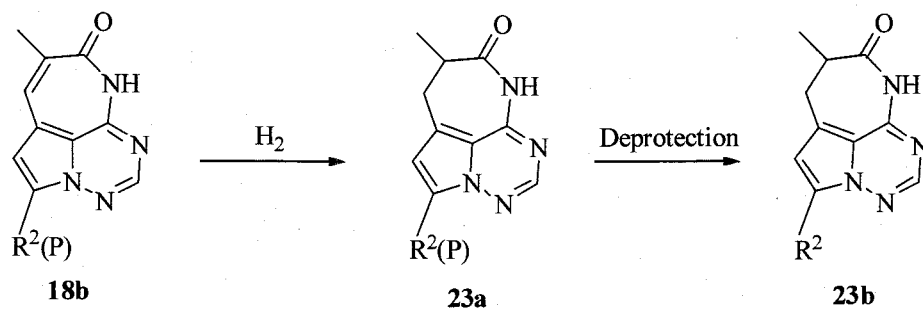
Scheme 22

5 Synthesis of a compound of formula 2; where $X^2 = \text{O}$, $Y^2 = \text{CH}_3$, $Z^2 = \text{H}$, $t = 1$, $R^1 = \text{H}$ (**22b**)



Scheme 23

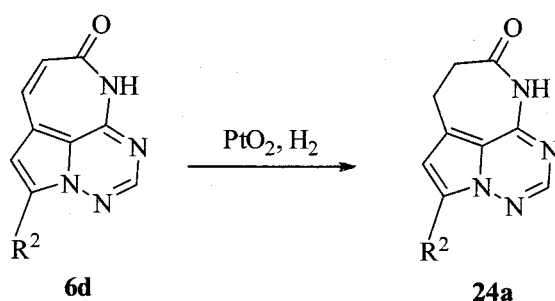
Synthesis of a compound of formula 2; where $X^2 = O$, $Y^2 = H$, $Z^2 = CH_3$, $t = 1$, $R^1 = H$ (**23b**)



5

Scheme 24

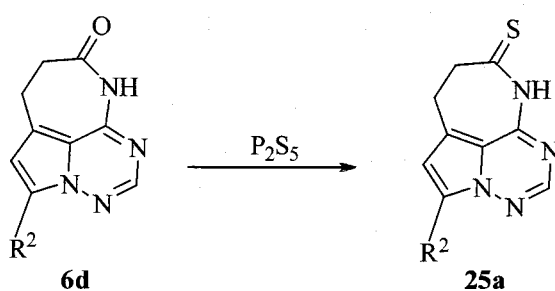
Synthesis of a compound of formula 2; where $X^2 = O$, $Y^2 = Z^2 = H$, $t = 1$, $R^1 = H$ (**24a**)



10

Scheme 25

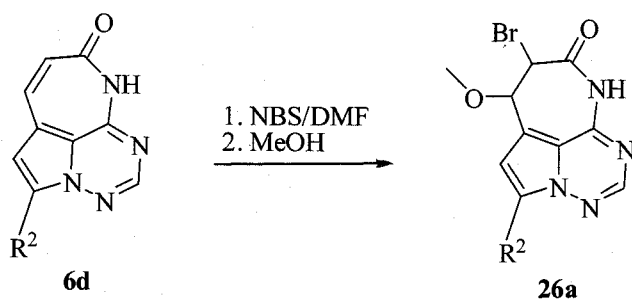
Synthesis of a compound of formula 2; where $X^2 = S$, $Y^2 = Z^2 = H$, $t = 1$, $R^1 = H$ (**25a**)



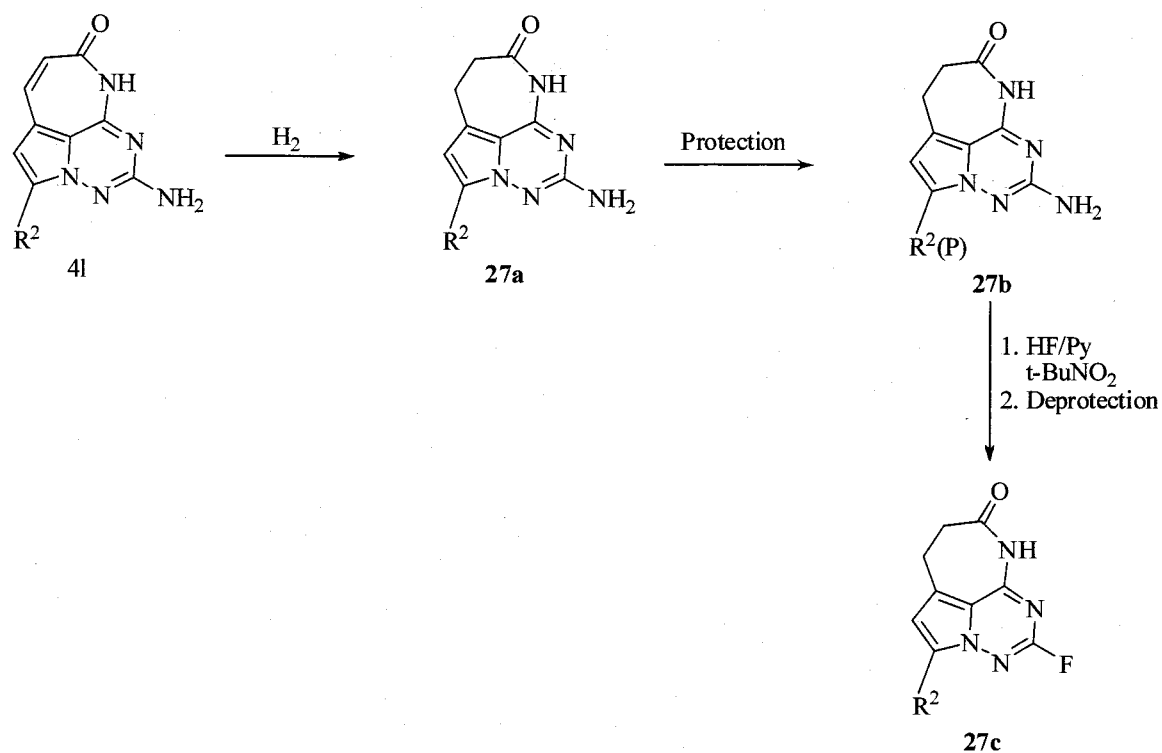
15

Scheme 26

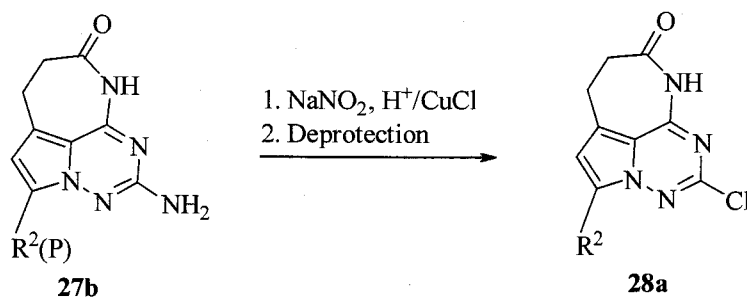
Synthesis of a compound of formula 2; where $X^2 = O$, $Y^2 = OCH_3$, $Z^2 = Br$, $t = 1$, $R^1 = H$ (**26a**)

**Scheme 27**

Synthesis of a compound of formula 2; where $X^2 = O$, $Y^2 = Z^2 = H$, $t = 1$, $R^1 = F$ (**27c**)

**Scheme 28**

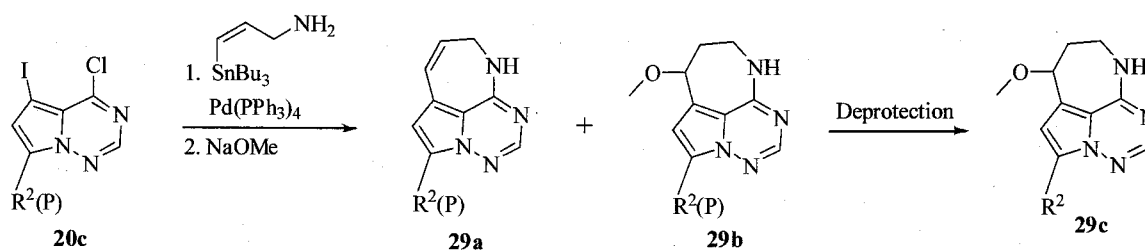
Synthesis of a compound of formula 2; where $X^2 = O$, $Y^2 = Z^2 = H$, $t = 1$, $R^1 = Cl$ (**28a**)



Scheme 29

Synthesis of a compound of formula 2; where X^2 = two hydrogens, Y^2 = OCH₃, Z^2 = H, t = 1, R^1 = H (29c)

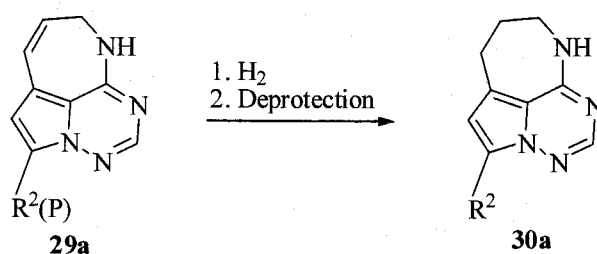
5



Scheme 30

Synthesis of a compound of formula 2; where X^2 = two hydrogens, Y^2 = Z^2 = H, t = 1, R^1 = H (30a)

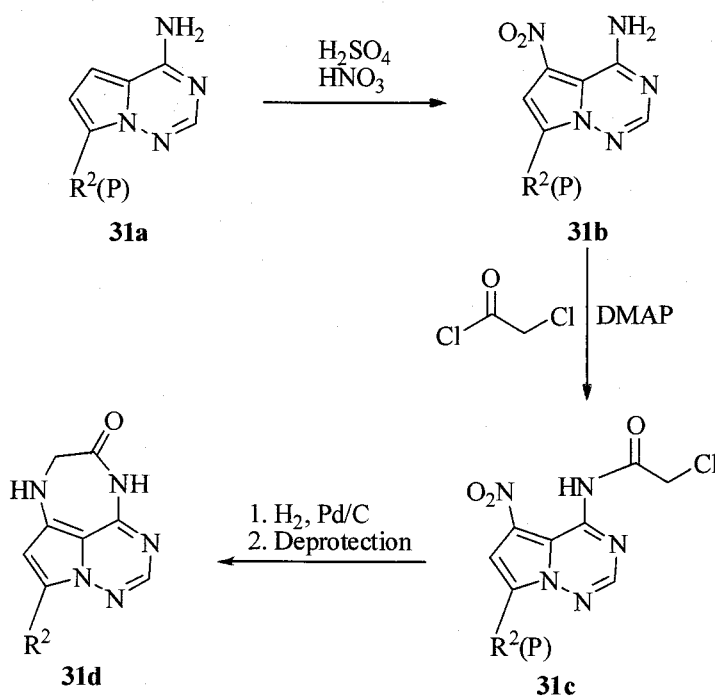
10



Scheme 31

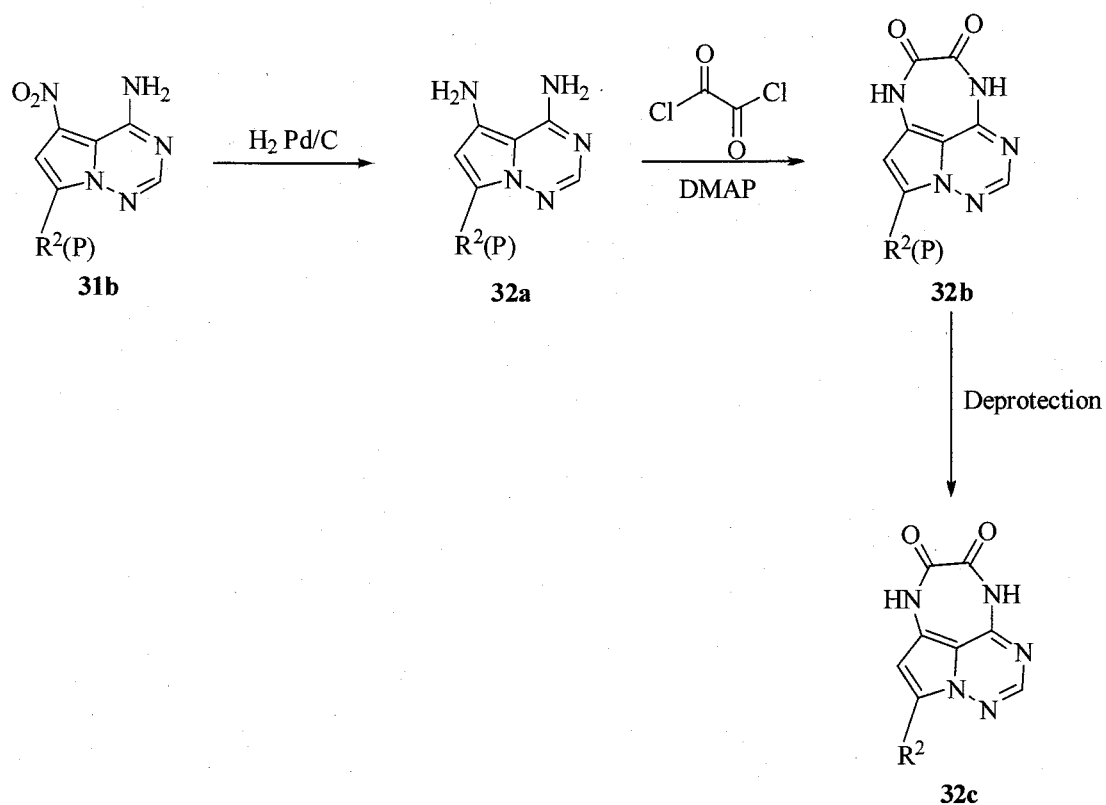
15

Synthesis of a compound of formula 4; where X^4 = O, Y^4 = two hydrogens, R^1 = H (31d)



Scheme 32

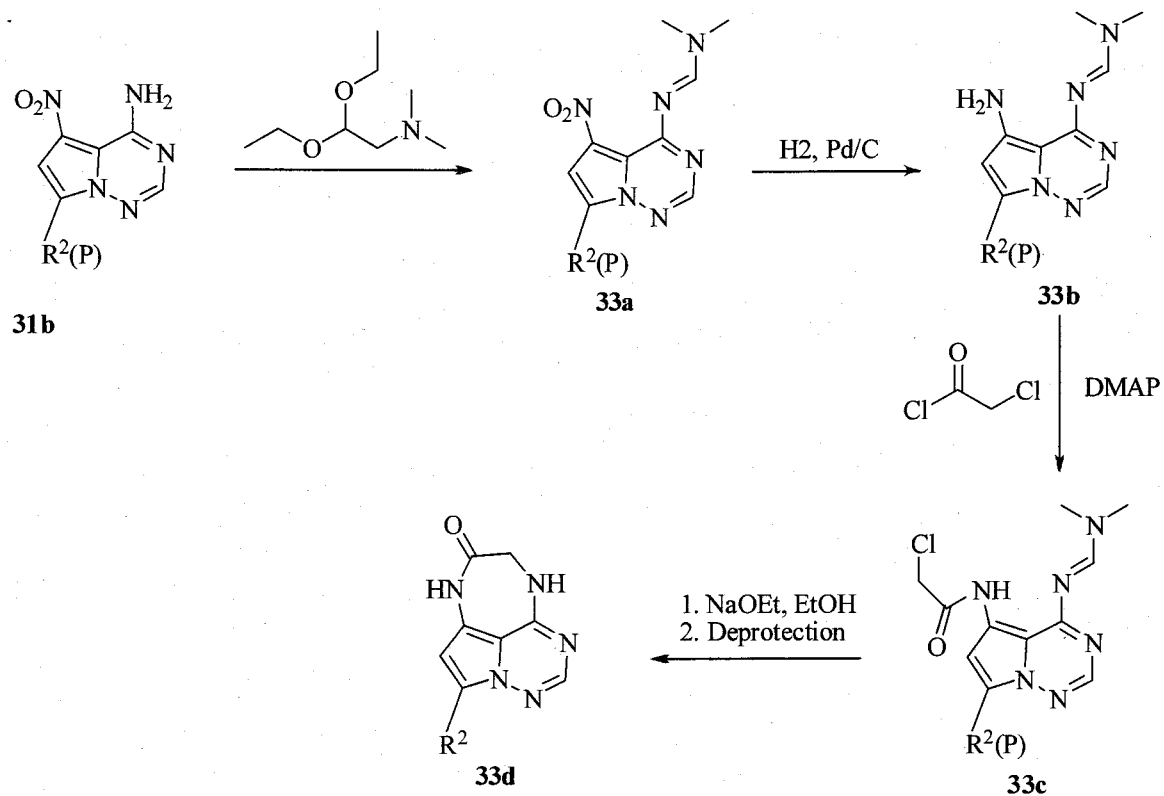
Synthesis of a compound of formula 4; where $X^4 = Y^4 = O$, $R^1 = H$ (**32c**)



5

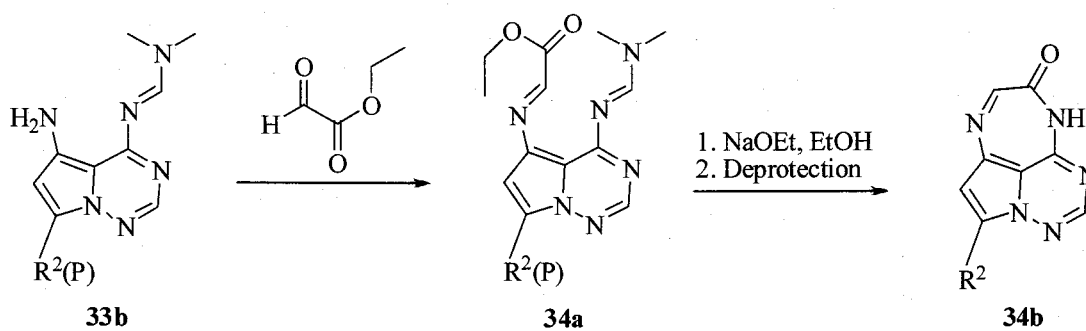
Scheme 33

Synthesis of a compound of formula 4; where $X^4 = \text{two hydrogens}$, $Y^4 = O$, $R^1 = H$ (**33d**)



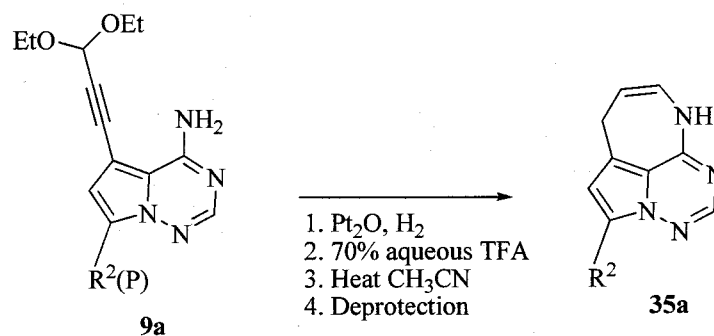
Scheme 34

5

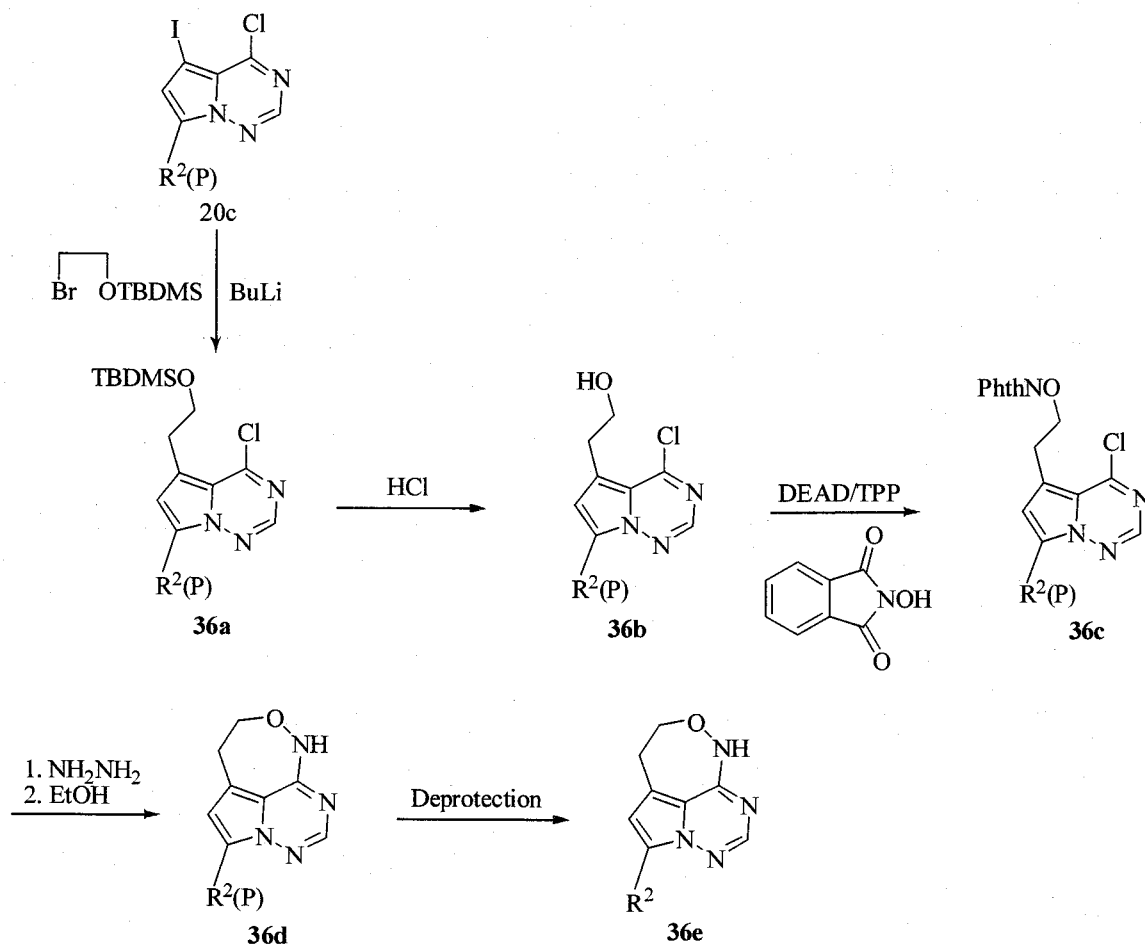
Synthesis of a compound of formula 5; where $X^5 = \text{O}$, $R^1 = \text{H}$ (**34b**)

Scheme 35

10

Synthesis of a compound of formula 6; where $R^1 = \text{H}$ (**35a**)

Scheme 36

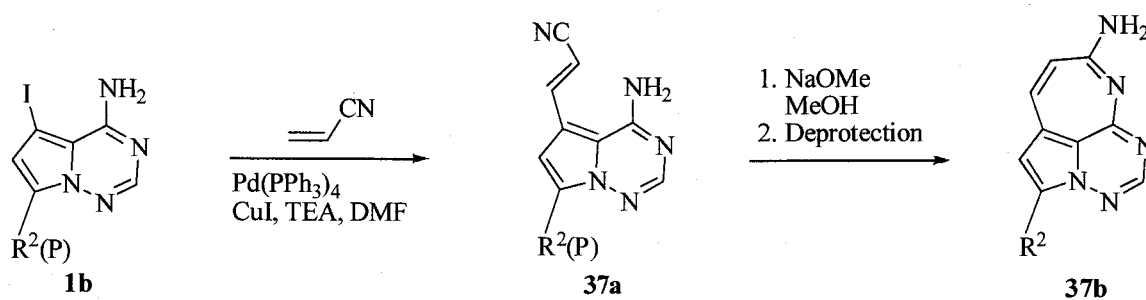
Synthesis of a compound of formula 7; where $R^1 = H$ (36e)

5

Scheme 37

Synthesis of a compound of formula 8; where $X^8 = NH_2$, $R^1 = H$ (37b)

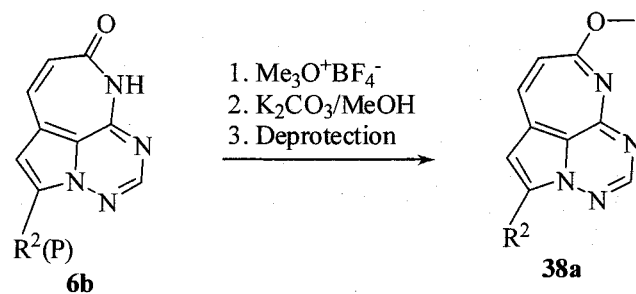
10



15

Scheme 38

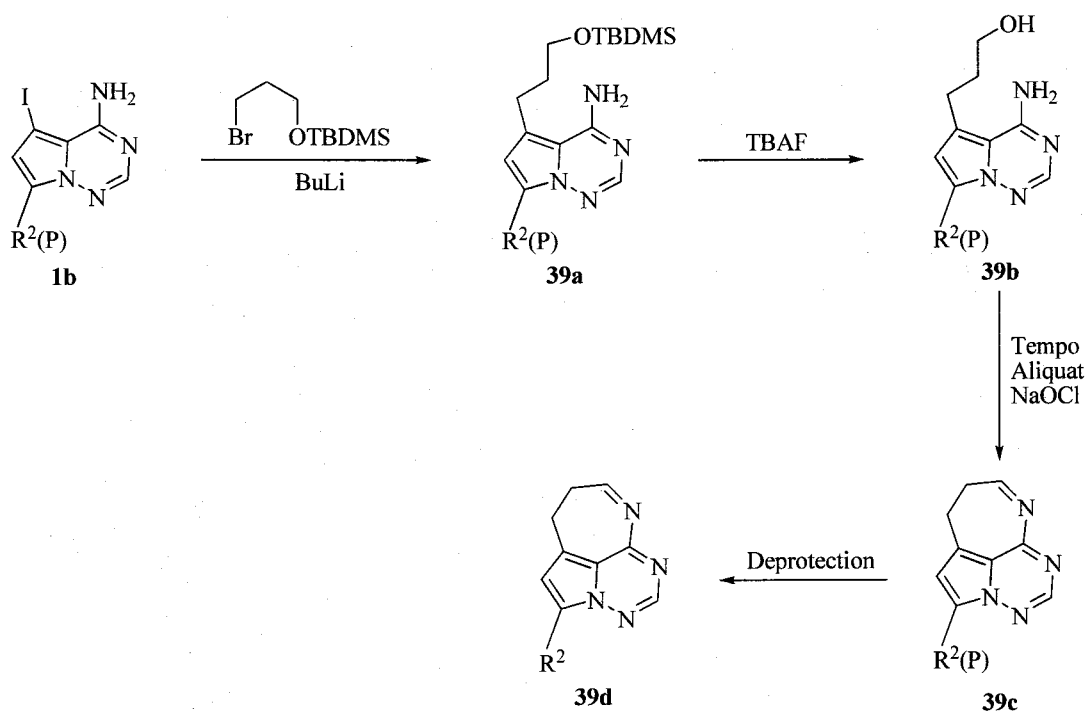
Synthesis of a compound of formula **8**; where $X^8 = \text{OCH}_3$, $R^1 = \text{H}$ (**38a**)



5

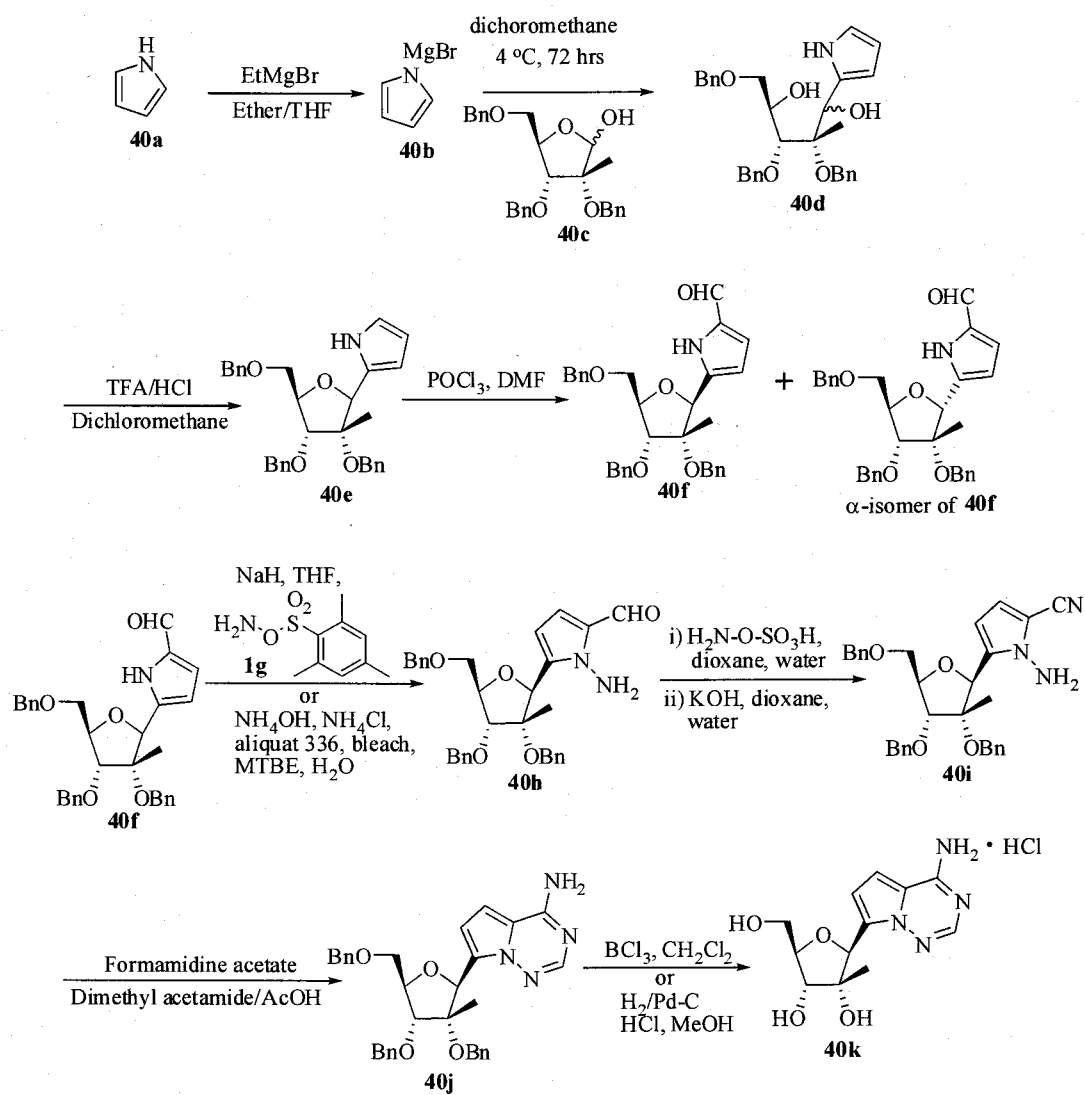
Scheme 39

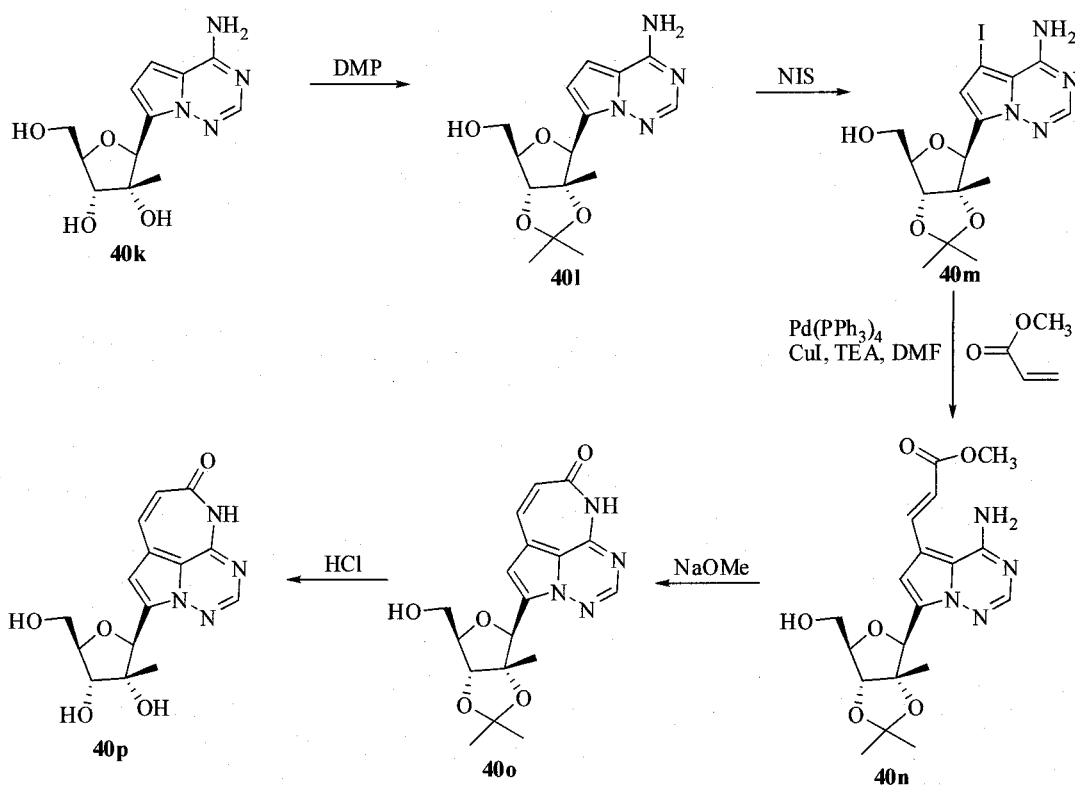
Synthesis of a compound of formula **9**; where $R^1 = \text{H}$ (**39d**)



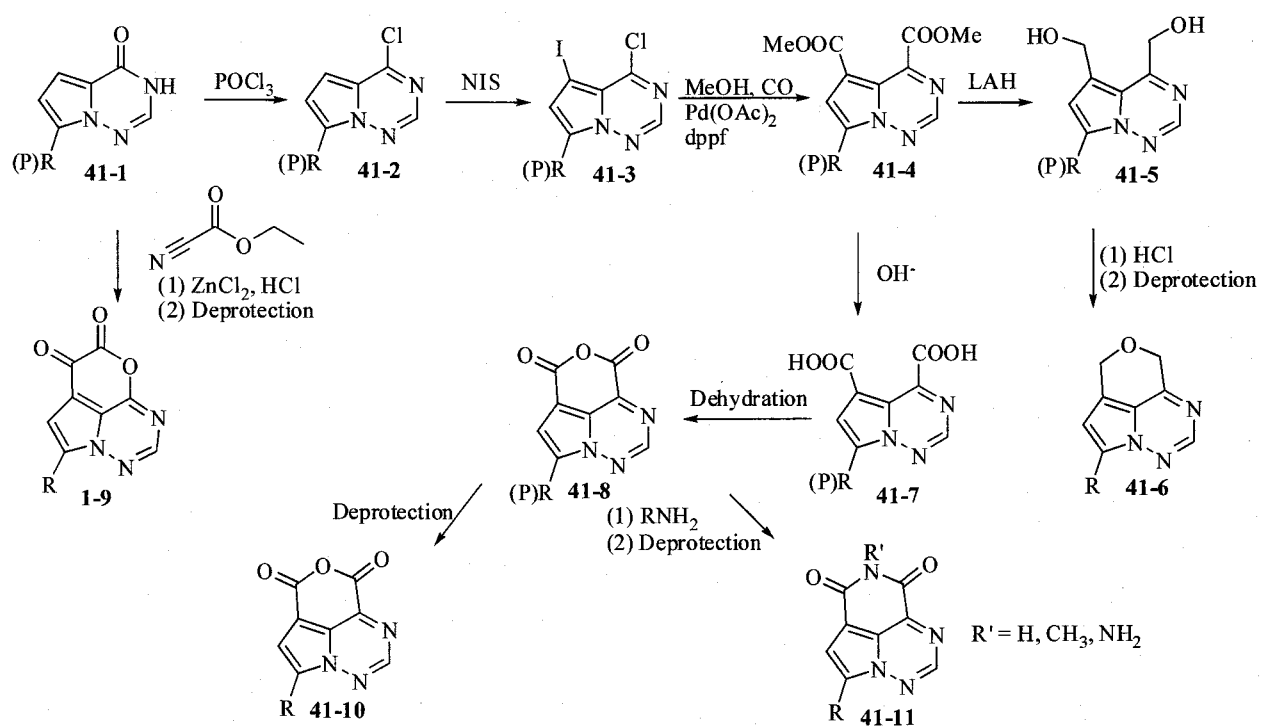
10

Scheme 40 for the Synthesis of Example 1

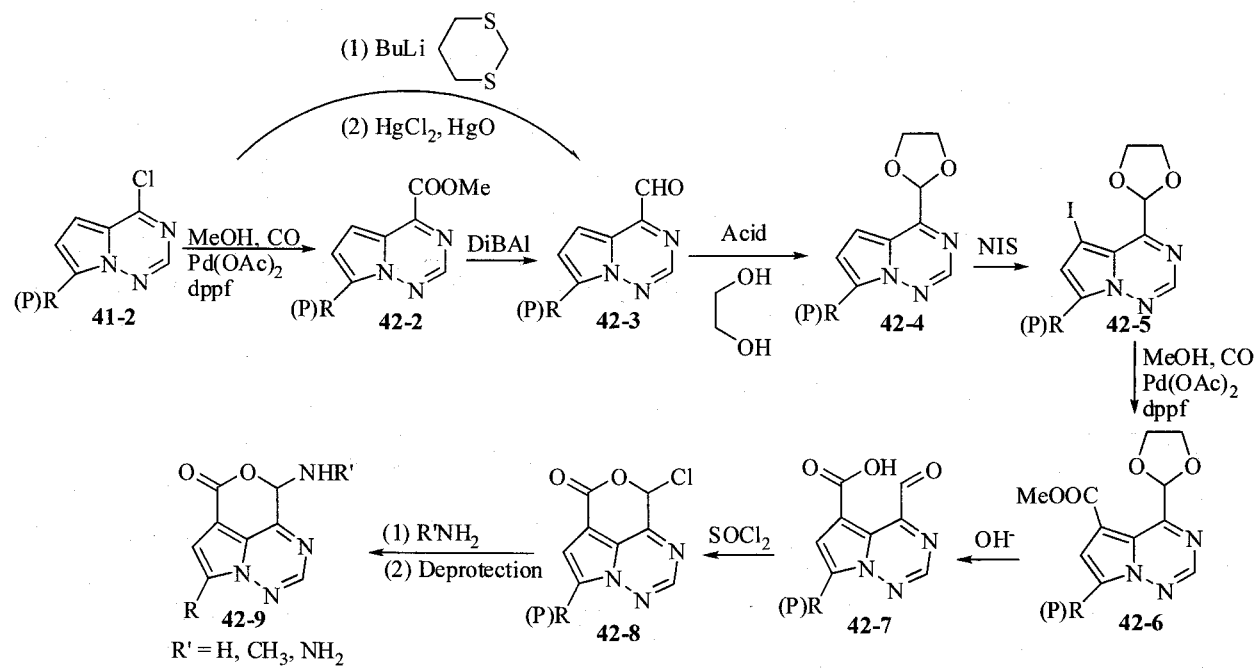




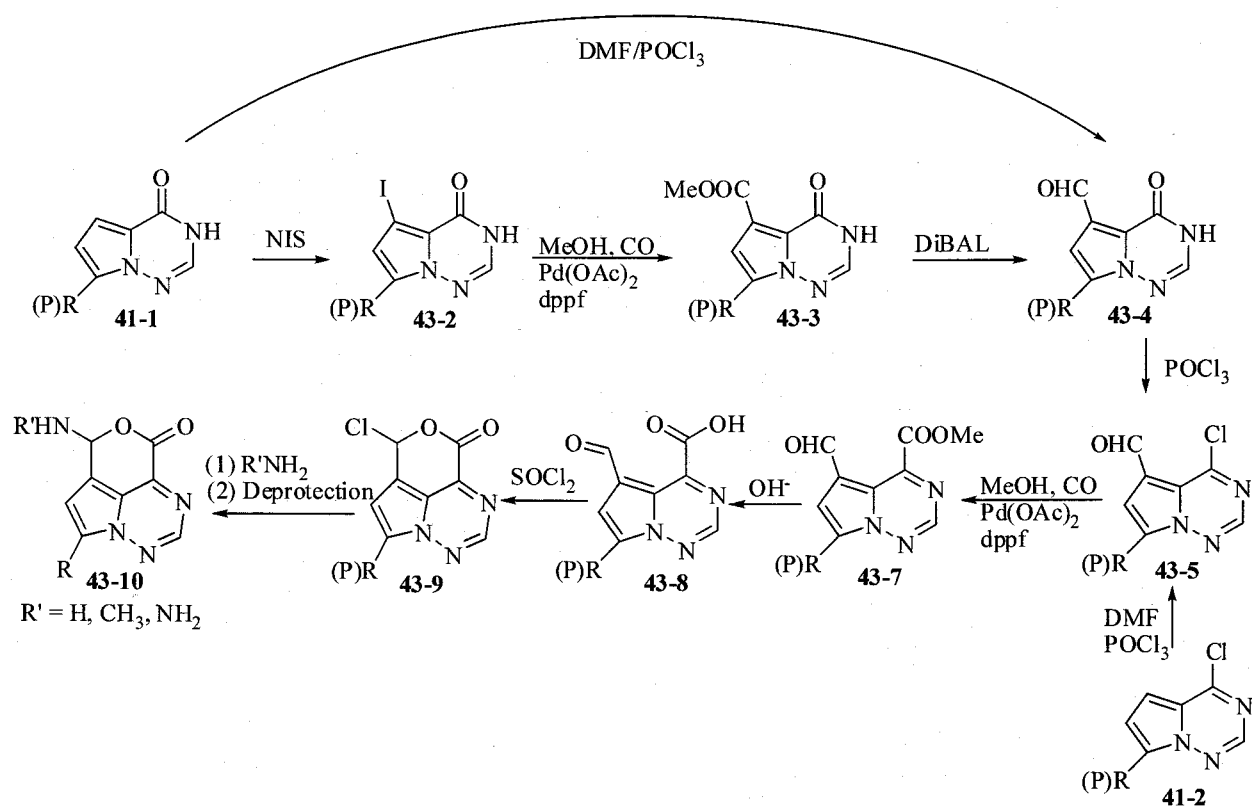
Scheme 41.



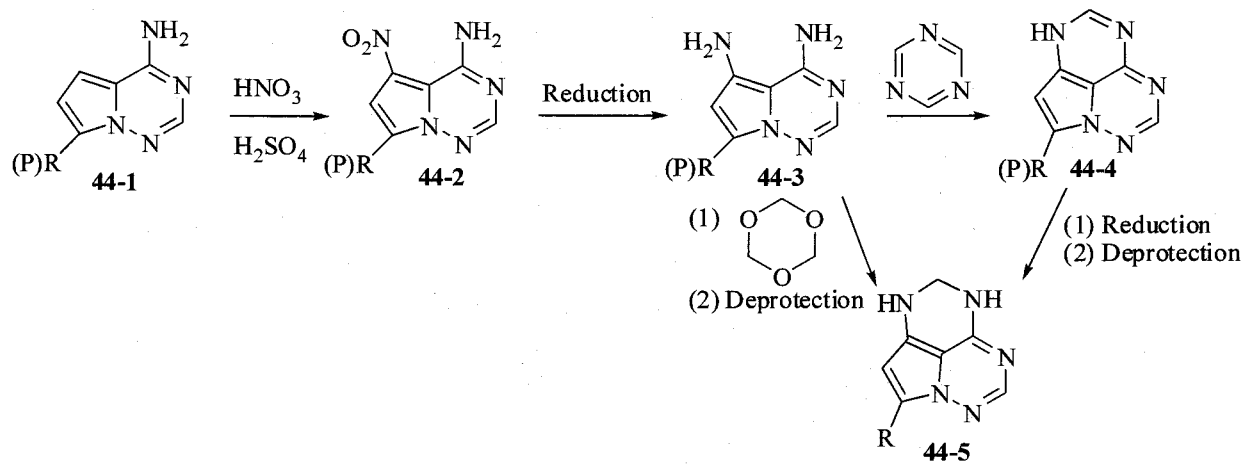
Scheme 42.



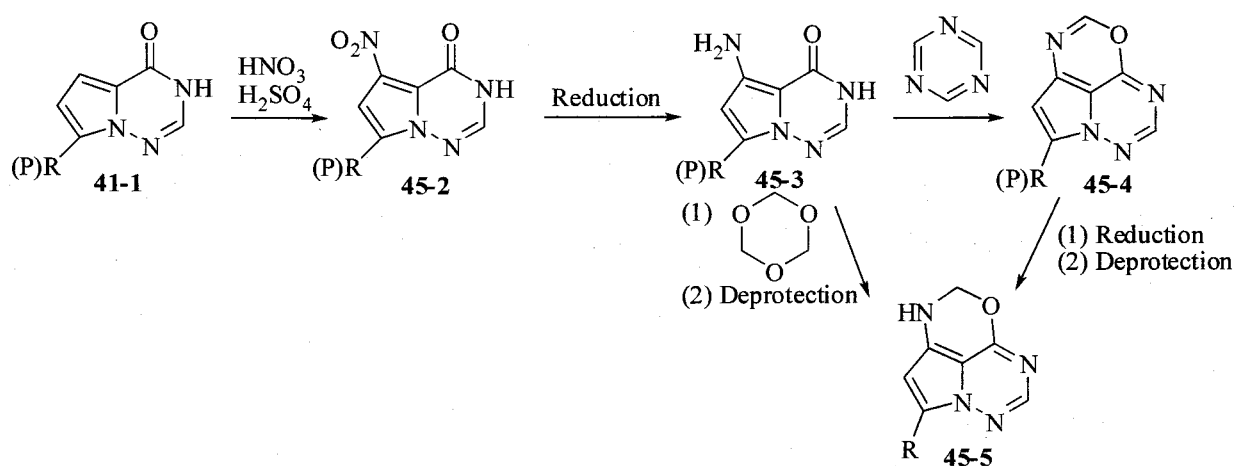
Scheme 43.



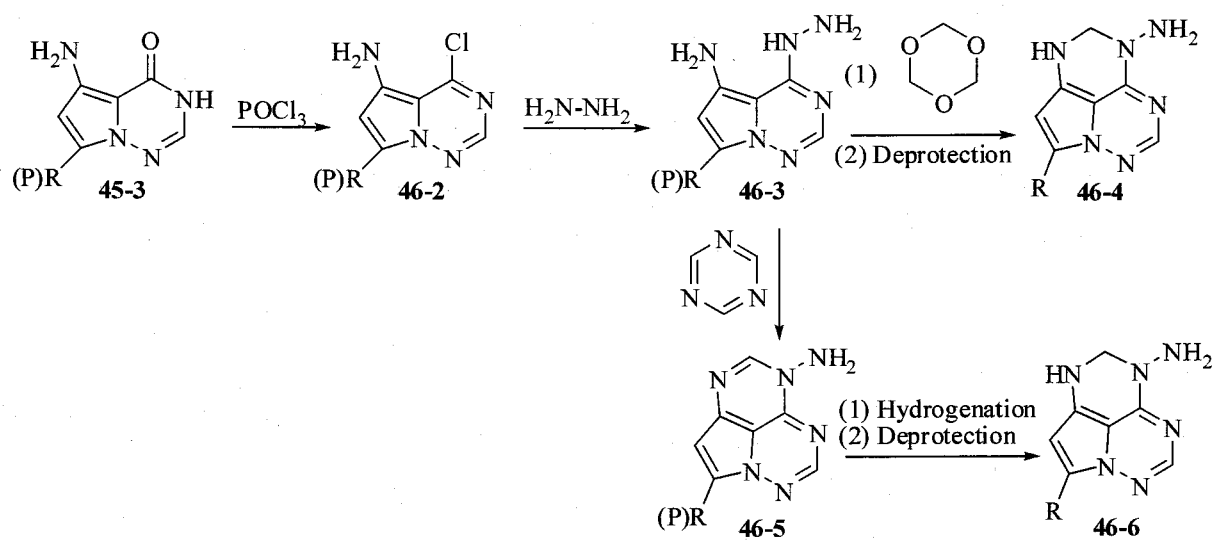
Scheme 44.



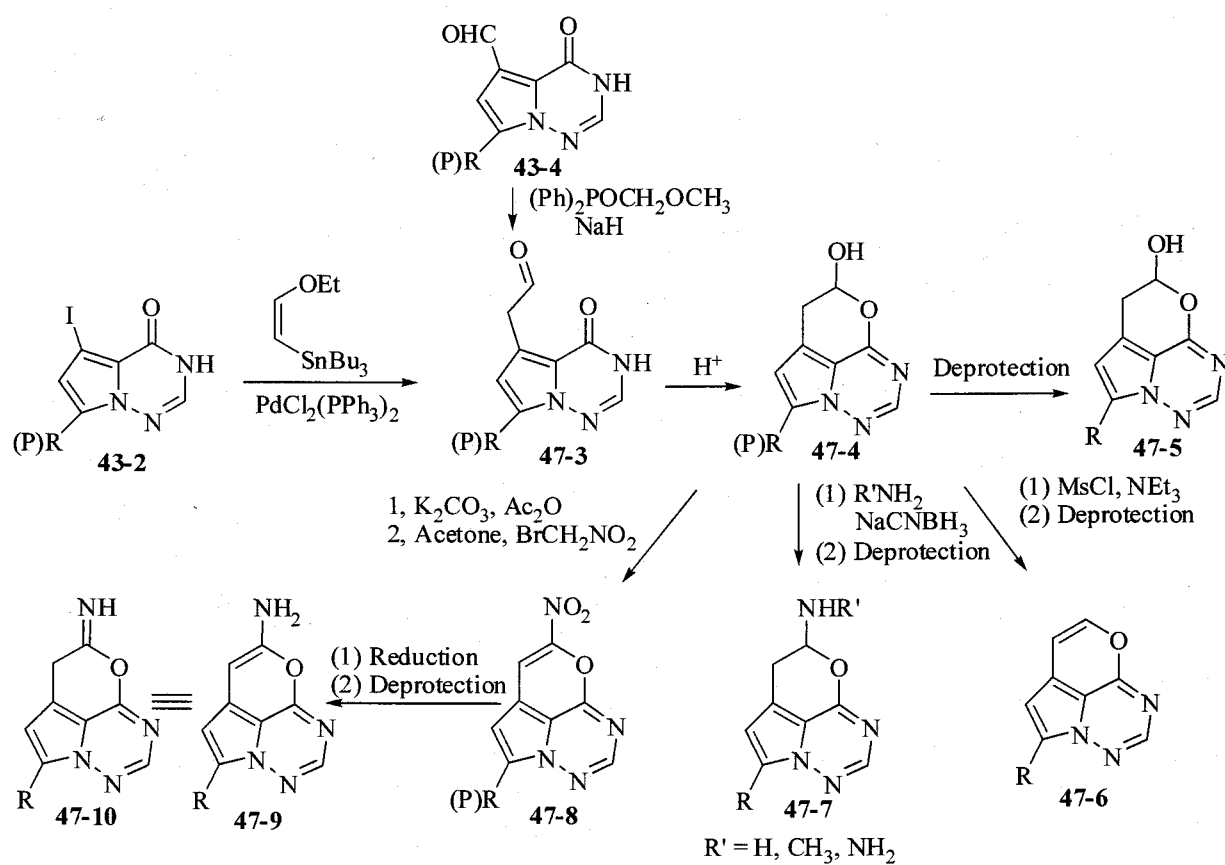
Scheme 45.



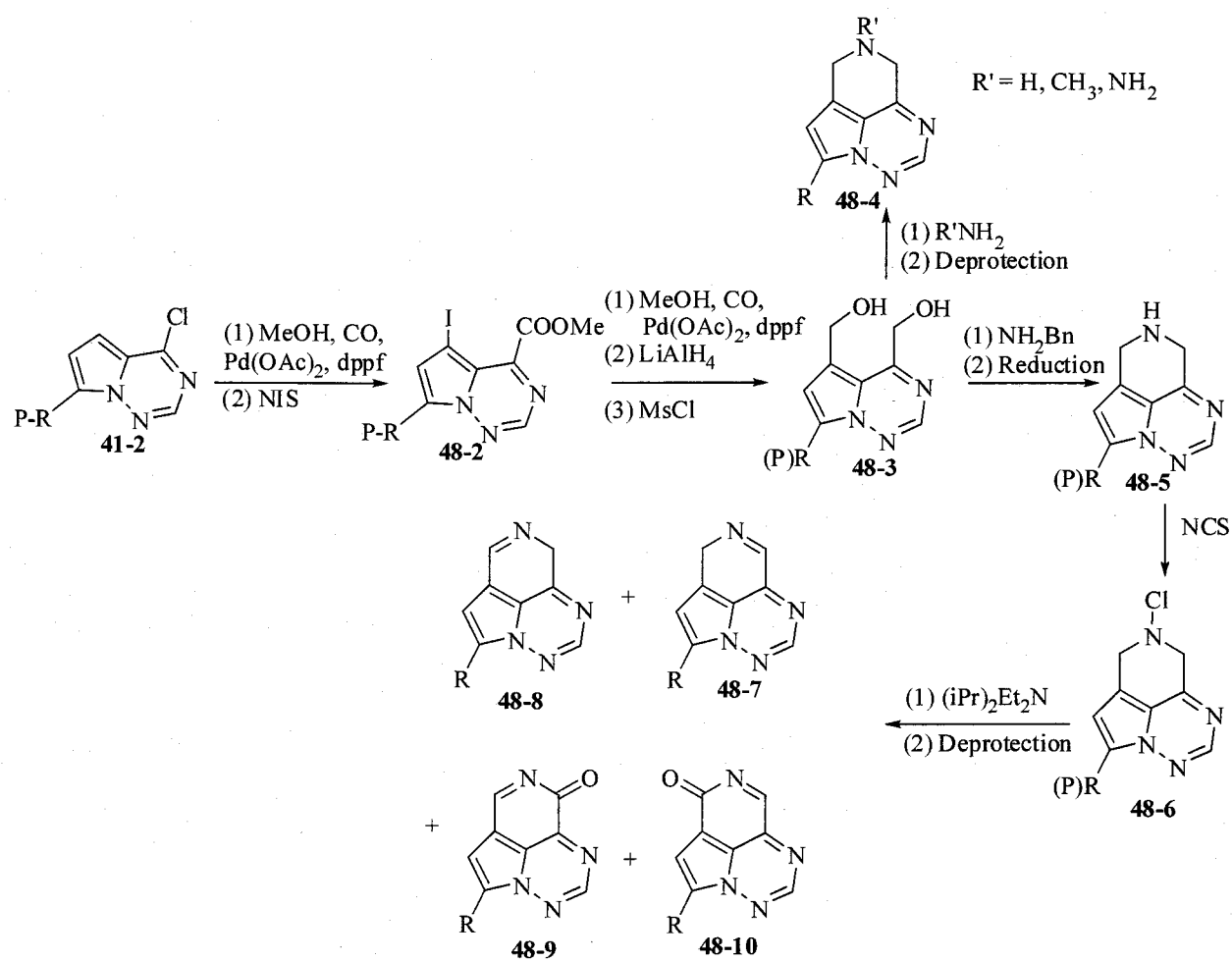
Scheme 46.



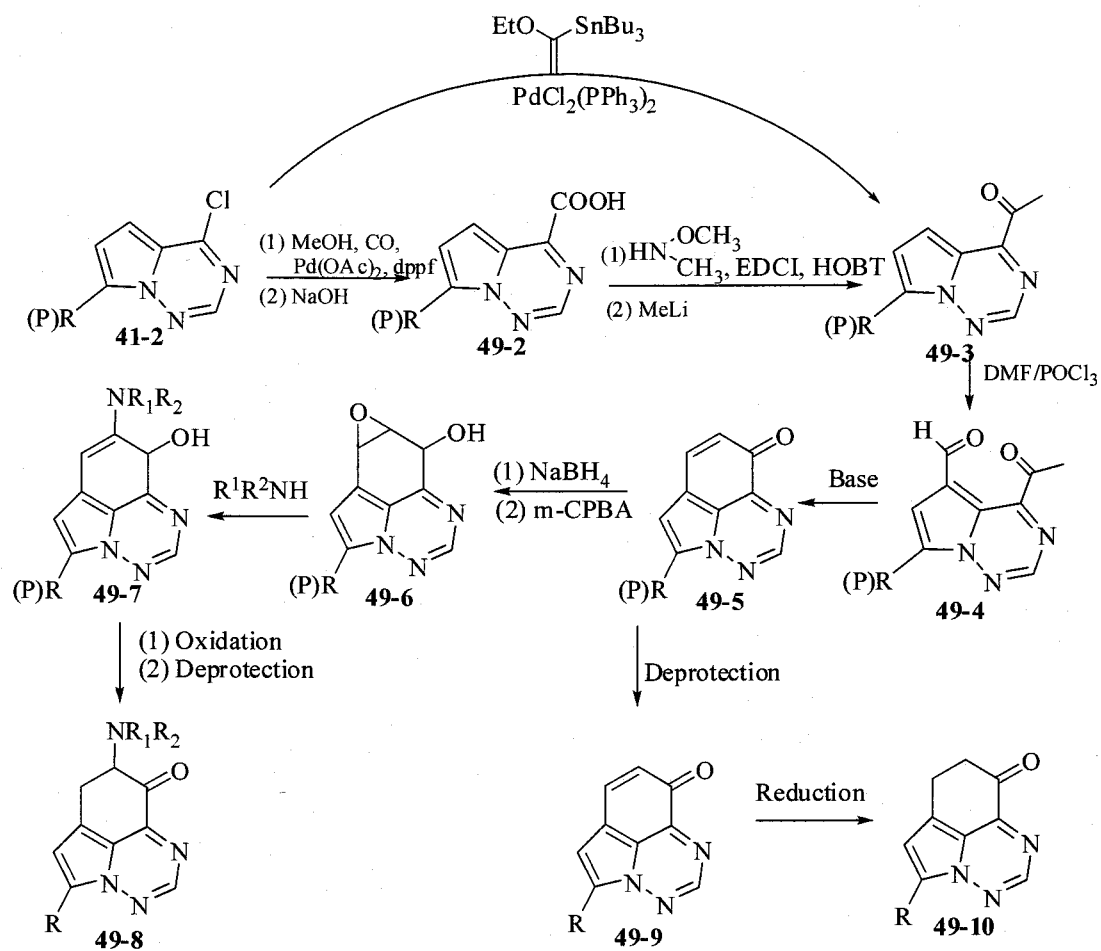
Scheme 47.



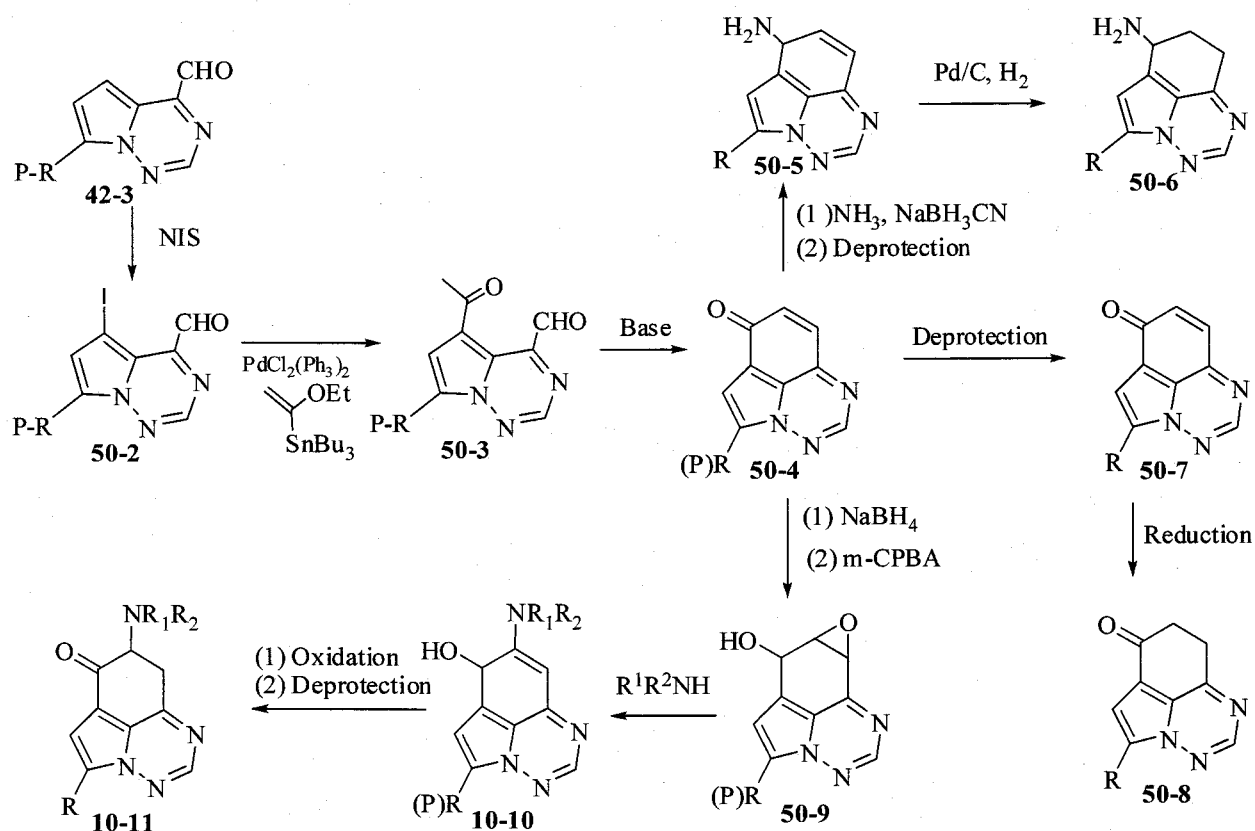
Scheme 48.



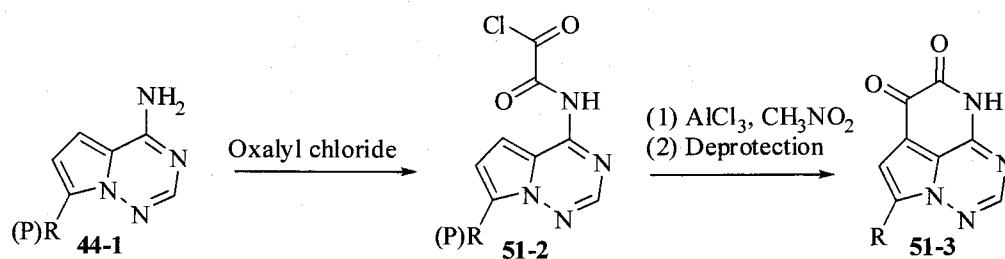
Scheme 49.



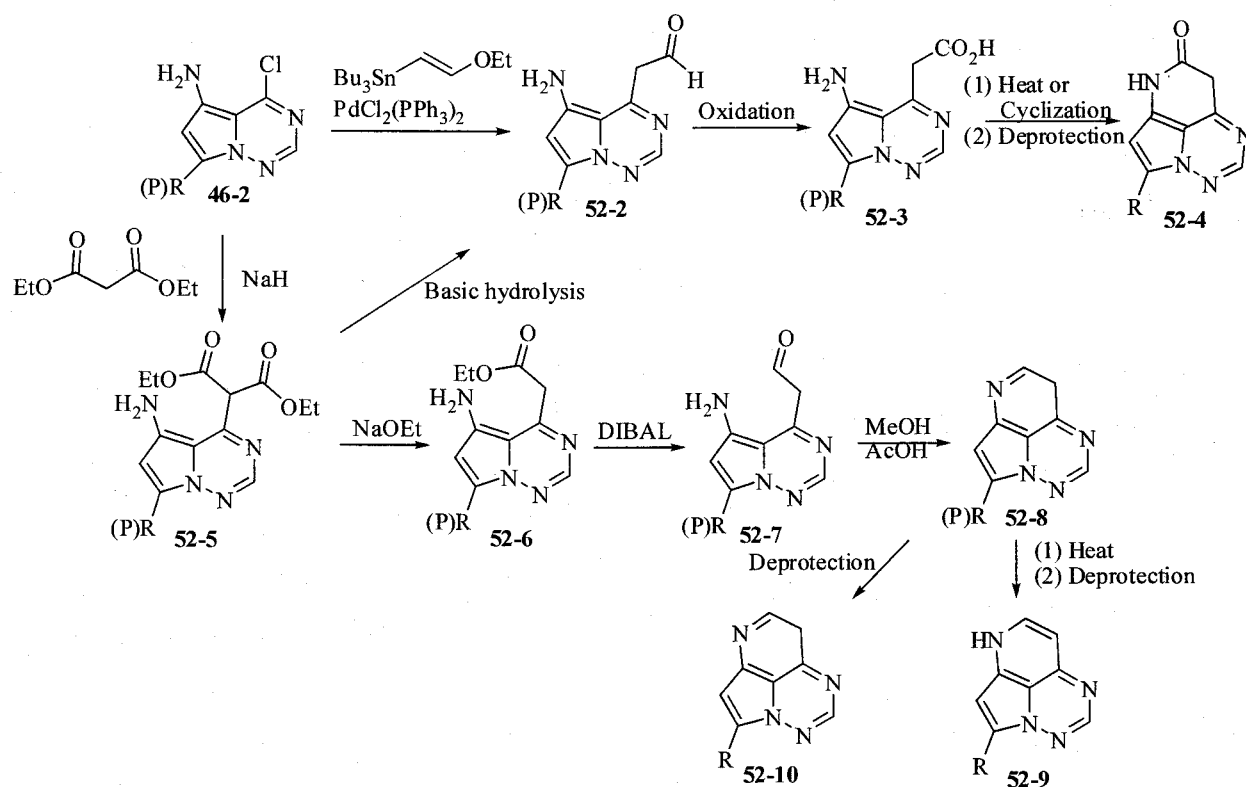
Scheme 50.



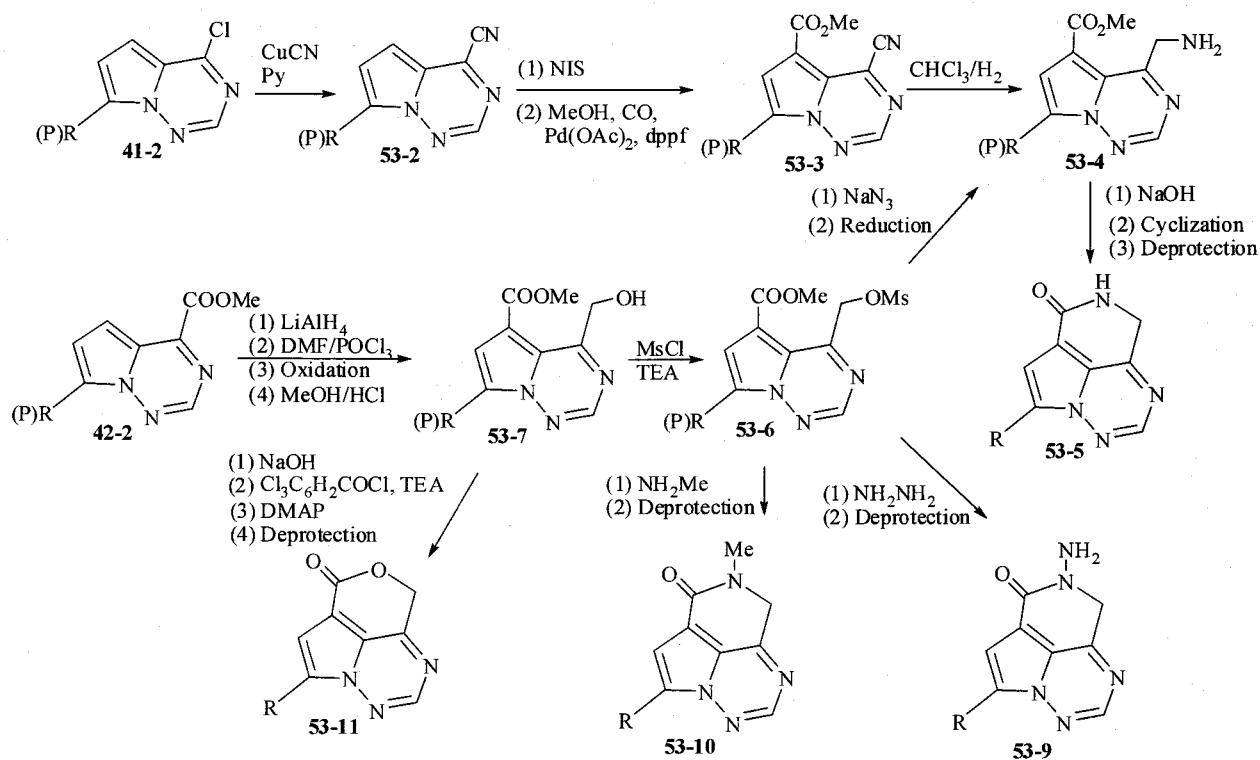
Scheme 51.



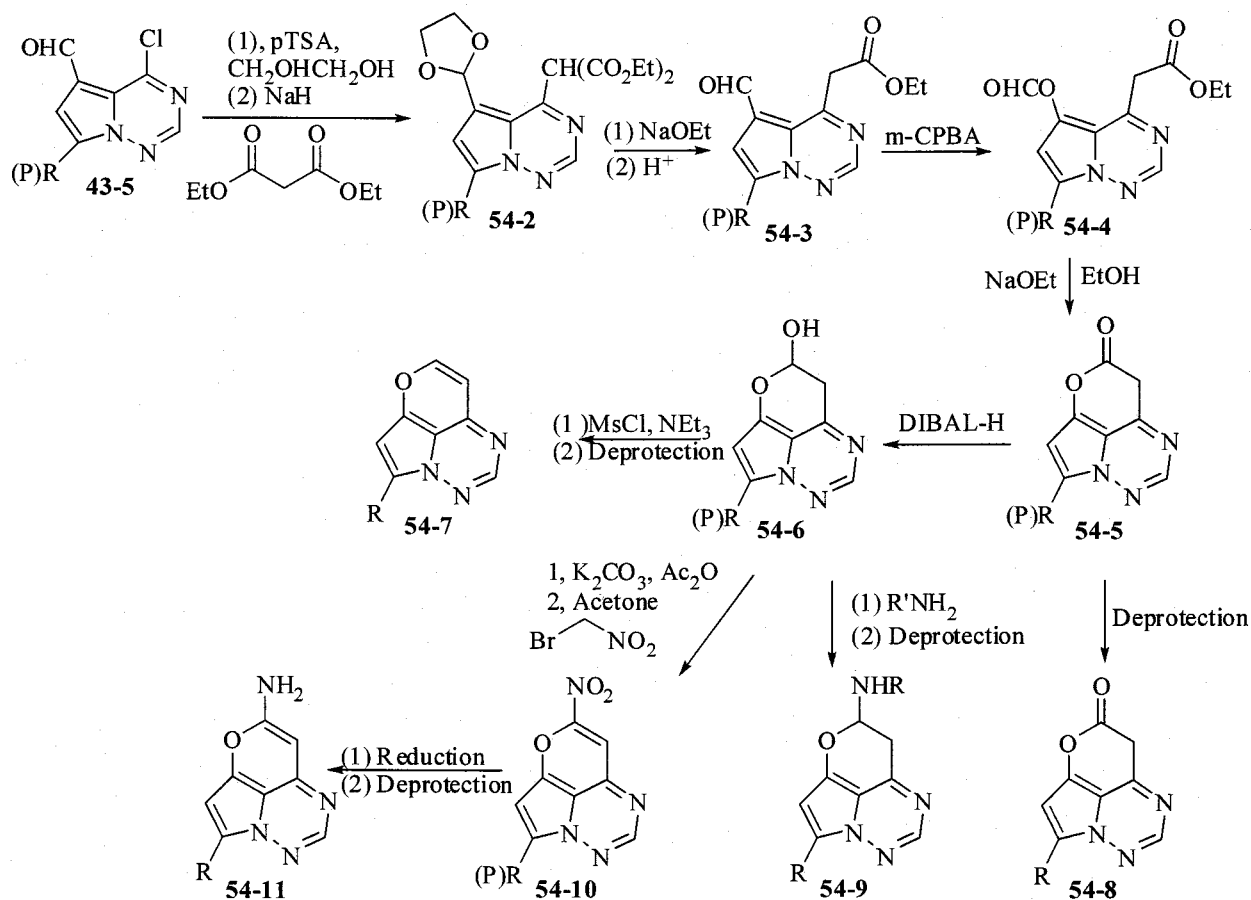
Scheme 52.



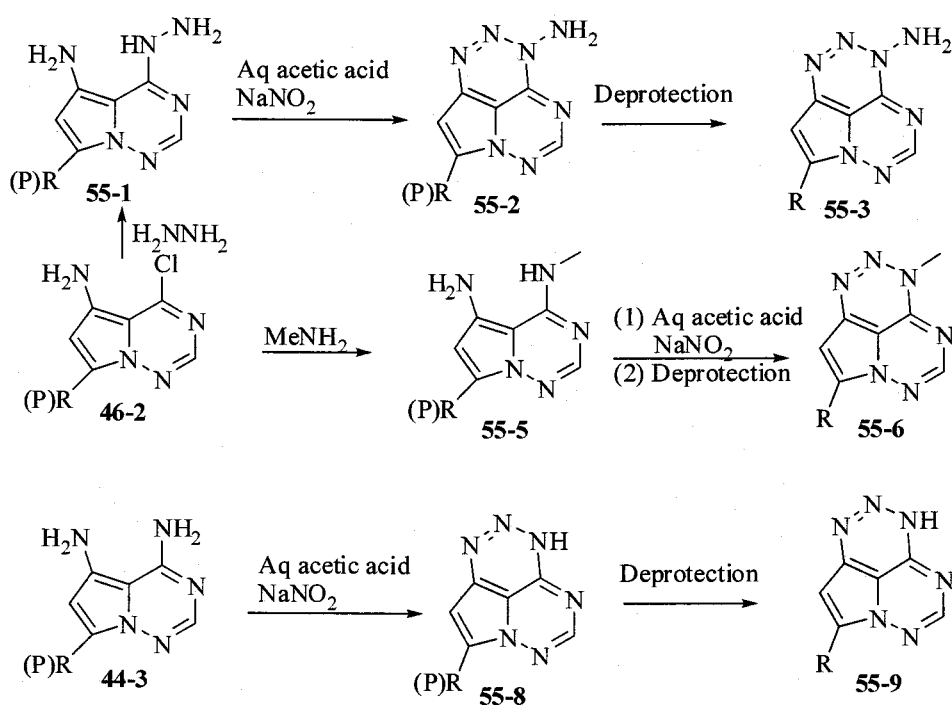
Scheme 53.



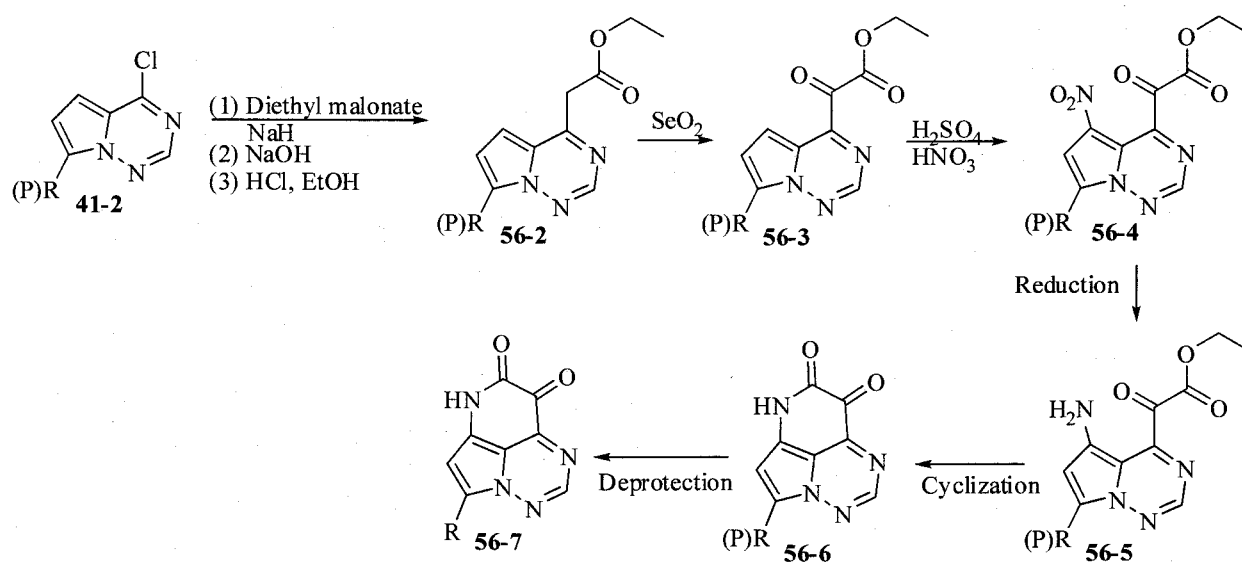
Scheme 54.



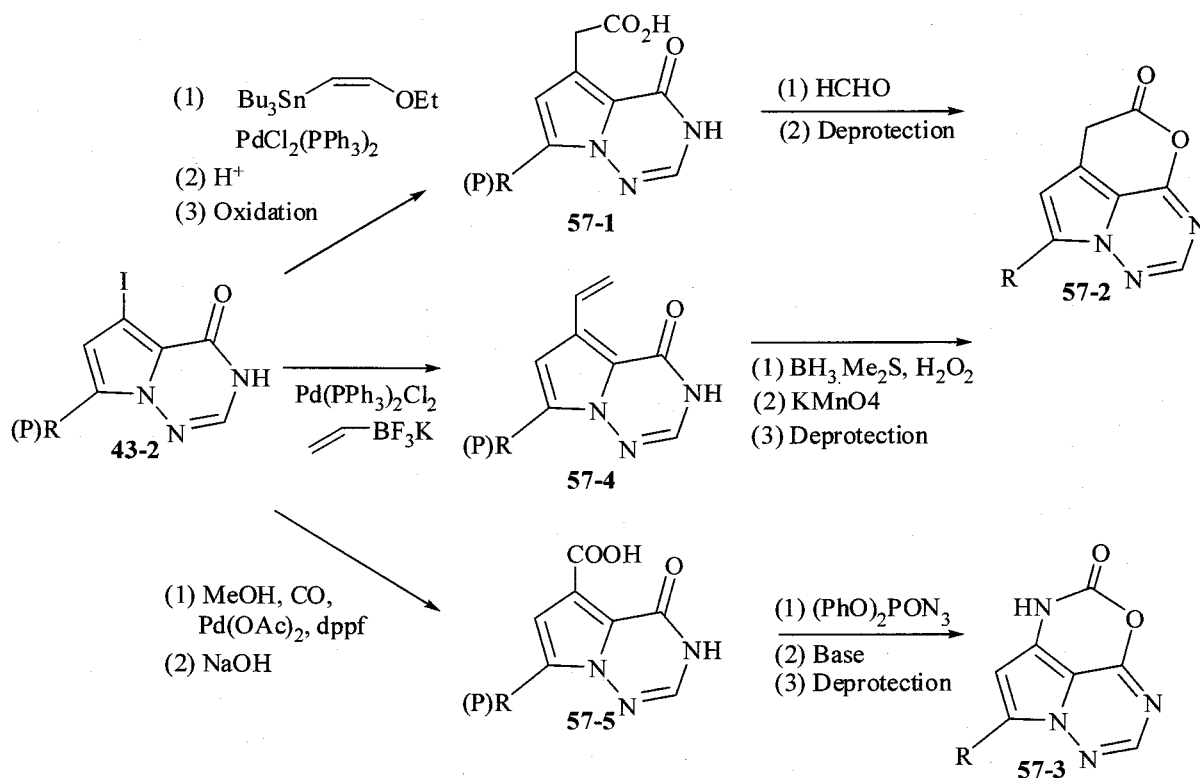
Scheme 55.



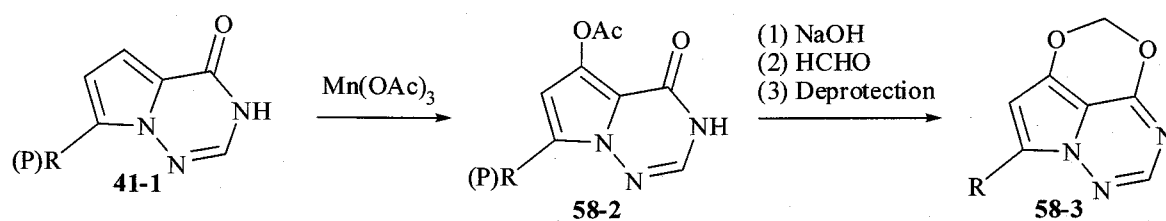
Scheme 56.



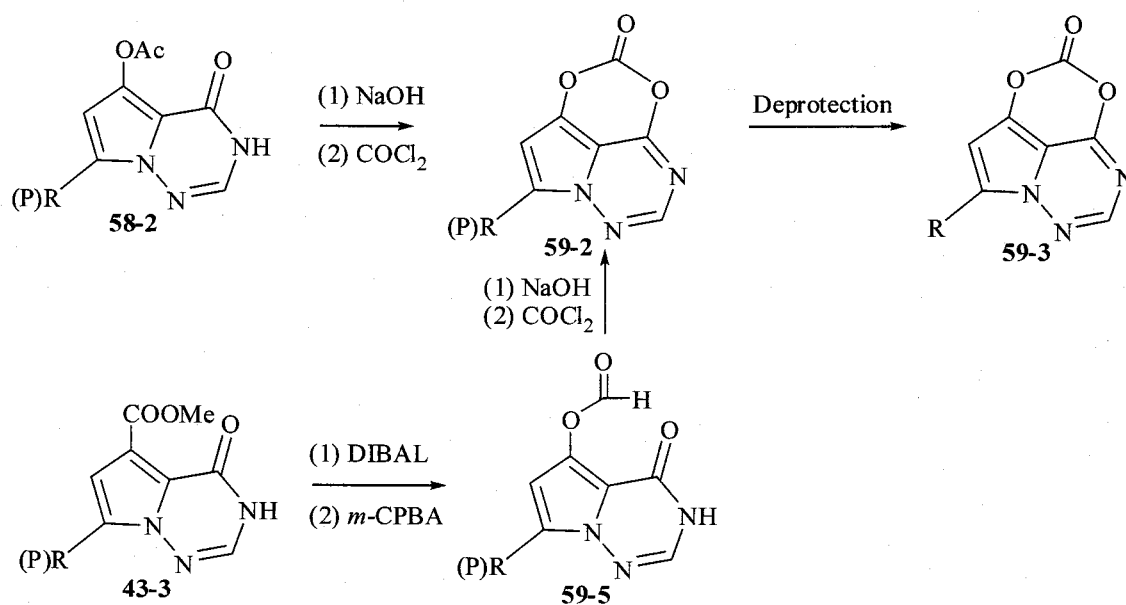
Scheme 57.



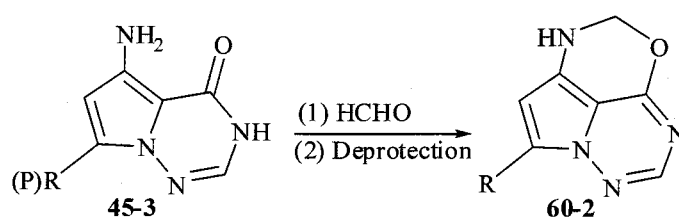
Scheme 58.



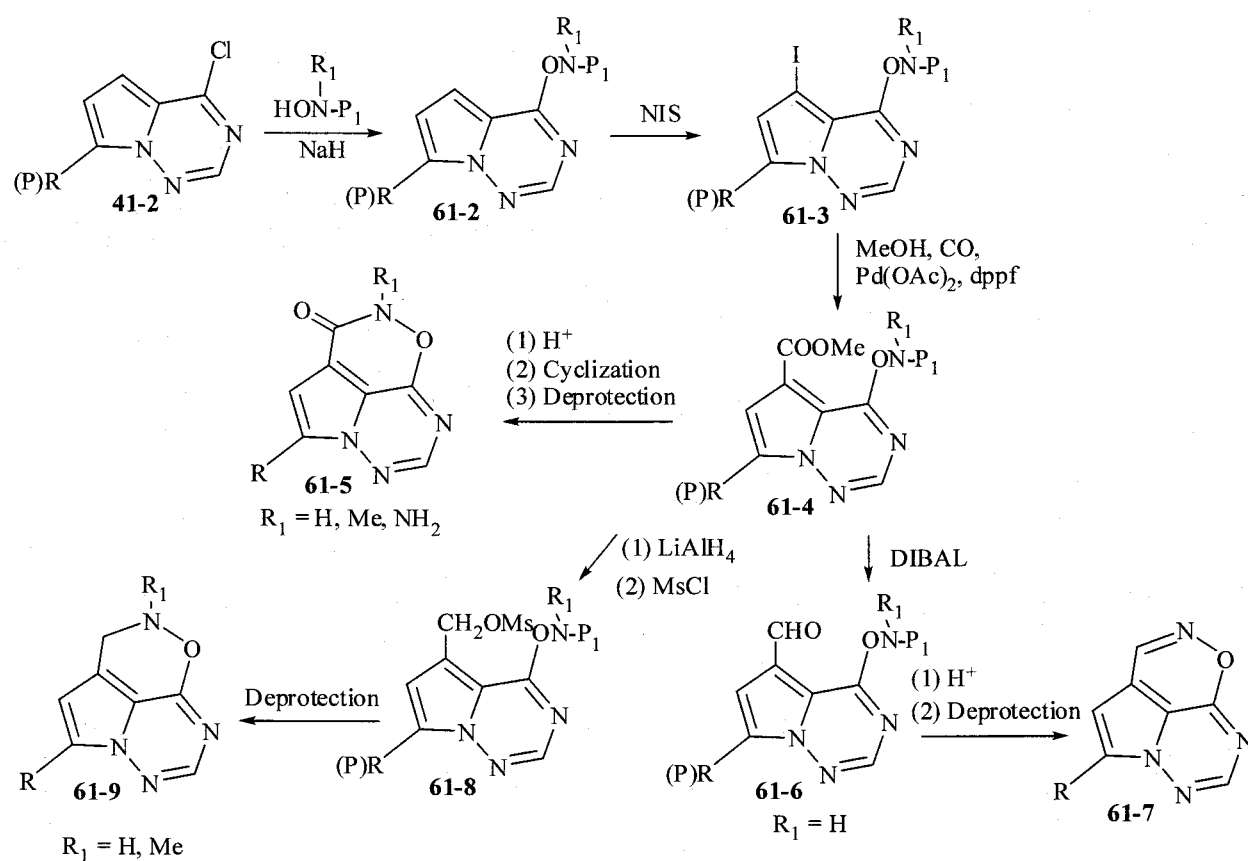
Scheme 59.



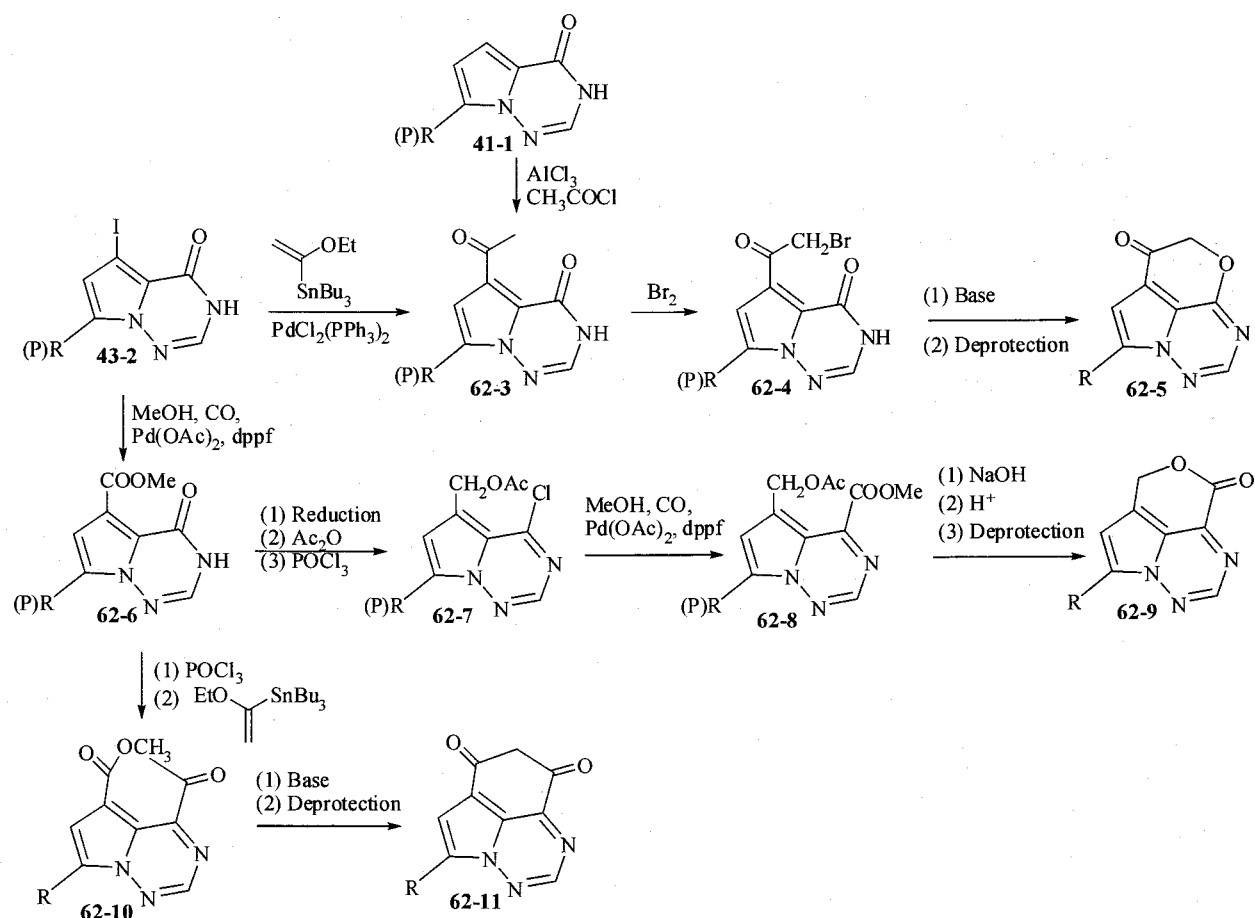
Scheme 60.



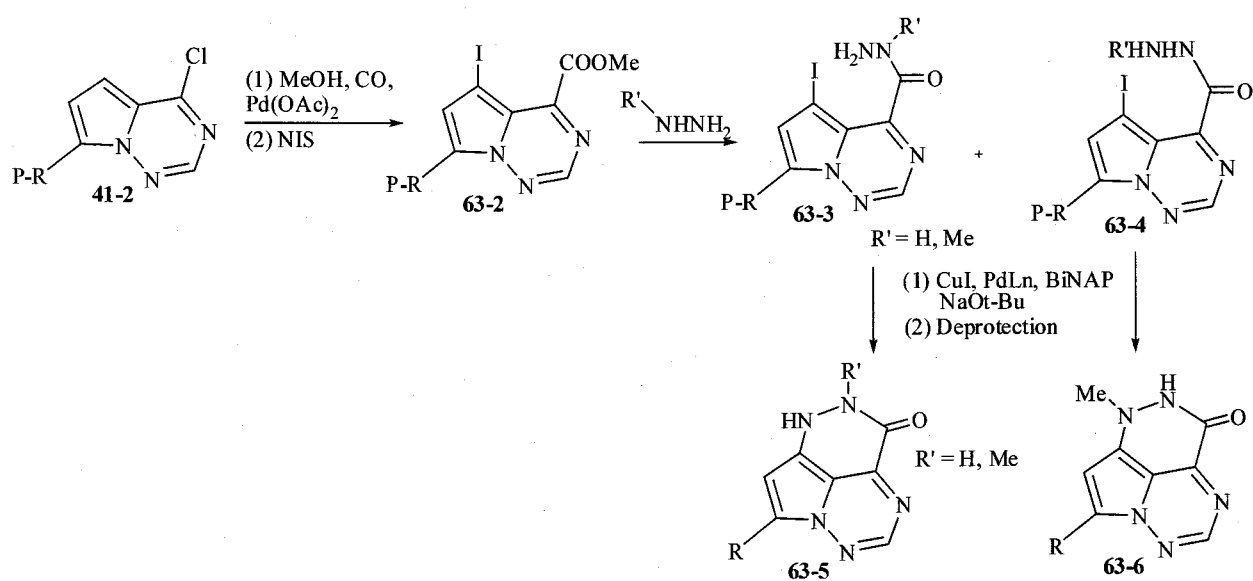
Scheme 61.



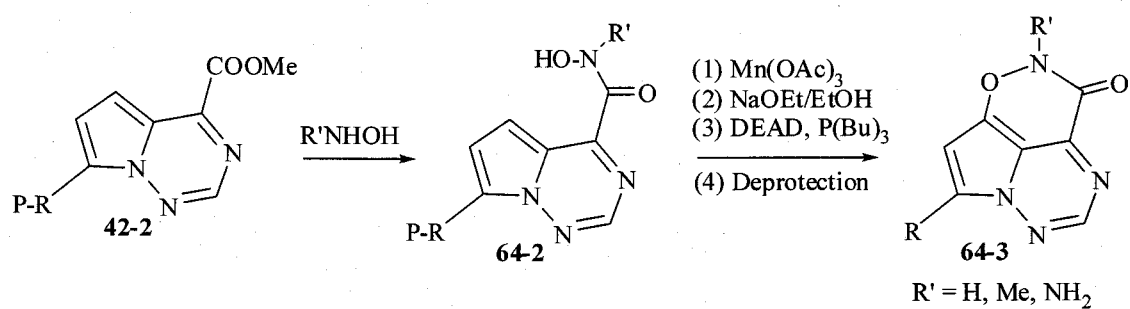
Scheme 62.



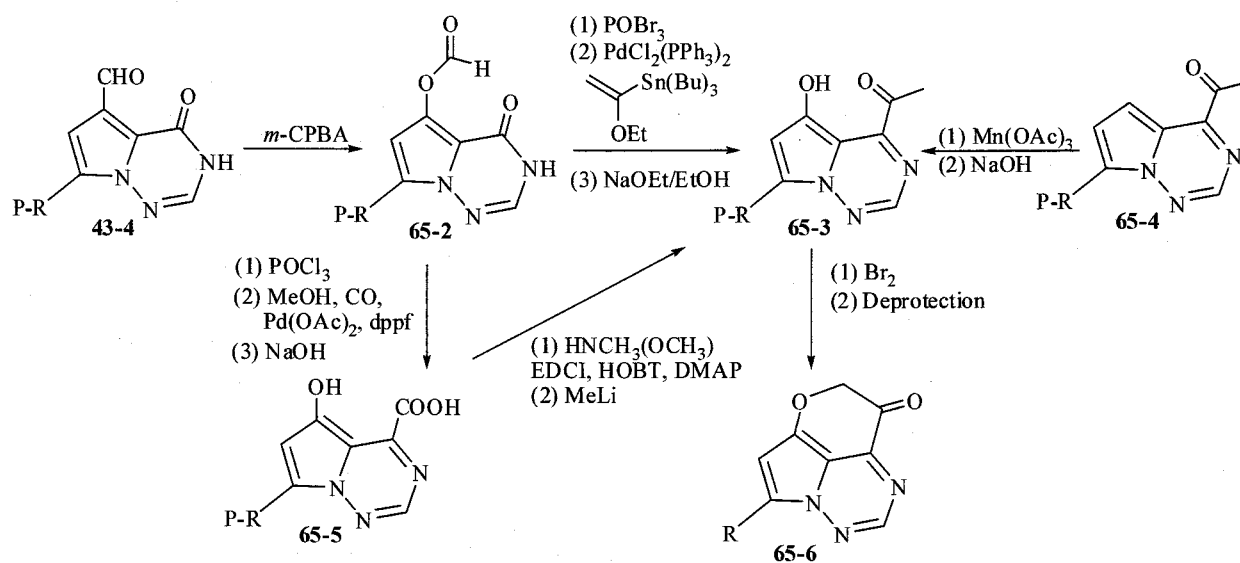
Scheme 63.



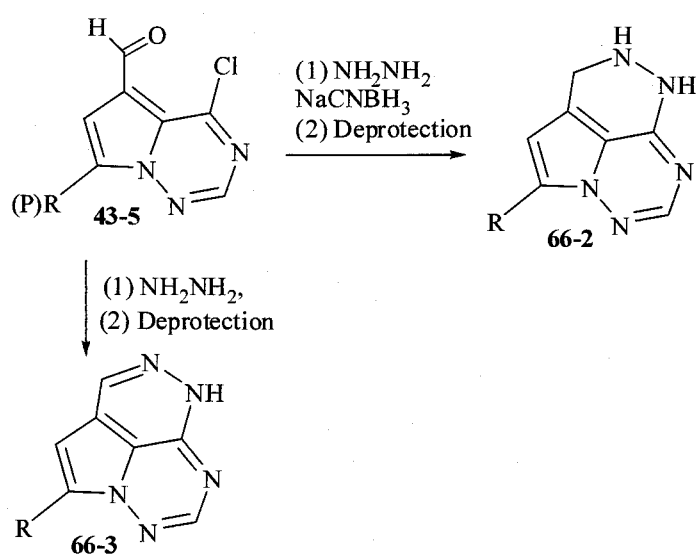
Scheme 64.



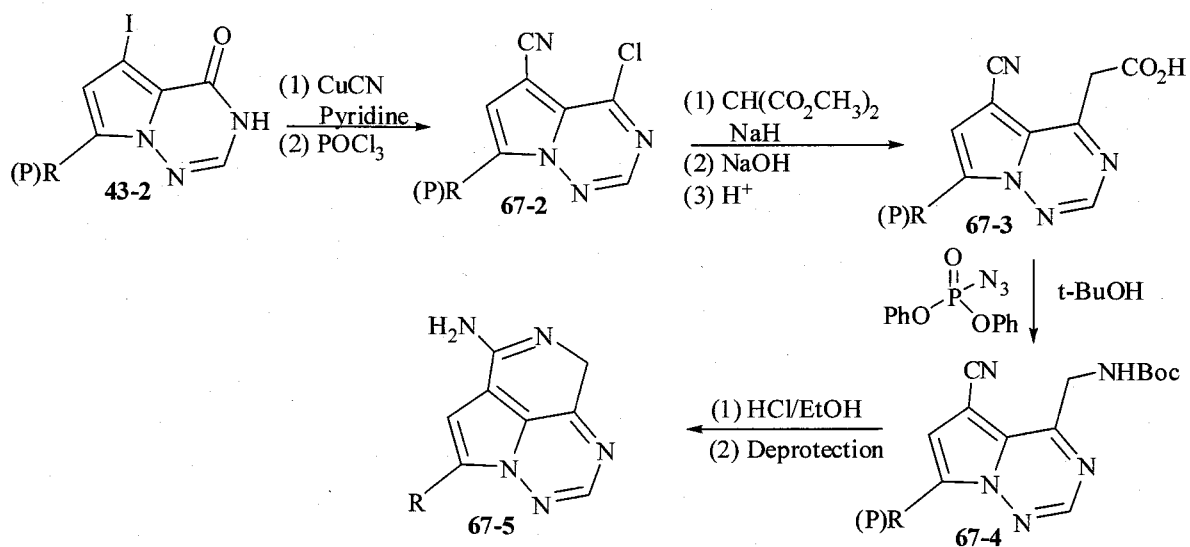
Scheme 65.



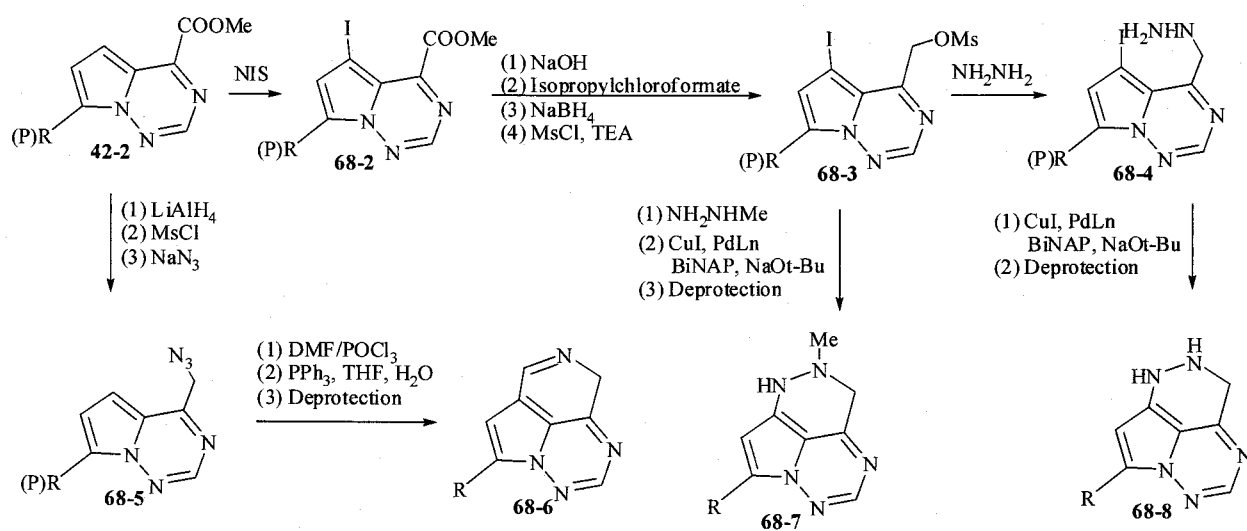
Scheme 66.



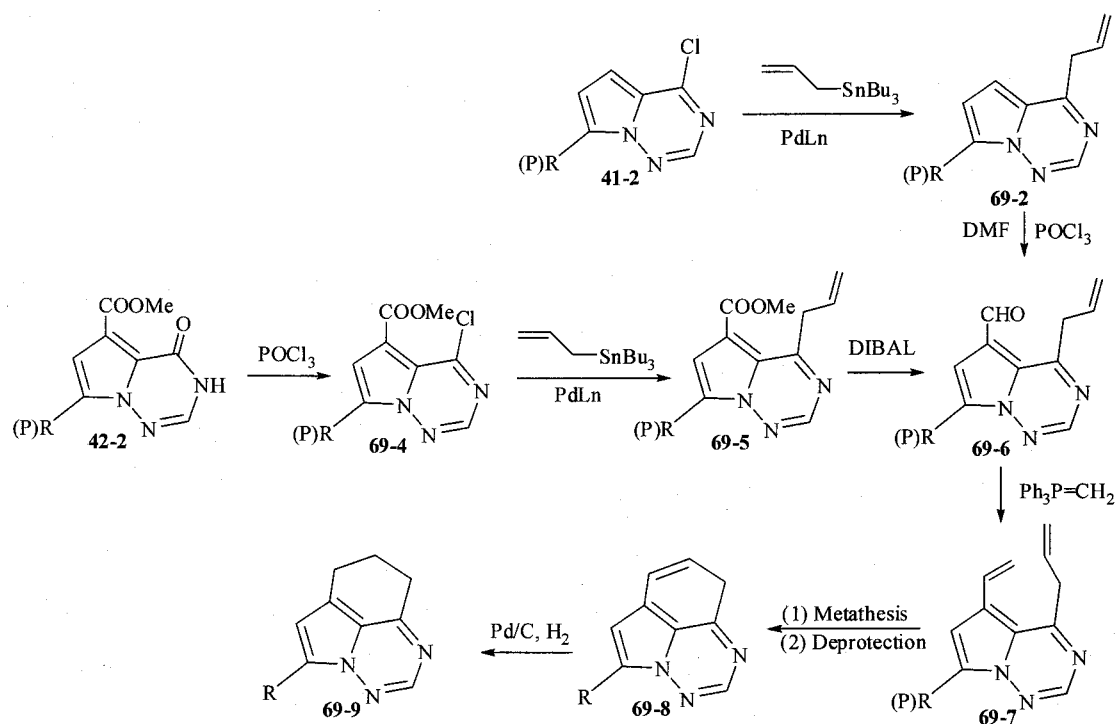
Scheme 67.



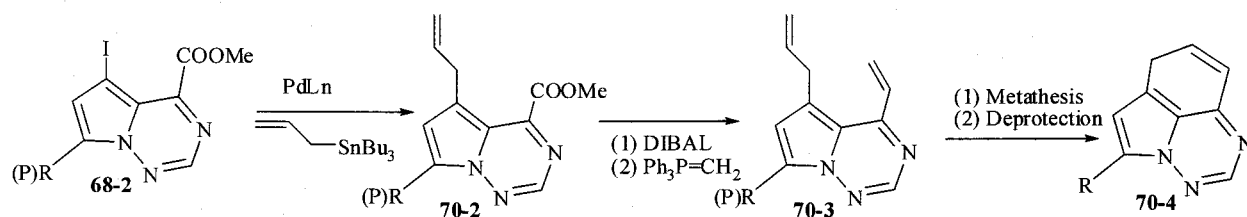
Scheme 68.



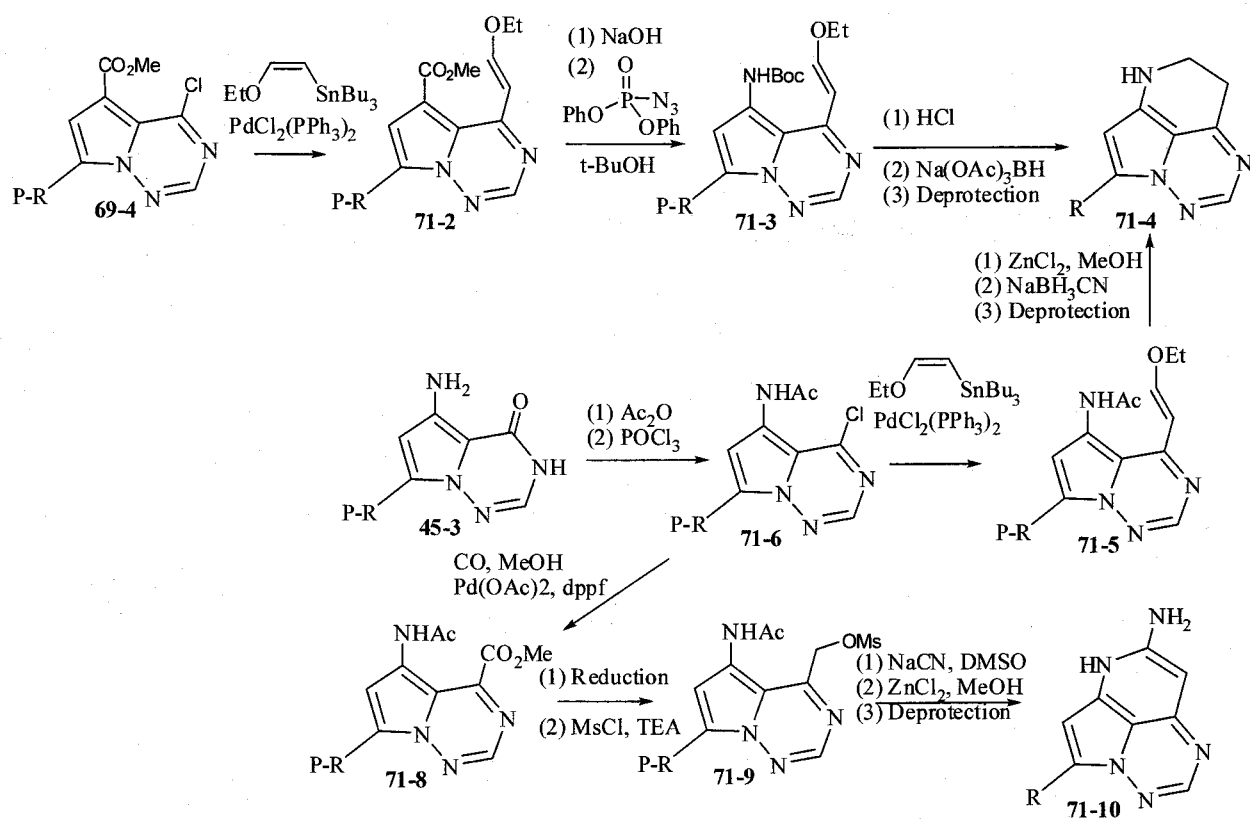
Scheme 69.



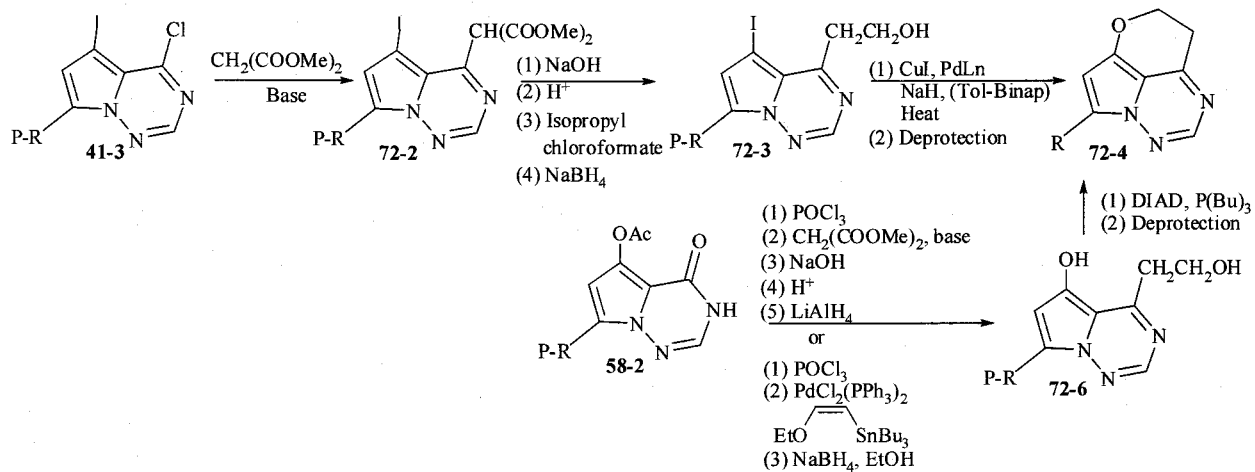
Scheme 70.



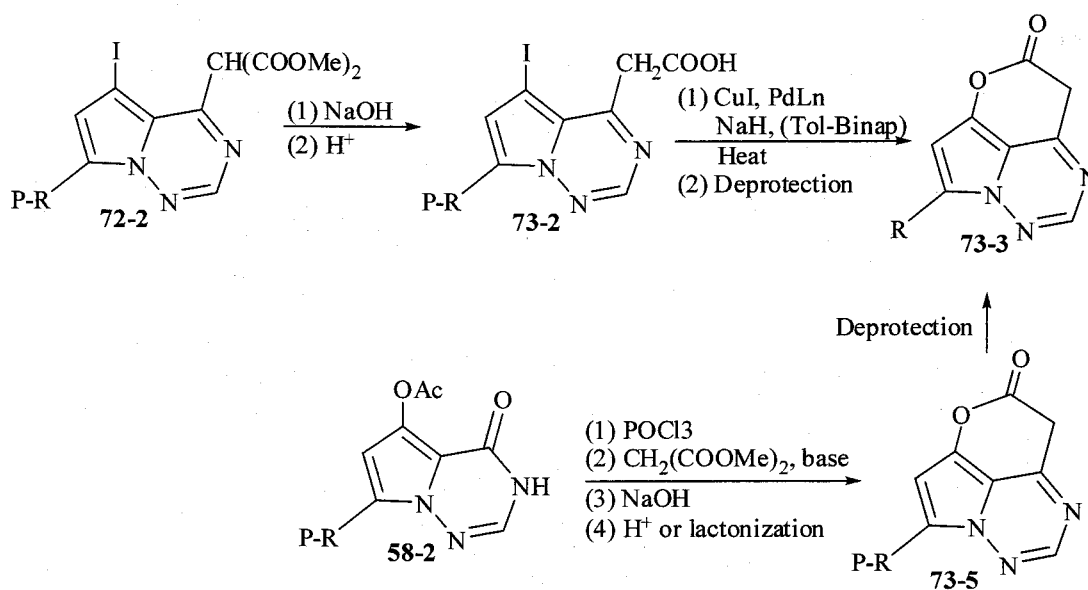
Scheme 71.



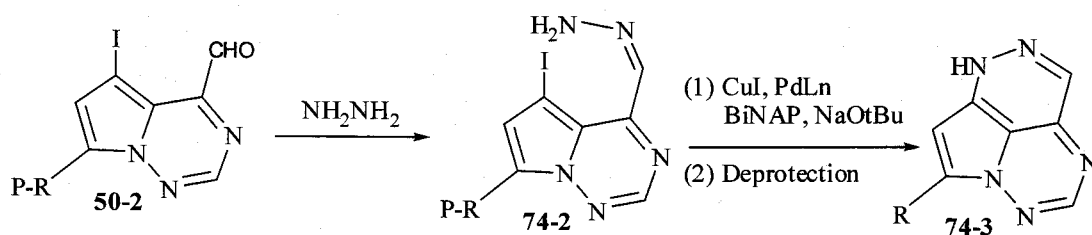
Scheme 72.



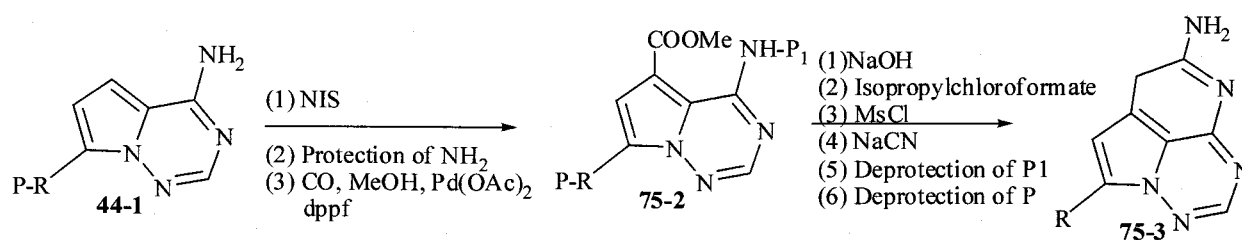
Scheme 73.



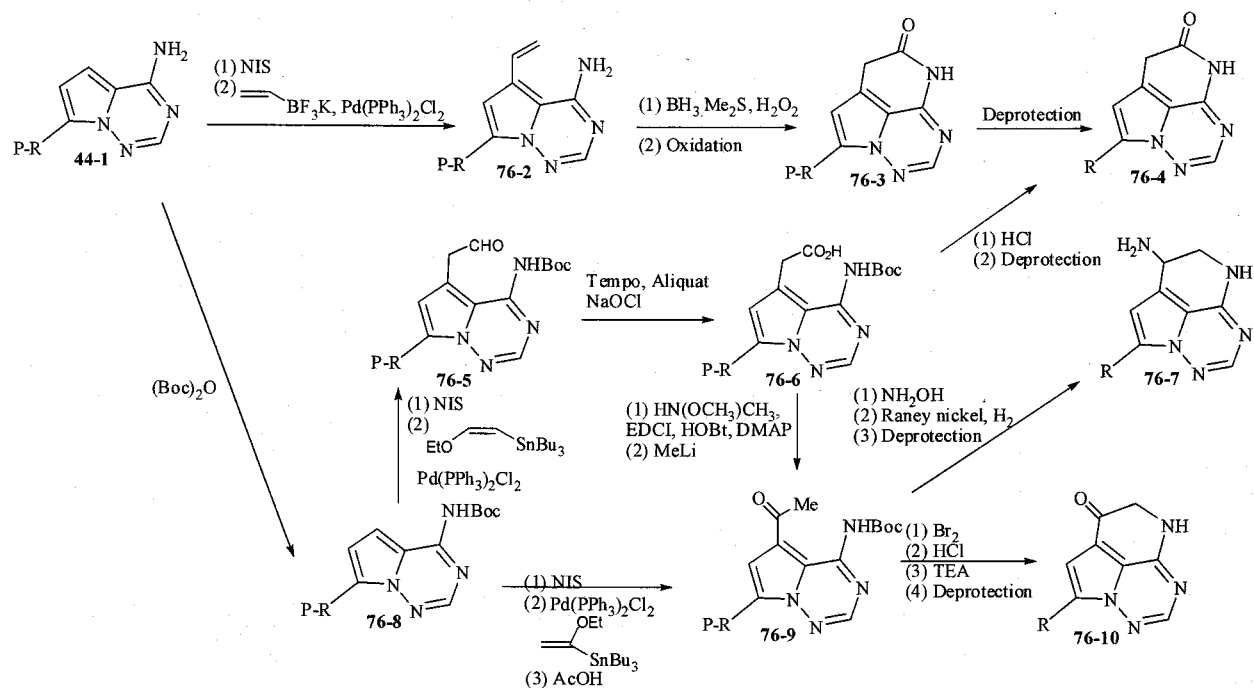
Scheme 74.



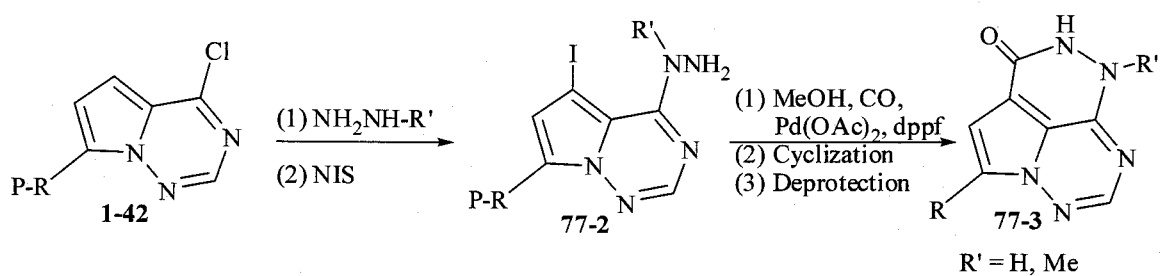
Scheme 75.



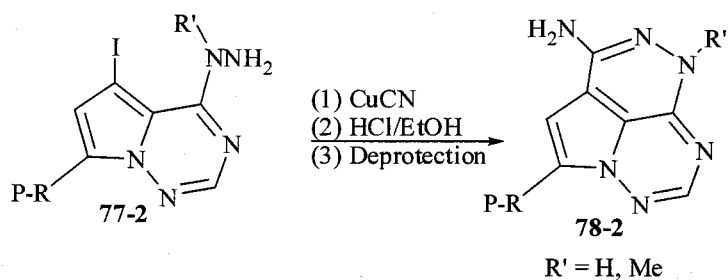
Scheme 76.



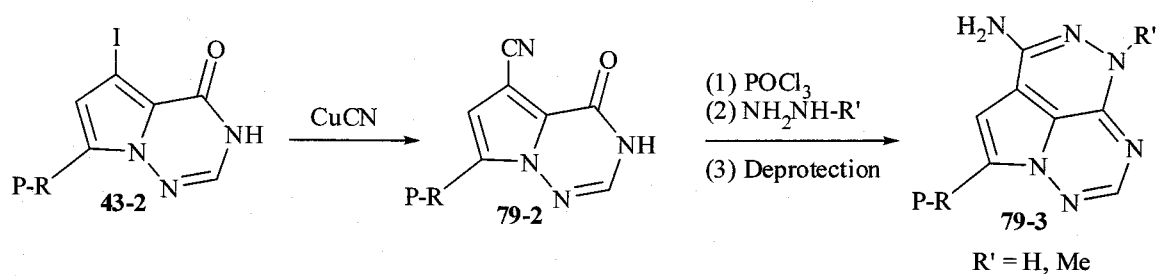
Scheme 77.



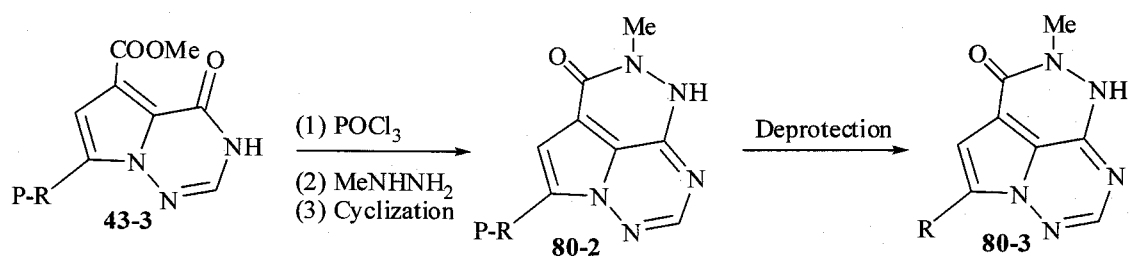
Scheme 78.



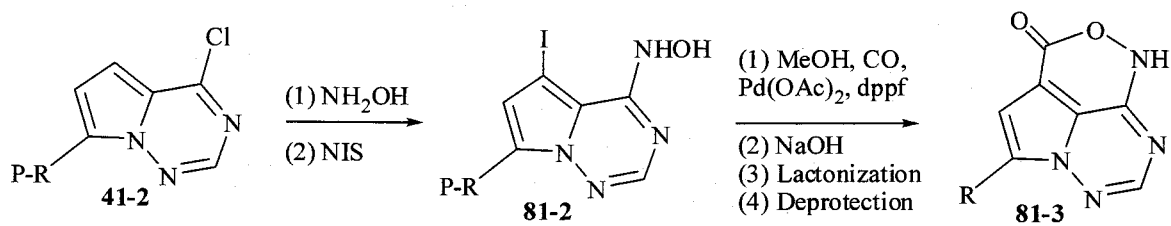
Scheme 79.



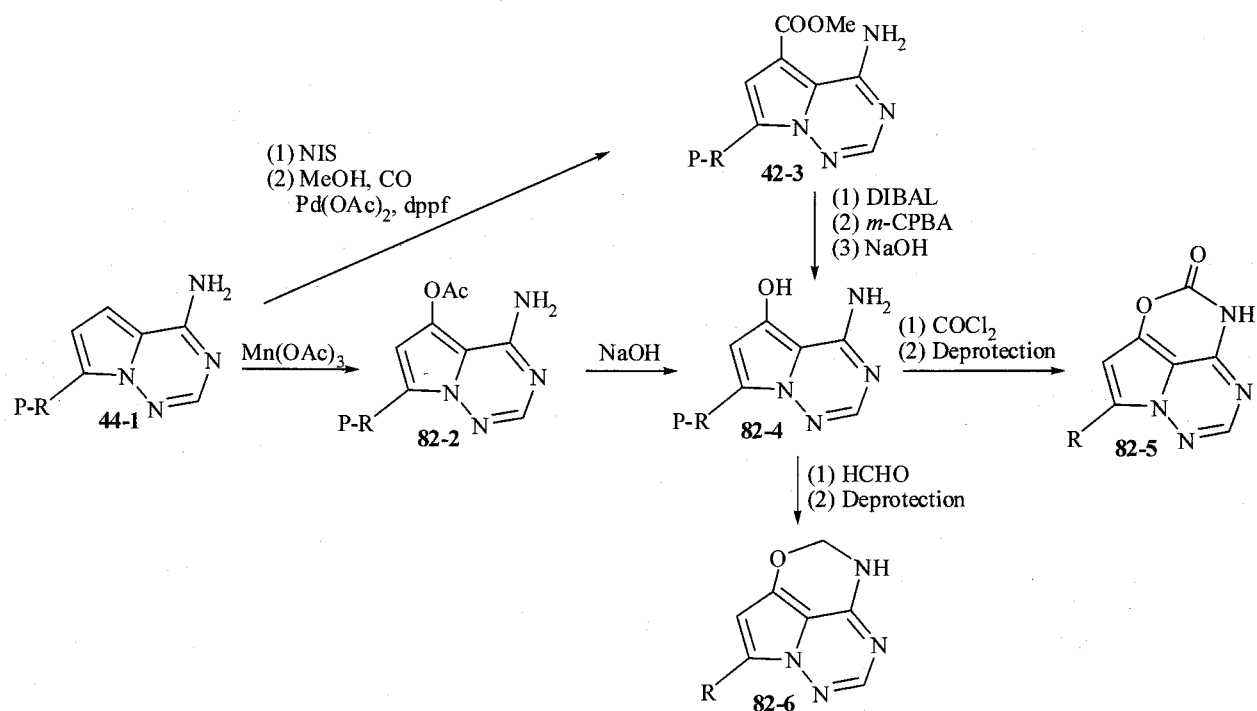
Scheme 80.



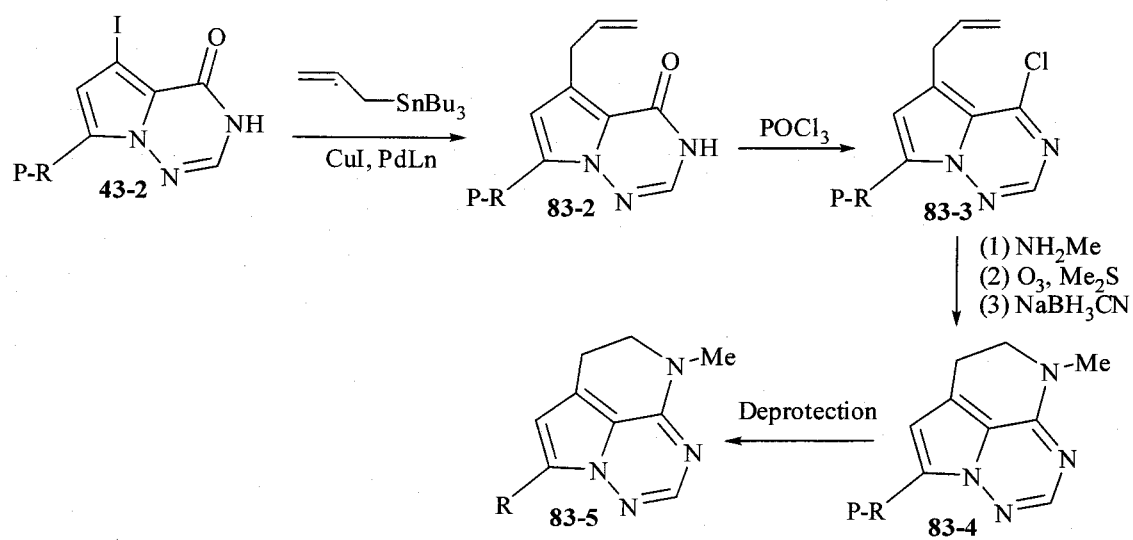
Scheme 81.



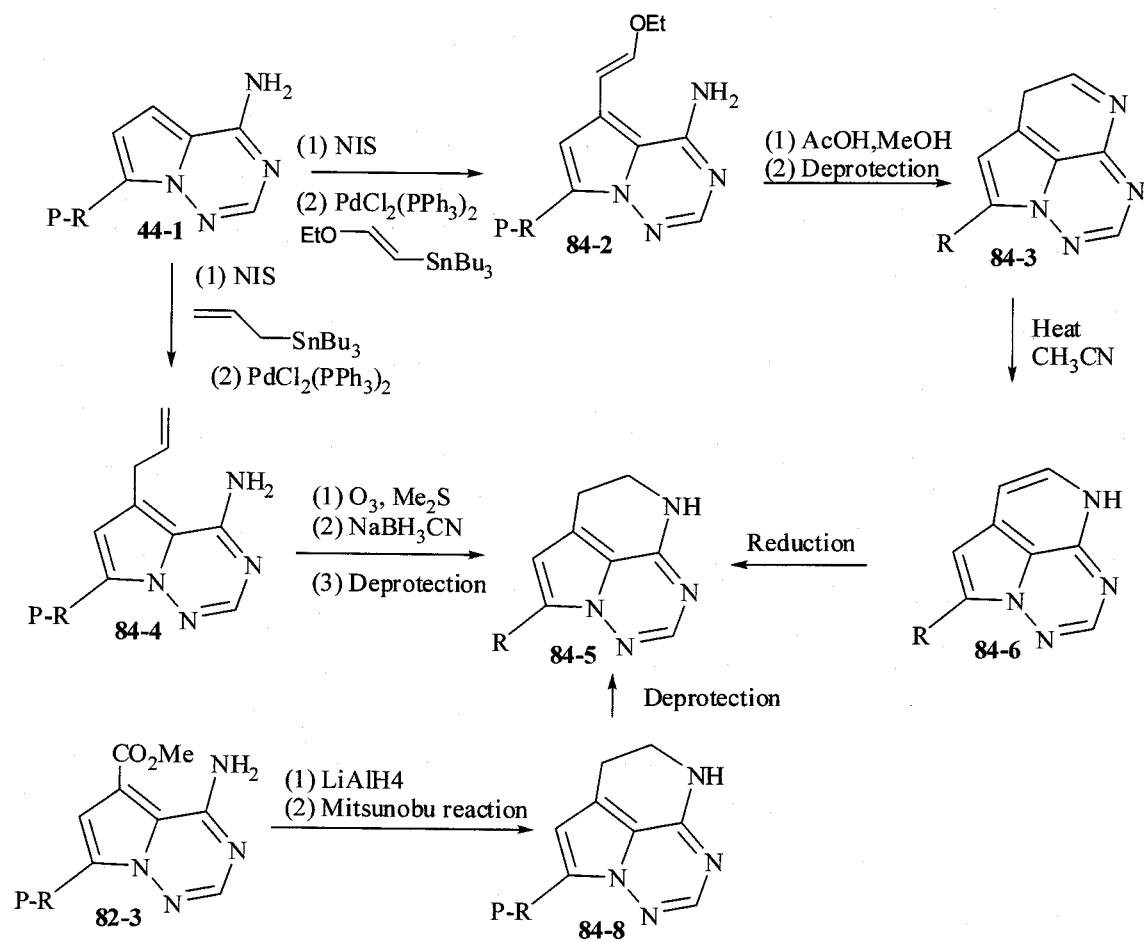
Scheme 82.



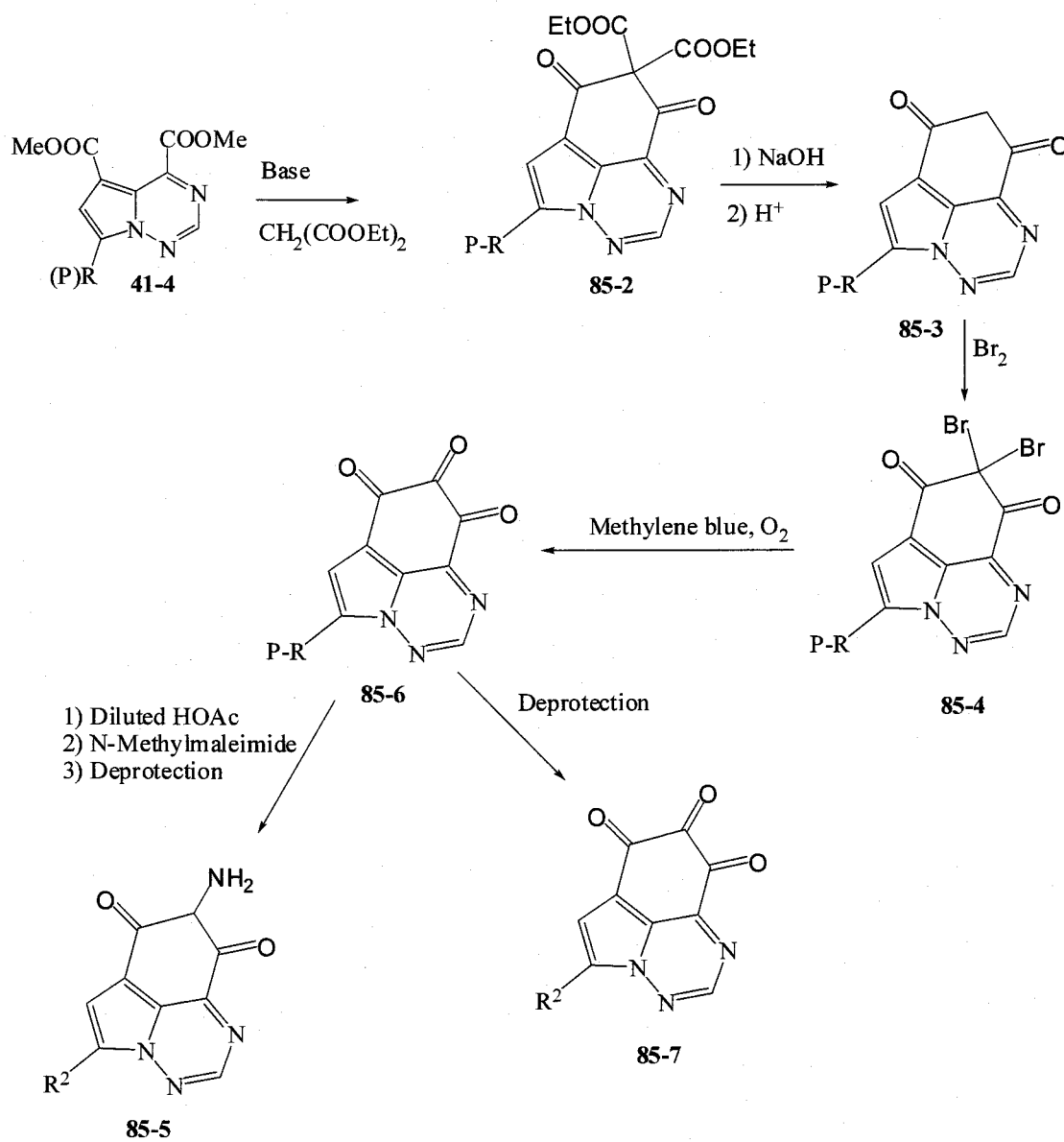
Scheme 83.



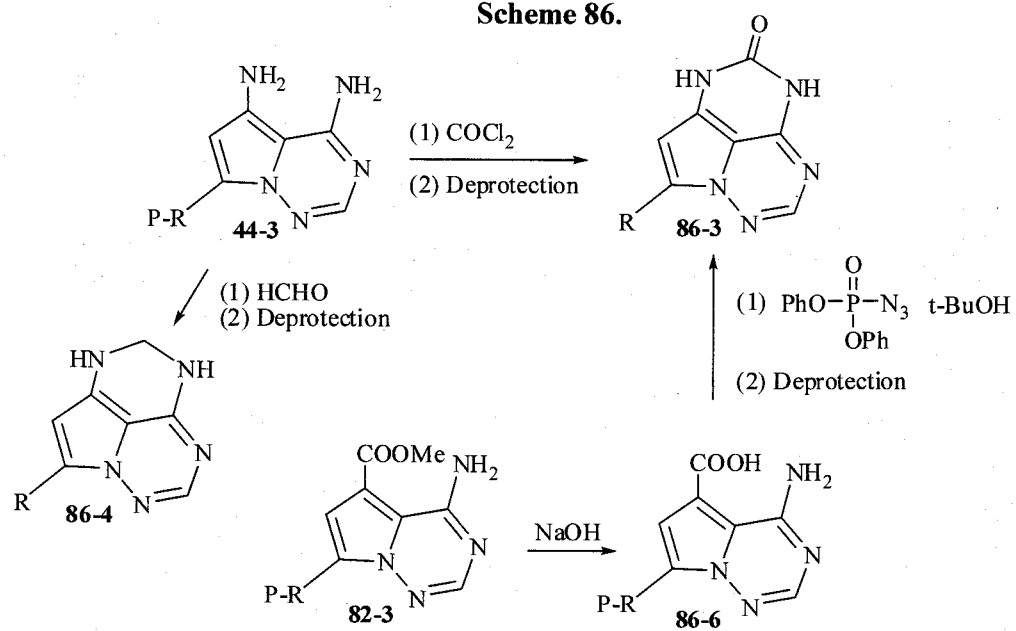
Scheme 84.



Scheme 85

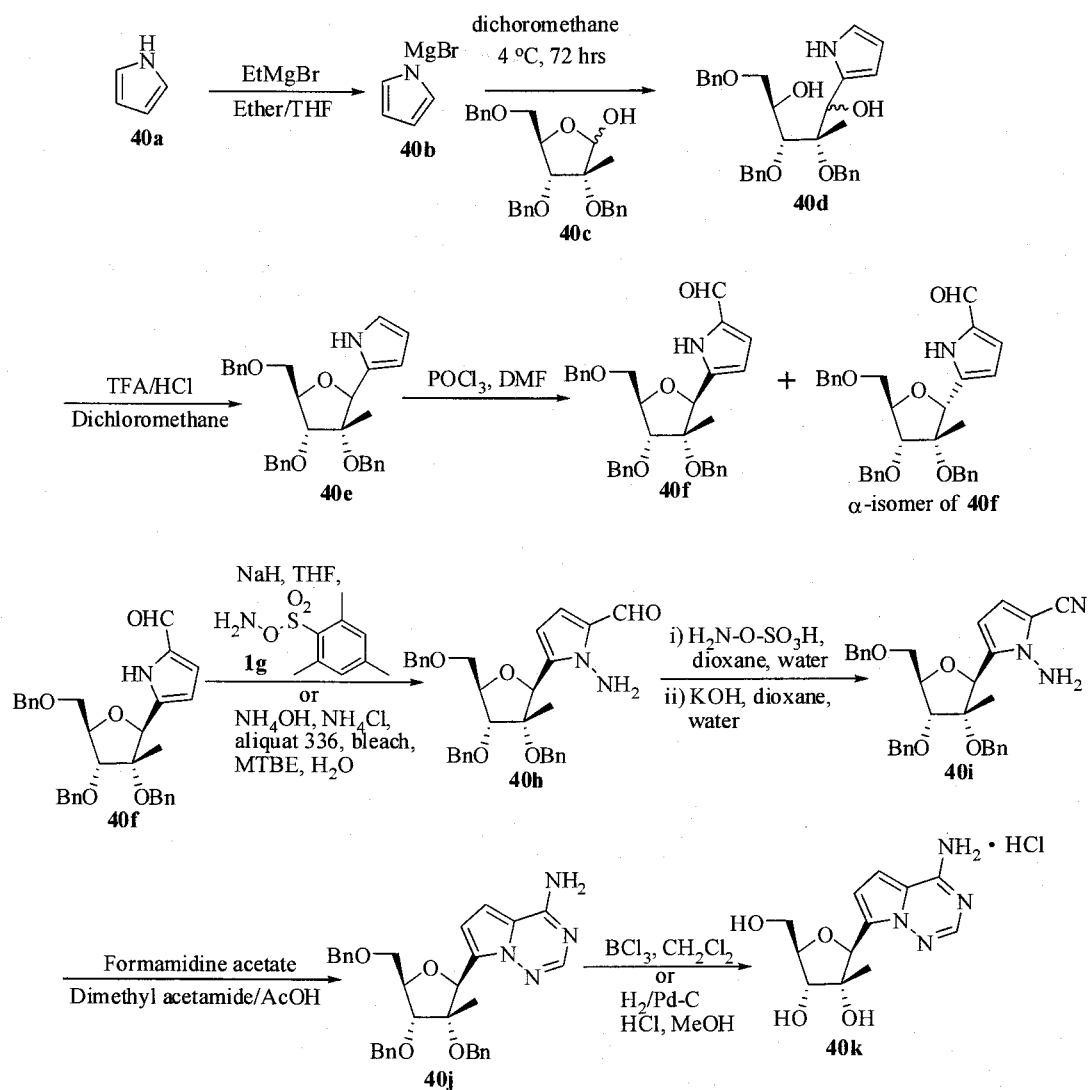


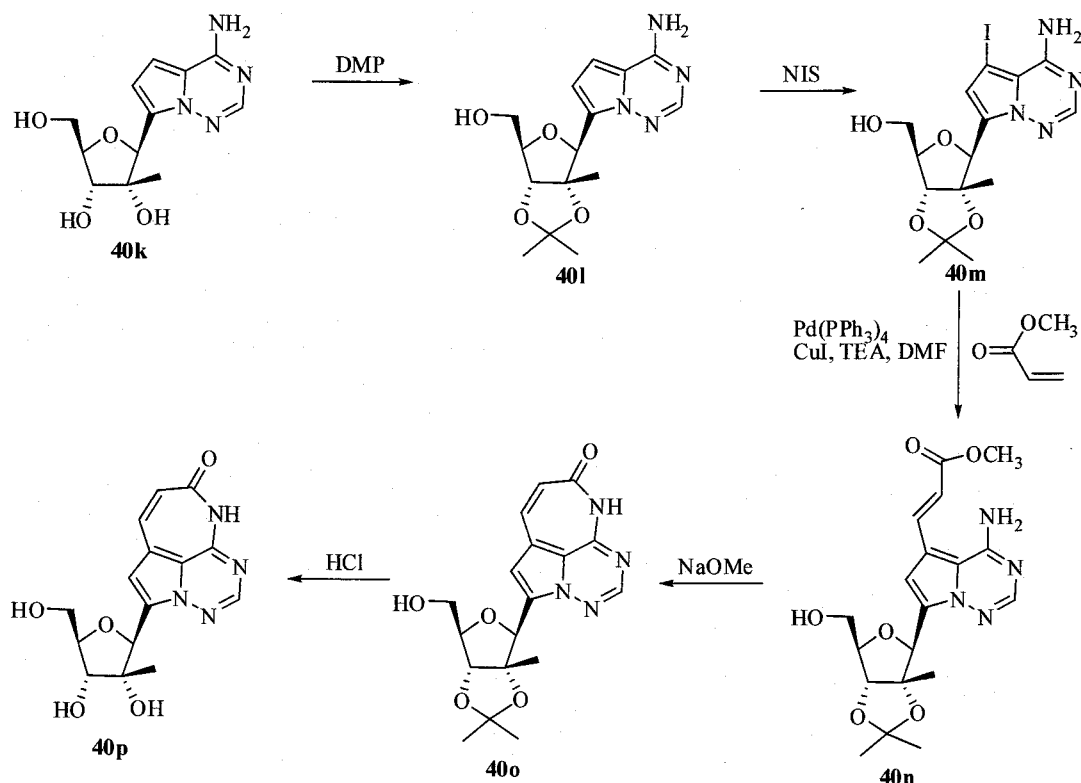
Scheme 86.



The invention will now be illustrated by the following non-limiting Examples.

Scheme 40 for the Synthesis of Example 1





Example 1

Synthesis of **40p**

To a solution of tricyclic product (**40o**, 0.1 g, 0.27 mmol) in methanol (2 mL) was added aqueous 1 N HCl (2 mL) and stirred at room temperature overnight. The reaction mixture was concentrated in vacuo to dryness. The residue obtained was triturated with methanol/ether and the solid obtained was collected by filtration washed with ether and dried in vacuo at acetone reflux temperature to furnish **40p** (0.08 g, 90 %) as a yellow solid; MP 240-242 °C. ^1H NMR (300 MHz, DMSO- d_6) δ 11.39 – 10.93 (m, 1H), 8.04 (s, 1H), 7.12 (d, J = 11.9, 1H), 7.00 (s, 1H), 6.09 (s, 3H), 5.76 (d, J = 11.9, 1H), 5.31 (s, 1H), 3.76 (d, J = 10.6, 2H), 3.68 (s, 2H), 0.84 (s, 3H); MS (ES $^-$) 330.9.

The intermediate **40o** was prepared as follows.

- a. To a stirred solution of freshly distilled pyrrole (6.79 g, 100.89 mmol) in diethyl ether (100 mL) was added ethyl magnesium bromide (33.6 mL, 100.89 mmol, 3M solution in ether) slowly at 20 °C. The reaction mixture was further stirred at 20 °C for 1 h and the solvent was removed under vacuum to give **40b**. To **40b** in dichloromethane (500 mL) at 0 °C was added a solution of **40c** (WO 2006/050161, 10.96 g, 25.22 mmol) in dichloromethane (100 mL) and further stirred at 4 °C for 72 h. The reaction mixture was quenched by adding saturated solution of ammonium chloride (200 mL) and organic layer was separated. The aqueous layer was

further extracted with dichloromethane (2 x 200 mL). The combined organic extracts were washed with water (2 x 50 mL) and brine (1 x 50 mL) and dried. After filtration, the filtrate containing **40d** was treated with trifluoroacetic acid (4.14 g, 36.34 mmol) at 20 °C and stirred for 14 h. The reaction mixture was washed with water (2 x 100 mL) and brine (1 x 50 mL) and dried. After filtration, the filtrate was concentrated to give 12.5g of crude **40e**.

NOTE: THF was also used to make Grignard reagent instead of diethyl ether. THF was removed by distillation and the traces by azeotrope with toluene.

b. Phosphorus oxychloride (19.33 g, 126.1 mmol) was added to N,N-dimethylformamide (100 mL) at 0 °C and stirred for 30 min. To this solution was added **40e** (12.1 g, 25.22 mmol) in dichloromethane (50 mL) slowly over a period of 15 min. at 0 °C and stirring was continued for 1h. The reaction mixture was quenched by adding saturated solution of sodium acetate (100 mL) and stirred for 30 min. The reaction mixture was concentrated to remove dichloromethane and the residue was diluted with ethyl acetate (200 mL). The organic layer was separated and washed with water (2 x 100 mL) and brine (1 x 50 mL) and dried. After filtration, the filtrate was concentrated and the residue was purified by flash chromatography using ethyl acetate in hexanes (0 to 12%) to give 2.92g (22.6% from **40e**) of **40f** as dark brown syrup. MS (ES⁺): 510.2.

NOTE: Only DMF was also used as solvent; there was no need of dichloromethane. For workup, 2N NaOH was used in place of sodium acetate.

c. To a stirred solution of above obtained **40f** (2.5 g, 4.88 mmol) in tetrahydrofuran (50 mL) was added sodium hydride (0.39 g, 9.77 mmol, 60% dispersion in mineral oil) at 0 °C. After stirring for 30 min at 0 °C, O-(mesitylsulfonyl)hydroxylamine (**40g**, 1.15 g, 5.37 mmol, prepared by the method of Krause, J.G. *Synthesis*, **1972**, 140) was added at 0 °C and further stirred for 2h. The reaction mixture was quenched by adding water (20mL) and extracted with ethyl acetate (2 x 50 mL). The combined organic extracts were washed with water (2 x 25 mL) and brine (1 x 25 mL) and dried. After filtration, the filtrate was concentrated to give 2.75 g of **1h** as dark syrup. MS (ES⁺): 527.43.

The compound **40h** can also be prepared as follows.

d. Aldehyde **40f** (5.2 Kg, 10.16 moles) was dissolved in methyl *tert*-butyl ether (72.8 L) and charged into a clean SS reactor (600 L). Aliquot 336 (0.25 Kg, 0.61 mole) and ammonium

chloride (6.53 Kg, 122.07 moles) were added to the reactor and reaction mixture was cooled to 0-5 °C. Ammonium hydroxide (19.08 L, 137 moles, 28% solution in water) was added at 0-5 °C followed by addition of a cold (0-5 °C) sodium hydroxide solution (16.59 Kg in 66 L water, 414.75 moles) at the same temperature over a period of 3 h. Sodium hypochlorite (251 L, 222.58 moles, 6% solution) addition was started at 0 °C and during the addition the temperature was allowed to rise to 15 °C. The reaction mixture was further stirred at room temperature for 2 h. TLC showed completion of the reaction. Ethyl acetate (104 L) was added to the reaction mixture and layers were separated. The aqueous layer was re-extracted with ethyl acetate (2 X 104 L). The combined organic layers were washed with water (52 L), sodium thiosulfate (2 X 156 L, 10% solution), water (52 L) and brine (70 L) and dried over sodium sulfate (10.4 Kg). After filtration, the filtrate was concentrated under vacuum below 40 °C to afford crude compound **40h** (4.4 kg) as dark syrup.

e. To a stirred solution of **40h** (2.56 g, 4.88 mmol) in dioxane (50 mL) was added water (15 mL) and cooled to 0 °C. To this cooled solution at 0 °C was added hydroxylamine-O-sulfonic acid (1.93g, 17.10 mmol). After stirring for 1h, a cold solution of potassium hydroxide (2.19 g, 39.0 mmol) in water and dioxane (20 mL + 20 mL) was added and further stirred at 0 °C for 1h. The reaction mixture was diluted with ethyl acetate (100 mL), the organic layer was separated and washed with water (2 x 50 mL) and brine (1 x 50 mL) and dried. After filtration, the filtrate was concentrated to afford 2.6 g of **40i**, which was used as such for the next step.

f. To a stirred solution of **40i** (2.55 g, 4.88 mmol) in N,N-dimethylacetamide (70 mL) was added formamidine acetate (5.08 g, 48.88 mmol) and the reaction mixture was stirred at 140 °C for 3h. Most of the N,N-dimethylacetamide was removed under vacuum and the residue was suspended in water (100 mL), which was extracted with ethyl acetate (2 x 250 mL). The combined organic extracts were washed with water (50 mL) and brine (50 mL) and dried. After filtration, the filtrate was concentrated and the residue was purified by flash chromatography using a mixture of ethyl acetate and methanol (9:1) in hexanes (0 to 30%) to provide impure compound (1.25 g). Further purification by chromatography on silica gel gave 0.48g (17.8% from **40f**) of **40j** as a light brown solid. ¹H NMR (CDCl₃): δ 7.87 (s, 1H), 7.43-7.21 (m, 15H), 6.88 (d, *J* = 4.5 Hz, 1H), 6.50 (d, *J* = 4.5 Hz, 1H), 5.87 (s, 1H), 5.36 (b, 2H, D₂O exchangeable), 4.83 (dd, *J* = 31.8, 12.2 Hz, 2H), 4.68-4.52 (m, 4H), 4.40-4.35 (m, 1H), 4.04 (d, *J* = 8.8 Hz, 1H), 3.88 (dd, *J* = 10.9, 2.3 Hz, 1H), 3.69 (dd, *J* = 11.1, 3.6 Hz, 1H), 1.00 (s, 3H). MS (ES⁺): 551.40.

NOTE: Acetic acid and n-BuOH can also be used as solvent in place of dimethyl acetamide.

g. To a stirred solution of **40j** (0.27 g, 0.484 mmol) in dichloromethane (25 mL) was added boron trichloride (4.84 mL, 4.84 mmol, 1M solution in dichloromethane) at -40 °C and the mixture was further stirred at -40 °C for 30 min and slowly brought to 0 °C in about 30 min and stirred at 0 °C for 20 min. The reaction was quenched by adding ethyl alcohol (50 mL) and concentrated under reduced pressure. Again, ethyl alcohol (50 mL) was added and concentrated. This operation was repeated 4 times. After concentration, the residue was dissolved in mixture of isopropyl alcohol and methanol (20 and 2 mL) and methanol was removed by concentration under vacuum. Solid separated out, which was collected by filtration and dried at 60 °C under vacuum to provide 39mg (25%) of **40k** as a colorless solid. ¹H NMR (300 MHz, DMSO-d₆): δ 9.71 (bs, 1H, D₂O exchangeable), 8.99 (bs, 1H, D₂O exchangeable), 8.16 (s, 1H), 7.41 (d, *J* = 4.5Hz, 1H), 6.97 (d, *J* = 4.7 Hz, 1H), 5.34 (s, 1H), 4.8-4.0 (m, 3H, D₂O exchangeable), 3.81-3.56 (m, 4H), 0.79 (s, 3H). MS (ES⁺): 281.6.

Compound **40k** can also be prepared as follows.

h. To a solution of compound **40j** (128 g) in methanol (1.4 L), conc. HCl (130 mL) was added followed by 10% Pd/C (12 g) and the mixture was hydrogenated at 70 psi for 10 h. Since the compound precipitated out of the solution, water (500 mL) was added to the mixture and heated at 60 °C for about 1 h and filtered through a Celite pad. The Celite pad with palladium was re-suspended in a mixture of water (400 mL) and methanol (400 mL) and heated at 60 °C for about 1 h and again filtered through Celite. This operation was repeated until there was no compound left un-dissolved. The combined filtrates were concentrated under vacuum and recrystallized from water and ethanol (1:20) to afford 32.5 g of the desired product **40k** as pale yellow crystals. The mother liquor was concentrated and recrystallized again to afford another crop of 5.6 g.

i. To a suspension of **40k** (0.962 g, 3.4 mmol) in DMF (30 mL) and acetone (30 mL) was added 2,2-dimethoxypropane (4.2 mL, 98%, 34 mmol) and *p*-TsOH (650 mg, 98.5%, 3.4 mmol) and stirred at room temperature for 3 days. The reaction mixture was neutralized with 2N NaOH (aq.) and concentrated in vacuo to dryness. The residue was taken in water (90 mL) and extracted with ethyl acetate (3 x 30 mL). The organic layers were combined dried, filtered and concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel, 40 g, eluting with 0-100% CMA 80 in chloroform) to give **40l** (360 mg, 33%) as a yellow solid. ¹H NMR (300 MHz, DMSO-d₆) δ 7.83 (s, 1H), 7.67 (s, 2H), 6.87

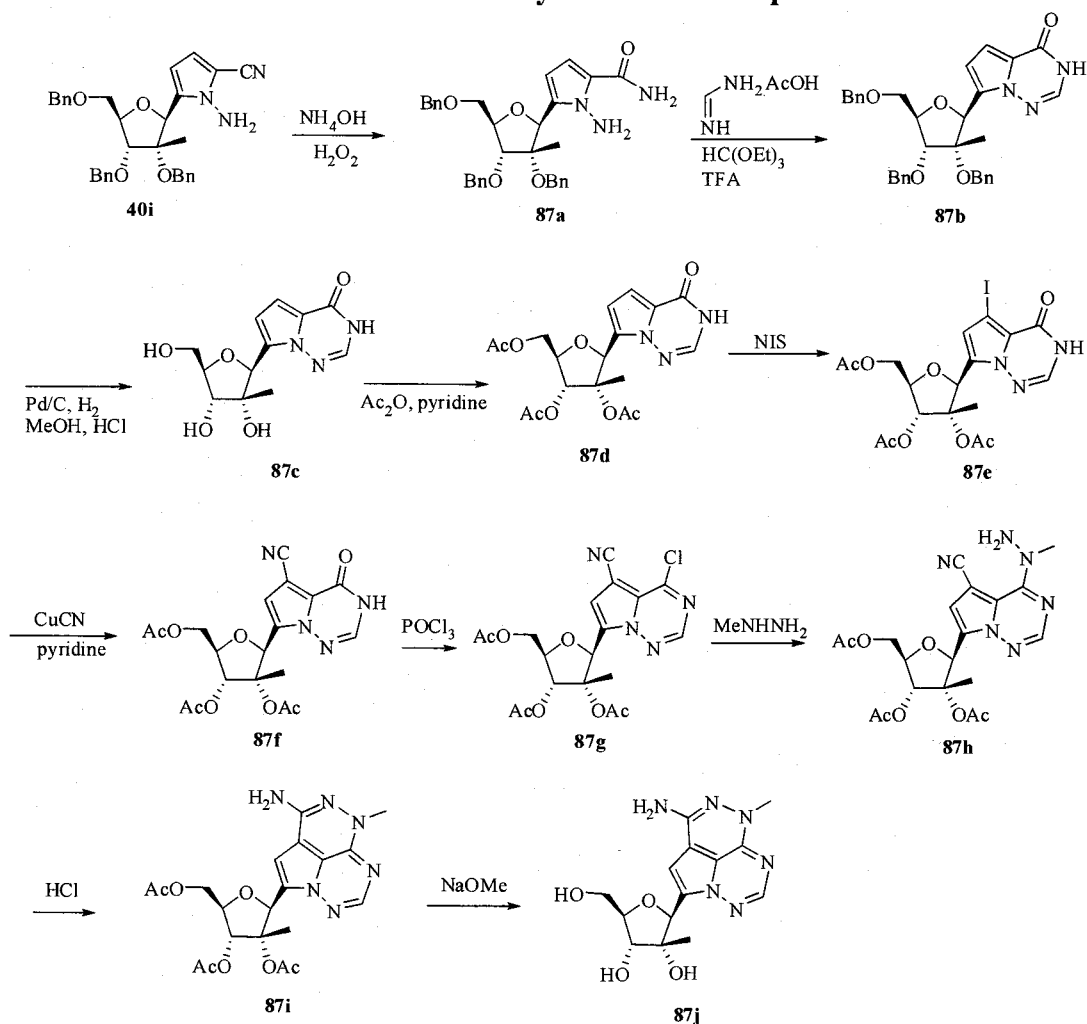
(d, $J = 4.5$, 1H), 6.63 (d, $J = 4.4$, 1H), 5.54 (s, 1H), 4.97 (t, $J = 5.7$, 1H), 4.37 (d, $J = 2.4$, 1H), 4.03 – 3.95 (m, 1H), 3.57 (dd, $J = 5.4$, 9.7, 2H), 1.55 (s, 3H), 1.33 (s, 3H), 1.15 (s, 3H).

j. To a solution of **40l** (375mg, 1.2 mmol) in DMF (10 mL) was added iodosuccinimide (290 mg, 1.3 mmol) and stirred at room temperature overnight. The reaction mixture was diluted with water (30 mL) and extracted with ethyl acetate (3 x 25 mL). The organic layers were combined washed with water (25 mL), brine (25 mL), dried, filtered, and concentrated in vacuo. The residue obtained was purified by flash column chromatography (silica gel 12 g, eluting with 0-100% CMA 80 in chloroform) to give **40m** (0.44 g, 83%) as an off white solid; MP 88-91 °C. ¹H NMR (300 MHz, DMSO- d_6) δ 7.88 (s, 1H), 6.91 (s, 1H), 5.50 (s, 1H), 4.98 (t, $J = 5.9$, 1H), 4.38 (d, $J = 2.5$, 1H), 4.02 (ddd, $J = 2.3$, 4.7, 7.2, 1H), 3.63 – 3.52 (m, 2H), 1.54 (s, 3H), 1.33 (s, 3H), 1.10 (s, 3H); MS (ES⁻) 444.83.

k. To a solution of **40m** (2.6 g, 5.8 mmol) in DMF (70 mL) was added copper iodide (440 mg, 2.3 mmol), methyl acrylate (22.7 ml, 252 mmol), triethylamine (3.5 mL, 25.2 mmol) and tetrakis(triphenylphosphine)Palladium (1.85 g, 1.16 mmol) and heated with stirring at 70°C for 3 days. The reaction was diluted with water (90 mL) and extracted with ethyl acetate (3 x 70 mL). The organic layers were combined washed with water (70 mL); brine (70 mL) dried, filtered, and concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel 110 g, eluting with 0-100% 9:1 EtOAc: MeOH in hexane) to give **40n** (0.43 g, 18 %) as a yellow solid. ¹H NMR (300 MHz, DMSO- d_6) δ 8.05 (d, $J = 15.4$, 1H), 7.94 (s, 1H), 7.61 (s, 2H), 7.27 (s, 1H), 6.45 (d, $J = 15.3$, 1H), 5.52 (s, 1H), 4.96 (t, $J = 6.0$, 1H), 4.40 (d, $J = 2.4$, 1H), 4.07 – 4.00 (m, 1H), 3.71 (s, 3H), 3.65 – 3.57 (m, 2H), 1.55 (s, 3H), 1.34 (s, 3H), 1.13 (s, 3H); MS (ES⁻) 402.8.

l. To a freshly prepared solution of sodium methoxide (69 mg sodium in 30 ml methanol, 0.1 M) in methanol was added **40n** (0.29 g, 0.72 mmol) and heated with stirring at reflux for 4 h and then at room temperature overnight. The reaction mixture neutralized with glacial acetic acid (0.18 mL) and the solid obtained was collected by filtration washed with methanol and dried in vacuo to furnish tricyclic product (**40o**, 0.126 g, 47%) as a yellow solid: ¹H NMR (300 MHz, DMSO- d_6) δ 11.15 (s, 1H), 8.04 (s, 1H), 7.14 (d, $J = 11.9$, 1H), 6.91 (s, 1H), 5.77 (d, $J = 11.9$, 1H), 5.44 (s, 1H), 5.01 (t, $J = 5.5$, 1H), 4.41 (d, $J = 2.3$, 1H), 4.05 (td, $J = 2.3$, 4.9, 1H), 3.58 (dt, $J = 5.6$, 11.5, 2H), 1.55 (s, 3H), 1.34 (s, 3H), 1.12 (s, 3H); MS (ES⁻) 370.9 (100%, M-1).

Scheme 87 for the Synthesis of Example 2

**Example 2**

5

Synthesis of 87j

A solution of **87i** (90 mg, 0.2 mmol) in methanol (1 mL) was added to a solution of freshly prepared NaOMe solution in methanol (0.17 M, 5 mL, 0.84 mmol) and stirred at room temperature overnight. The reaction mixture was neutralized by acetic acid (0.5 mL) and concentrated in vacuo. The residue obtained was purified by flash column chromatography (silica gel, 5 g, eluting with 0 to 100% CMA80 in chloroform) to yield **87j** (27 mg, 48%) as a bright yellow solid; mp 212 °C. ^1H NMR (300 MHz, DMSO-d_6) 7.51 (s, 1H), 6.53 (s, 1H), 6.37 (s, 2H), 5.12 (s, 1H), 5.01 (d, $J = 6.9$ Hz, 1H), 4.79 (s, 1H), 4.74 (t, $J = 5.4$ Hz, 1H), 3.84–3.67 (m, 2H), 3.60 (dd, $J = 4.7, 10.4$ Hz, 2H), 3.36 (s, 3H), 0.86 (s, 3H). MS (ES^+) 335.1.

15 The intermediate **87i** was prepared as follows:

a. To a solution of **40i** (11.1 g, 21.3 mmol) in EtOH (500 mL) was added conc. NH_4OH (28-30%, 200 mL) followed by dropwise addition of H_2O_2 (30% in H_2O , 7.2 mL). After the addition, the reaction mixture was stirred at room temperature overnight and concentrated in vacuo to dryness. The residue obtained was dissolved in chloroform (500 mL) washed with water, brine, dried, filtered and the filtrate was concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel 300 g, eluting with 0-100%, ethyl acetate in hexane) to furnish **87a** (3.45 g, 30%) as a brown oil. ^1H NMR (300 MHz, $\text{DMSO}-d_6/\text{D}_2\text{O}$) δ 7.45-7.26 (m, 15H), 6.67 (d, $J = 4.3$, 1H), 6.02 (d, $J = 4.3$, 1H), 5.29 (s, 1H), 4.66-4.55 (m, 6H), 4.15 (s, 1H), 3.92 (d, $J = 6.6$, 1H), 3.73 (m, 2H), 1.10 (s, 3H); MS (ES^+): 542.2.

b. To a solution of **87a** (3g, 5.5 mmol) in triethyl orthoformate (60 mL) was added TFA (0.43 mL, 5.5 mmol) and heated at 80 °C for 45 min. The reaction mixture was concentrated in vacuo to dryness and the residue obtained was purified by flash column chromatography (silica gel, eluting with hexanes/EtOAc, 1:0 to 1:1) to furnish **87b** (1.783 g, 58.4%) as a light brown syrup. ^1H NMR (300 MHz, $\text{DMSO}-d_6$): δ 11.70 (bs, 1H), 7.90 (d, $J = 3.1$ Hz, 1H), 7.43-7.24 (m, 15H), 6.85 (d, $J = 4.4$ Hz, 1H), 6.67 (d, $J = 4.4$ Hz, 1H), 5.57 (s, 1H), 4.80-4.56 (m, 6H), 4.27-4.13 (m, 1H), 4.01-3.96 (m, 1H), 3.82 (dd, $J = 2.6, 11.0$ Hz, 1H), 3.70 (dd, $J = 4.3, 11.0$ Hz, 1H), 1.07 (s, 3H); MS (ES^-): 550.0.

c. To a solution of **87b** (3.8 g, 6.9 mmol) in methanol (100 mL) was added Pd on carbon (10%, 580 mg) and conc. HCl (3 mL). The reaction mixture was hydrogenated at 50 psi for 4 h. The reaction mixture was filtered through a pad of Celite and the filtrate was concentrated in vacuo to dryness to furnish **87c** (2.18 g, 100%) as brown syrup which was pure enough to be used as such for next step. MS (ES^+): 282.1; (ES^-): 280.4.

d. To a solution of **87c** (2.18 g, 7.75 mmol) in pyridine (30 mL) was added acetic anhydride (6.5 mL, 69 mmol), DMAP (10 mg) and stirred at 70 °C overnight. The reaction mixture was cooled to room temperature, diluted with water (50 mL) and ethyl acetate (50 mL). The aqueous layer was separated and extracted with ethyl acetate (50 mL). The organic layers were combined, washed with water (50 mL), brine (50 mL), dried and concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel 80g, eluting with methanol in chloroform 0-20%) to afford **87d** (1.88g, 70%) as off white solid, MP 147-154 °C. ^1H NMR (300MHz, $\text{DMSO}-d_6$): δ 11.78 (s, 1H), 8.32 (s, 1H), 7.93 (s, 1H), 6.93 (d, $J = 4.4$ Hz, 1H), 6.62 (d, $J = 4.4$ Hz, 1H), 5.60 (s, 1H), 5.20 (d, $J = 4.1$ Hz, 1H), 4.47-4.32 (m,

1H), 4.21 (dd, $J = 7.8, 19.6$ Hz, 1H), 2.70 (s, 6H), 2.01 (s, 3H), 1.87 (s, 3H); MS (ES^+): 430.0 (M+Na).

5 e. To a solution of **87d** (1.08 g, 2.66 mmol) in dichloromethane (75 mL) at 0 °C was added *N*-iodosuccinimide (719.2 mg, 3.2 mmol). The reaction was allowed to warm to room temperature overnight and concentrated in vacuo. The residue obtained was purified by flash column chromatography (silica gel 40 g, eluting with 0 to 100% ethyl acetate in hexane) to afford **87e** (1.09 g, 77%) as an orange solid; mp 212 °C. 1H NMR (300 MHz, DMSO- d_6) δ 11.83 (s, 1H), 7.94 (s, 1H), 6.81 (s, 1H), 5.56 (s, 1H), 5.17 (d, $J = 4.2$ Hz, 1H), 4.35 (s, 1H), 4.20 (d, $J = 11.7$ Hz, 2H), 2.07 (d, $J = 2.2$ Hz, 6H), 2.00 (s, 3H), 1.39 (s, 3H).

15 f. To hot refluxing pyridine (14 mL) was added a solution of **87e** (1.09 g, 2.04 mmol) in pyridine (2 mL) and copper cyanide (2.15 g, 24 mmol). The reaction mixture was heated at reflux overnight, cooled to room temperature and diluted with water (50 mL) and ethyl acetate (50 mL). The insoluble inorganic impurities were removed by filtration; the aqueous layer was separated and extracted with ethyl acetate (2 x 100 mL). The organic layers were combined washed with brine (100 mL), dried, filtered, and concentrated in vacuo. The residue obtained was purified by flash column chromatography (silica gel, 20 g, eluting with 10 to 90% [9:1] of ethyl acetate:methanol in hexane) to yield **87f** (270 mg, 31%) as a colorless oil. 1H NMR (300 MHz, DMSO- d_6) δ 12.48 (s, 1H), 8.16 (s, 1H), 7.21 (s, 1H), 5.56 (s, 1H), 5.17 (s, 1H), 4.35 (s, 1H), 4.17 (s, 2H), 2.07 (s, 6H), 1.99 (s, 3H), 1.38 (s, 3H).

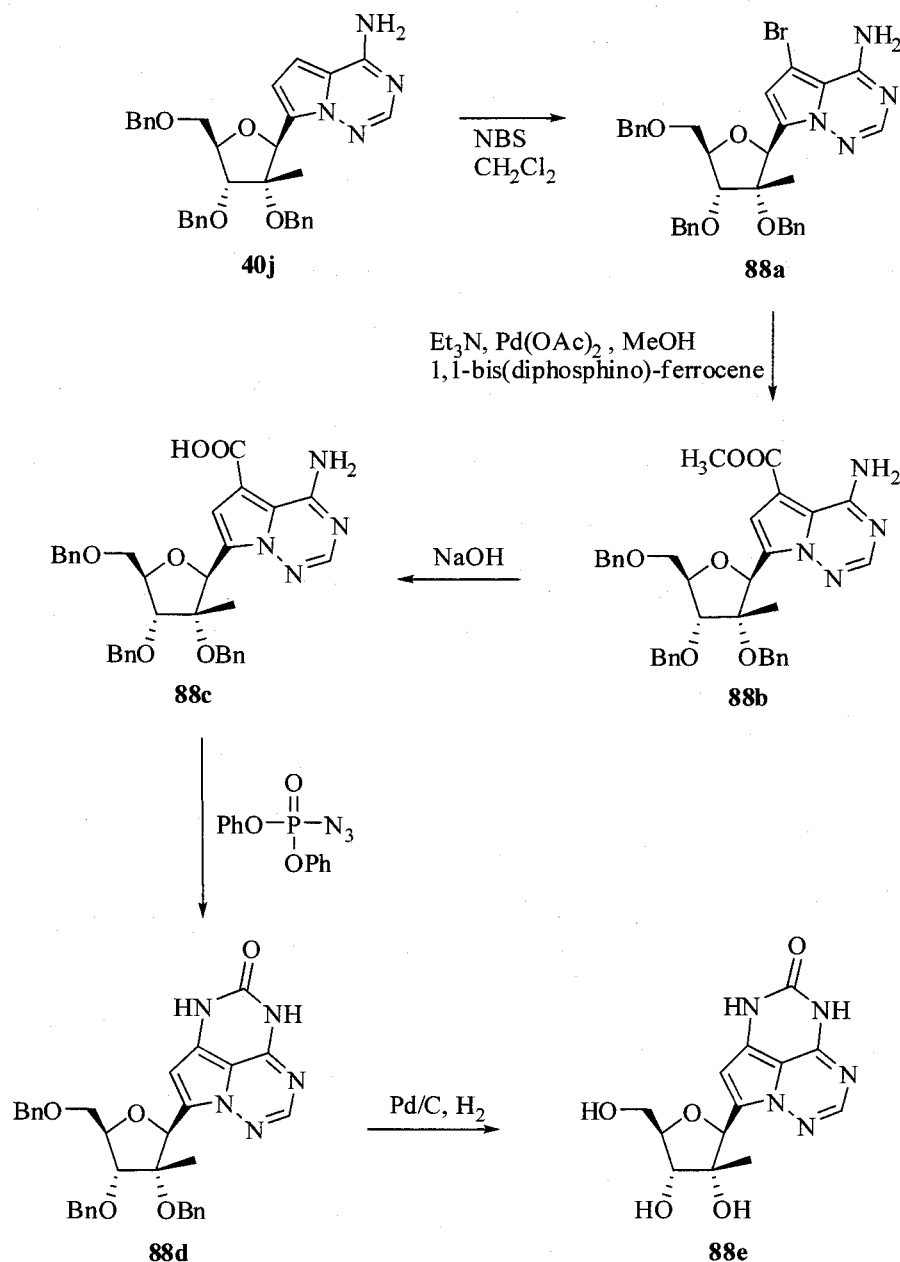
25 g. A solution of **87f** (460 mg, 1.06 mmol) in phosphorous oxychloride (10 mL) was heated at reflux temperature for 2 h. The reaction was cooled with ice water, quenched with ice water and stirred vigorously until all phosphorous oxychloride was destroyed. This aqueous layer was extracted with ethyl acetate (3 x 100 mL). The organic layers were combined washed with brine (100 mL), dried, filtered, and concentrated in vacuo to yield **87g** (653 mg).

30 h. To a solution of crude **87g** in chloroform (15 mL) and ethanol (30 mL) was added methyl hydrazine (0.1 mL, 1.74 mmol) and stirred at room temperature overnight. The reaction mixture was concentrated in vacuo and the residue purified by flash column chromatography (silica gel, 12 g, eluting with 0 to 100% [9:1] of ethyl acetate:methanol in hexane) to yield **87h** (140 mg, 28%) as a yellow solid. 1H NMR (300 MHz, DMSO- d_6) δ 8.07 (s, 1H), 7.27 (s, 1H), 5.75 (s, 1H), 5.48 (s, 2H), 5.21 (d, $J = 4.2$ Hz, 1H), 4.37 (s, 1H), 4.22 (d, $J = 11.6$ Hz, 2H), 3.36 (d, $J = 11.0$ Hz, 3H), 2.08 (s, 6H), 1.99 (s, 3H), 1.40 (s, 3H).

i. To a solution of **87h** (140 mg, 0.29 mmol) in ethanol (20 mL) was added concentrated hydrochloric acid (2 drops) and heated at reflux temperature for 2 h. The reaction mixture was concentrated in vacuo to give **87i** (90 mg, 64.3%).

5

Scheme 88 for the Synthesis of Example 3



Example 3

Synthesis of 88e

10

To a solution of **88d** (1.31 g, 2.21 mmol) in MeOH (110 mL) and EtOAc (60 mL) was added 1N HCl (9.5 mL), Pd/C (10%, 200 mg) and hydrogenated at 60 psi for 24 h. The reaction mixture was filtered through Celite, and the filtrate was concentrated in vacuo. The residue

obtained was purified by flash column chromatography (silica gel, eluting with CMA80/CMA50 1:0 to 1:1) to give **88e** (489 mg) as a yellow solid. The product obtained was triturated with water, collected by filtration and dried in vacuo to furnish **88e** (251 mg, 35%) as an off-white solid; mp 210 °C. ¹H NMR (300 MHz, DMSO-d₆): 11.07 (bs, 1H), 10.53 (bs, 1H), 7.70 (s, 1H), 6.18 (s, 1H), 5.16 (s, 1H), 4.95 (d, *J* = 6.1 Hz, 1H), 4.84 (t, *J* = 5.2 Hz, 1H), 4.80 (s, 1H), 3.80-3.65 (m, 3H), 3.61-3.50 (m, 1H), 0.84 (s, 3H); MS (ES⁺): 322.1.

The intermediate **88d** was prepared as follows:

10 a. To a solution of **40j** (100 mg, 0.18 mmol) in CH₂Cl₂ (9 mL) cold (ice water bath) was added NBS (32 mg, 0.18 mmol) and stirred at room temperature for 1 h. The reaction mixture was concentrated in vacuo and the residue obtained was purified by flash column chromatography (silica gel, eluting with chloroform/methanol, 1:0 to 20:1) to furnish **88a** (102 mg, 90%) as a yellow solid. ¹H NMR (300 MHz, DMSO-d₆): δ 7.89 (s, 1H), 7.42-7.25 (m, 15H), 6.91 (s, 1H), 5.64 (s, 1H), 4.74 (s, 2H), 4.66-4.52 (m, 4H), 4.22-4.16 (m, 1H), 4.03 (d, *J* = 8.7 Hz, 1H), 3.90-3.68 (m, 2H), 1.05 (s, 3H); MS (ES⁺): 631.3.

20 b. A solution of **88a** (35 g, 55.6 mmol) in methanol (350 mL) in a 2-L stainless steel bomb was added triethylamine (7.7 mL, 55.6 mmol), Pd(OAc)₂ (3.5 g) and 1,1-bis(diphosphino)-ferrocene (3.5 g). The bomb was vacuum flushed and charged with CO to 150 psi. The reactor was heated with stirring at 150°C overnight and cooled to room temperature. The catalyst was filtered through a pad of Celite and concentrated in vacuo to obtain crude product. The crude was purified by flash column chromatography (silica gel 1.2 kg, eluting with ethyl acetate in Hexane (0-50%, 2 L each) to give 10.7 g of **88b** as yellow semisolid. ¹H NMR (300 MHz, DMSO-d₆): δ 9.05 (s, 1H, exchangeable), 8.41 (s, 1H, exchangeable), 8.07 (s, 1H), 7.49-7.20 (m, 16H), 5.66 (s, 1H), 4.76 (s, 2H), 4.72-4.45 (m, 4H), 4.19 (s, 1H), 4.09-3.98 (m, 1H), 3.86 (d, *J* = 8.9, 1H), 3.76 (s, 3H), 3.75-3.68 (m, 1H), 1.09 (s, 3H); MS (ES⁺): 609.1.

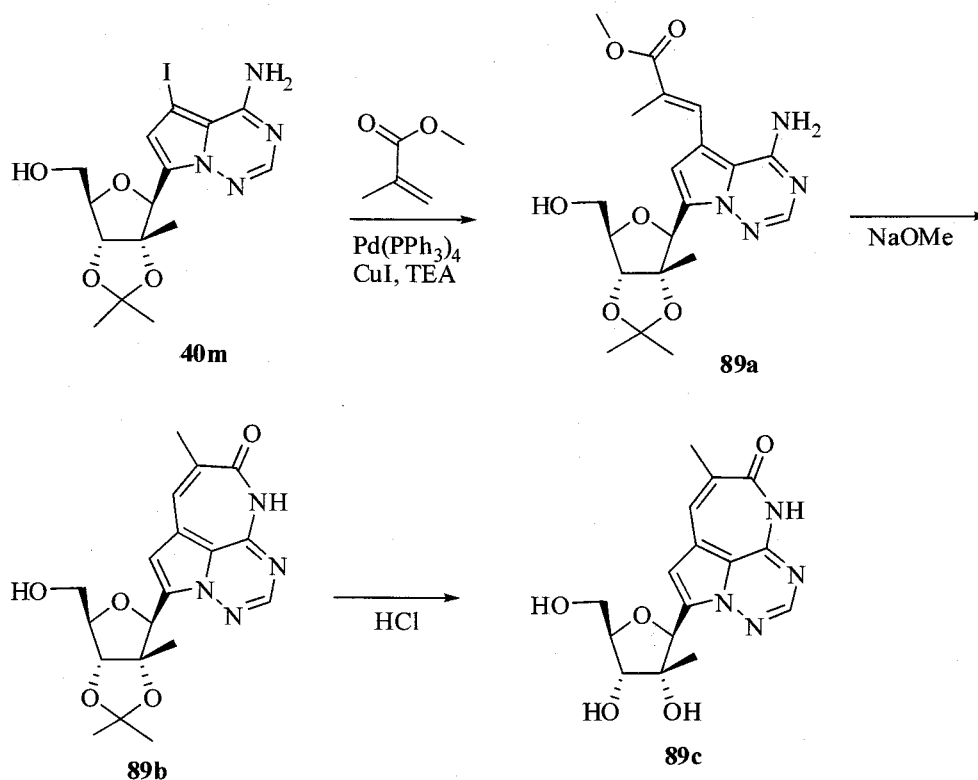
30 c. To a solution of **88b** (8.5 g, 14 mmol) in methanol (140 mL) was added THF (140 mL) and 1 N NaOH (140 mL). The reaction was heated with stirring at 40 °C for 1.5 h. The reaction mixture was concentrated in vacuo to remove methanol and THF. The pH was adjusted to 6 using 2.5N HCl and the aqueous layer was extracted twice with ethyl acetate (500mL and 200 mL). The organic layers were combined, dried and concentrated in vacuo to furnish crude product. The crude was purified by flash column chromatography (silica gel 200 g, eluting with 35 0-50 % CMA 80 in chloroform) to furnish **88c** (9.5 g, 100%) as a light yellow solid; MP 164 °C.

^1H NMR (300 MHz, DMSO- d_6) δ 13.37-12.95 (bs, 1H), 9.42 (s, 1H), 8.32 (s, 1H), 8.04 (s, 1H), 7.35 (dd, J = 13.6, 23.4 Hz, 15H), 5.66 (s, 1H), 4.68 (d, J = 42.2 Hz, 6H), 4.18 (s, 1H), 4.01 (d, J = 8.4 Hz, 1H), 3.83 (s, 2H), 3.33 (s, 1H), 1.07 (s, 3H); MS (ES^+): 595.0.

- 5 **d.** To a solution of **88c** (2 g, 3.36 mmol) in benzene (30 mL) was added triethylamine (0.54 mL, 3.87 mmol) and diphenyl phosphoryl azide (0.82 mL, 97%, 3.68 mmol) and heated at reflux for 14 h. The reaction mixture was cooled to room temperature and quenched with 1M NaHCO_3 (100 mL). The reaction mixture was extracted with EtOAc (2 x 200 mL). The combined organic extracts were washed with brine (150 mL), dried, filtered and concentrated in vacuo. The residue
- 10 obtained was purified by flash column chromatography (silica gel, chloroform/methanol, 1:0 to 20:1) to give **88d** (1.42 g, 71%) as a brown solid. ^1H NMR (300 MHz, DMSO- d_6): 11.17 (s, 1H), 10.55 (s, 1H), 7.72 (s, 1H), 7.40-7.20 (m, 15H), 6.11 (s, 1H), 5.41 (s, 1H), 4.70-4.52 (m, 6H), 4.18-4.10 (m, 1H), 3.96 (d, J = 7.7 Hz, 1H), 3.77-3.60 (m, 2H), 1.12 (s, 3H); MS (ES^+): 592.1.

15

Scheme 89 for the Synthesis of Example 4



Example 4**Synthesis of 89c**

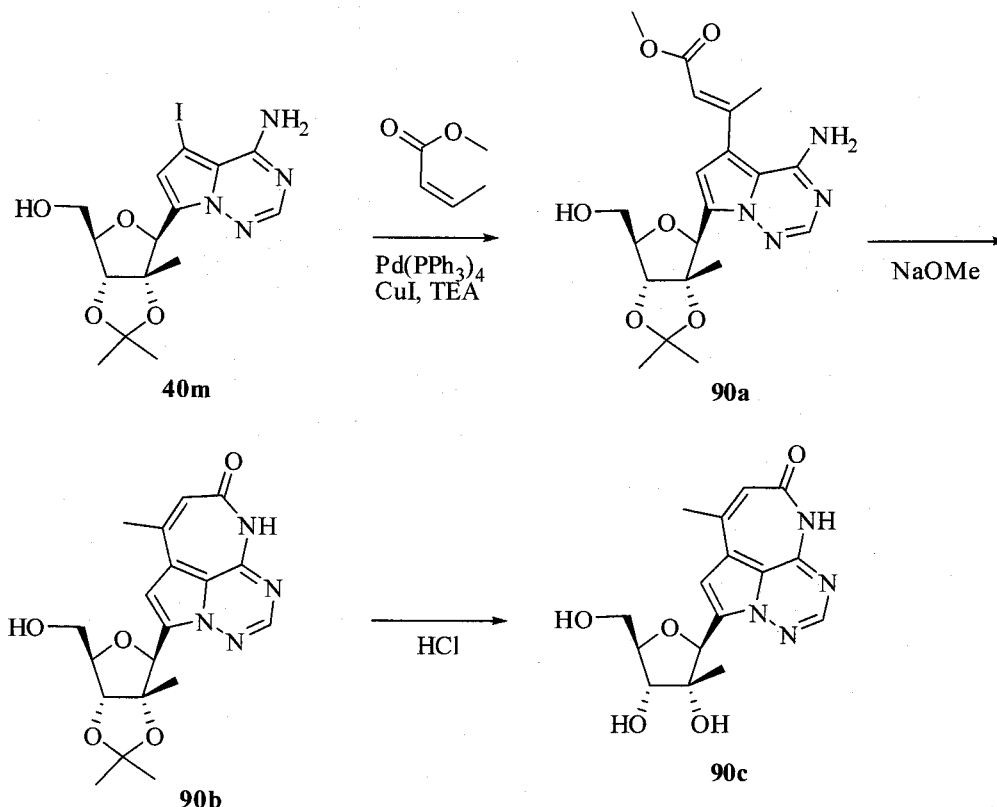
To a solution of tricyclic product **89b** (0.165 g, 0.43 mmol) in methanol (5 mL) was added aqueous 1 N HCl (5 mL) and stirred at room temperature overnight. The reaction mixture was concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel 12 g, eluting with 0-100% CMA 80 in chloroform) to give **89c** (0.014 g, 9 %) as a yellow solid; mp 169 °C. ¹H NMR (300 MHz, DMSO-d₆) δ 8.00–7.91 (m, 1H), 7.23–7.15 (m, 1H), 6.91–6.85 (m, 1H), 5.32–5.27 (m, 1H), 5.03–4.93 (m, 1H), 4.86–4.79 (m, 2H), 3.89–3.70 (m, 3H), 3.65–3.55 (m, 2H), 2.00–1.93 (m, 3H), 0.87–0.79 (m, 3H); MS (ES⁺) 344.8.

The intermediate **89b** was prepared as follows:

a. To a solution of **40m**, (2 g, 4.5 mmol) in DMF (20 mL) was added copper iodide (17 mg, 0.9 mmol), methyl methacrylate (9.5 ml, 90 mmol), triethylamine (1.25 mL, 9 mmol) and tetrakis(triphenylphosphine)Palladium (0.5 g, 0.45 mmol) and heated with stirring at 70 °C for 68 h. The reaction was diluted with water (60 mL) and extracted with ethyl acetate (3 x 25 mL). The organic layers were combined washed with water (25 mL), brine (25 mL), dried, filtered, and concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel 40 g, eluting with 0-100% [9:1] of EtOAc: MeOH in hexane) to give **89a** (0.615 g, 33 %) as a brown solid. ¹H NMR (300 MHz, DMSO-d₆) δ 7.93 (s, 1H), 7.84 (s, 1H), 7.35 (s, 2H), 6.86 (s, 1H), 5.56 (s, 1H), 5.00 (t, *J* = 5.8 Hz, 1H), 4.39 (d, *J* = 2.4 Hz, 1H), 4.10–4.00 (m, 1H), 3.73 (d, *J* = 4.6 Hz, 3H), 3.59 (t, *J* = 5.4 Hz, 2H), 2.07 (d, *J* = 1.2 Hz, 3H), 1.56 (s, 3H), 1.34 (s, 3H), 1.14 (s, 3H).

b. To a freshly prepared solution of sodium methoxide (1.57 mL, 0.1 M) in methanol (14 mL) was added **89a** (0.657 g, 1.57 mmol) and heated with stirring at reflux temperature overnight. The reaction mixture was neutralized with glacial acetic acid (0.3 mL) and concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel 12 g, eluting with 0-100% [9:1] of EtOAc: MeOH in hexane) to give **89b** (0.165 g, 27 %) as a yellow solid.

Scheme 90 for the Synthesis of Example 5

Example 5

5

Synthesis of 90c

To a solution of **90b** (0.050 g, 0.13 mmol) in methanol (0.5 mL) was added aqueous 1 N HCl (0.5 mL) and stirred at room temperature for 48 h. The reaction mixture was concentrated in vacuo to dryness. The solid obtained was triturated with ether, collected by filtration, washed with ether and dried in vacuo at acetone reflux temperature to furnish **90c** (0.008 g, 18 %) as an off white solid; mp 234 °C. ¹H NMR (300 MHz, DMSO-*d*₆) δ 11.33–10.90 (m, 1H), 8.05 (s, 1H), 7.13 (s, 1H), 5.80 (d, *J* = 1.2 Hz, 1H), 5.34 (s, 1H), 4.99 (s, 3H), 3.83–3.70 (m, 3H), 3.61 (dd, *J* = 4.2, 12.5 Hz, 1H), 2.20 (d, *J* = 1.1 Hz, 3H), 0.84 (s, 3H); MS (ES⁺) 344.9.

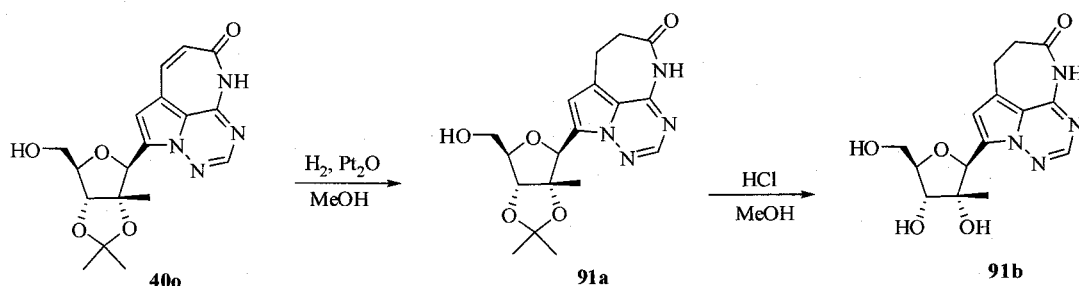
15 Intermediate **90b** was prepared as follows:

a. To a solution of **40m** (1.3 g, 3 mmol) in DMF (25 mL) was added copper iodide (110 mg, 0.6 mmol), methyl crotonate (6.36 mL, 60 mmol), triethylamine (0.84 mL, 6 mmol) and tetrakis(triphenylphosphine) palladium (0.350 g, 0.3 mmol) and heated at 70 °C for 48 h. The reaction was diluted with water (75 mL) and extracted with ethyl acetate (2 x 25 mL). The organic layers were combined, washed with water (2 x 25 mL), brine (25 mL), dried, filtered,

and concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel 40 g, eluting with 0-100% [9:1] of EtOAc: MeOH in hexane) to give **90a** (0.565 g, 46 %). ^1H NMR (300 MHz, DMSO- d_6) δ 7.95 (d, J = 2.8 Hz, 2H), 6.87 (s, 1H), 5.78 (d, J = 1.3 Hz, 1H), 5.56 (s, 1H), 4.98 (t, J = 5.8 Hz, 1H), 4.39 (d, J = 2.5 Hz, 1H), 4.07–3.98 (m, 1H), 3.65 (s, 3H), 3.59 (t, J = 5.4 Hz, 2H), 3.33 (s, 1H), 2.55 (d, J = 1.1 Hz, 3H), 1.56 (s, 3H), 1.34 (s, 3H), 1.15 (s, 3H).

b. To a freshly prepared solution of sodium methoxide (0.67 mL, 0.1 M) in methanol (6 mL) was added **90a** (0.280 g, 0.67 mmol) and heated with stirring at reflux overnight. The reaction mixture was concentrated in vacuo and the residue obtained was purified by flash column chromatography (silica gel 4 g, eluting with 0-100% CMA 80 in chloroform) to give **90b** (0.100 g, 39 %) as a yellow solid; mp 152 °C. ^1H NMR (300 MHz, DMSO- d_6) δ 11.14 (s, 1H), 8.06 (s, 1H), 6.97 (s, 1H), 5.82 (s, 1H), 5.47 (s, 1H), 5.01 (t, J = 5.9 Hz, 1H), 4.41 (d, J = 2.5 Hz, 1H), 4.11–4.01 (m, 1H), 3.62 (t, J = 5.3 Hz, 2H), 2.22 (d, J = 1.1 Hz, 3H), 1.56 (s, 3H), 1.34 (s, 3H), 1.12 (s, 3H); MS (ES $^-$) 384.9.

Scheme 91 for the Synthesis of Example 6



Example 6

Synthesis of 91b

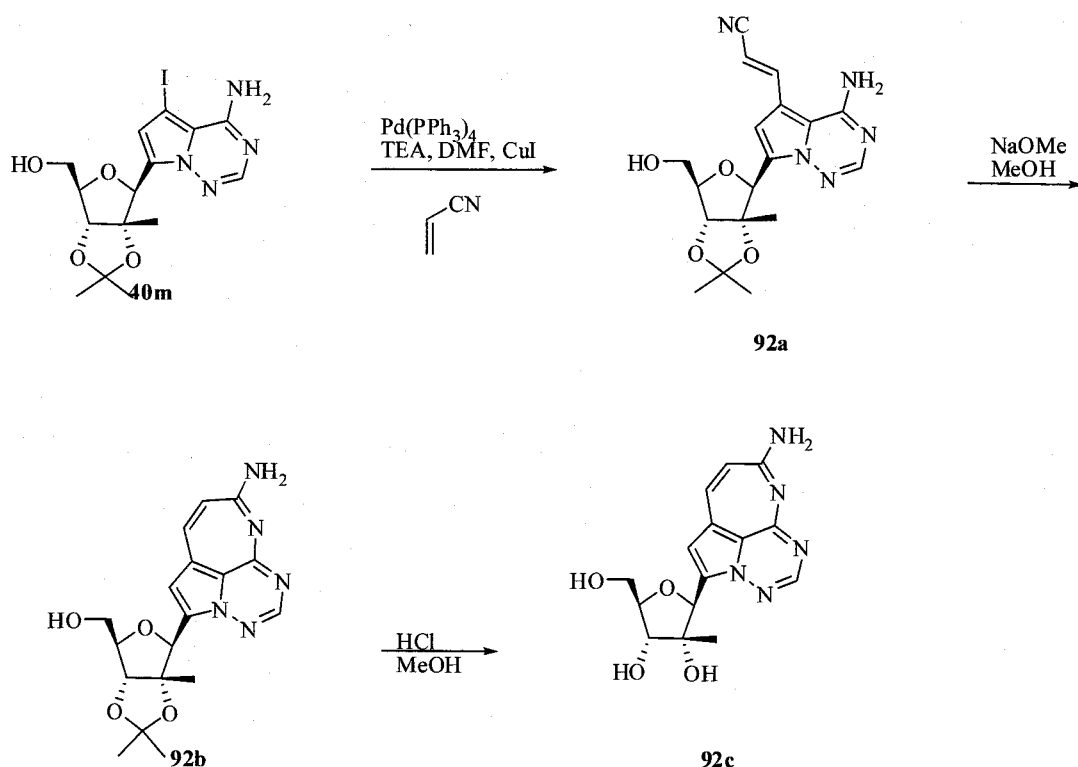
To a solution of tricyclic product **91a** (20 mg, 0.05 mmol) in methanol (0.5 mL) was added aqueous 1 N HCl (0.5 mL) and stirred at room temperature overnight. The reaction mixture was concentrated in vacuo to dryness to furnish **91b** (19 mg, 100%) as a white solid; mp 59-64 °C. ^1H NMR (300 MHz, DMSO- d_6) δ 8.73–8.30 (m, 2H), 8.02 (s, 1H), 6.79 (s, 1H), 5.32 (s, 1H), 4.06–3.84 (m, 3H), 3.75 (d, J = 11.7 Hz, 3H), 3.63 (d, J = 8.8 Hz, 2H), 3.14 (d, J = 7.3 Hz, 2H), 0.77 (s, 3H); MS (ES $^-$) 332.9.

Intermediate **91a** was prepared as follows.

To a solution of tricyclic product **40o** (100 mg, 0.27 mmol) in methanol (100 mL) was added platinum oxide (50 mg) and hydrogenated at 50 psi for 3 days. The catalyst was removed by filtration through a pad of Celite and the filtrate concentrated in vacuo to give crude product.

- 5 The crude residue was purified by flash column chromatography (silica gel 4 g, eluting with $\text{CHCl}_3/\text{CMA-80}$, 0-100%) to furnish crude **91a** (64 mgs). The crude material was recrystallized from methanol (2 mL) to furnish pure **91a** (25 mg, 25%) as a white solid. ^1H NMR (300 MHz, $\text{DMSO}-d_6$) δ 11.02 (s, 1H), 8.17 (s, 1H), 6.78 (s, 1H), 5.58 (s, 1H), 5.00 (s, 1H), 4.40 (s, 1H), 4.05 (s, 1H), 3.58 (s, 2H), 3.02 (s, 2H), 2.91 (s, 2H), 1.56 (s, 3H), 1.34 (s, 3H), 1.14 (s, 3H); MS
- 10 (ES^+) 375.0, (ES^-) 373.3.

Scheme 92 for the synthesis of Example 7



15

Example 7

Synthesis of 92c

- To a solution of tricyclic product **92b** (220 mg, 0.59 mmol) in methanol (4 mL) was added aqueous 1 N HCl (4 mL) and stirred at room temperature overnight. The reaction mixture was concentrated in vacuo to dryness. The residue obtained was triturated with ether and the solid obtained was collected by filtration, washed with ether and dried in vacuo at acetone reflux
- 20

temperature to furnish **92c** (145 mg, 74 %) as a mustard solid; mp 152-159 °C. ¹H NMR (300 MHz, DMSO-d₆) δ 12.60 (s, 1H), 9.76 (s, 1H), 9.27 (s, 1H), 8.02 (s, 1H), 7.55 (d, *J* = 11.6 Hz, 1H), 7.13 (s, 1H), 6.39 (d, *J* = 11.6 Hz, 1H), 5.23 (s, 1H), 4.99–4.20 (m, 3H), 3.77 (d, *J* = 10.1 Hz, 2H), 3.70–3.57 (m, 2H), 0.87 (s, 3H); MS (ES⁺) 332.0, (ES⁻) 329.9.

5

Intermediate **92b** was prepared as follows.

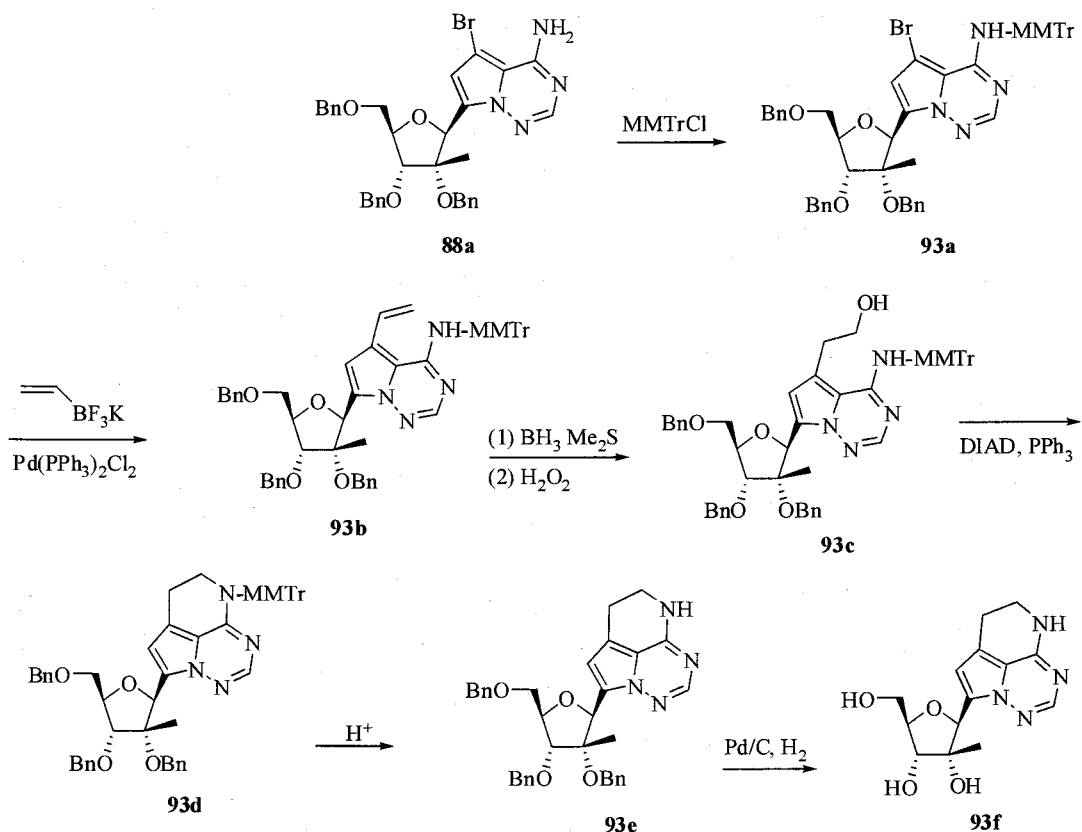
a. To a solution of **40m** (2.23 g, 4.99 mmol) in DMF (70 mL) was added copper iodide (380 mg, 1.99 mmol), triethylamine (3 mL, 21.8 mmol) and tetrakis(triphenylphosphine) palladium (1.15 g, 1 mmol). To the suspension was added acrylonitrile (14.3 mL, 217 mmol) in 4 portions over a period of 3 h and heated with stirring at 70 °C for 3 days. The reaction was diluted with water (210 mL) and extracted with ethyl acetate (3 x 70 mL). The organic layers were combined, washed with water (70 mL), brine (70 mL) dried, filtered, and concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel, 110 g, eluting with 0-100% [9:1] of EtOAc: MeOH in hexane) to give **92a** (619 mg, 33%) as a mustard-colored solid; mp 238 °C. ¹H NMR (300 MHz, DMSO-d₆) δ 8.15 (d, *J* = 15.9 Hz, 1H), 7.74 (s, 2H), 7.42 (s, 1H), 7.20 (s, 1H), 6.19 (d, *J* = 15.7 Hz, 1H), 5.51 (s, 1H), 4.96 (t, *J* = 5.8 Hz, 1H), 4.39 (d, *J* = 2.4 Hz, 1H), 4.03 (d, *J* = 2.4 Hz, 1H), 3.66–3.55 (m, 2H), 1.55 (s, 3H), 1.33 (s, 3H), 1.12 (s, 3H); IR (KBr) 2209 cm⁻¹; MS (ES⁻) 370.1.8.

20

To a freshly prepared solution of sodium methoxide (36 mg sodium in 1.6 mL methanol, 0.1 M) was added **92a** (0.58 g, 1.56 mmol) and heated with stirring at reflux for 4 h and then at room temperature overnight. The reaction mixture was neutralized with glacial acetic acid (0.094 mL) and concentrated in vacuo to dryness. The residue obtained was purified by flash column chromatography (silica gel 12g, eluting with CHCl₃/CMA-80, 0-100%) to furnish **92b** (265 mg, 44%) as a rust solid; mp 112-114 °C. ¹H NMR (300 MHz, DMSO-d₆) δ 8.05 (s, 1H), 7.96 (s, 1H), 7.68 (s, 1H), 6.99 (d, *J* = 11.4 Hz, 1H), 6.60 (s, 1H), 5.73 (d, *J* = 11.5 Hz, 1H), 5.34 (s, 1H), 4.98 (t, *J* = 5.7 Hz, 1H), 4.37 (d, *J* = 2.4 Hz, 1H), 4.03–3.98 (m, 1H), 3.64–3.48 (m, 2H), 1.52 (s, 3H), 1.33 (s, 3H), 1.12 (s, 3H); MS (ES⁺) 372.1, (ES⁻) 369.9.

30

Scheme 93 for the Synthesis of Example 8

**Example 8****Synthesis of 93f**

To a suspension of **93e** (310 mg, 0.54 mmol) in MeOH was added 1N aqueous HCl (1.8 mL) Pd/C (10%, 100 mg) and hydrogenated at 60 psi for 25 h. The reaction mixture was filtered and the filtrate was concentrated in vacuo. The residue obtained was purified by flash column chromatography (silica gel, 30 g, eluting with chloroform/CMA80, 1:0 to 1:1) to furnish **93f** (137 mg, 83%) as a white solid; mp: 254.2 °C. ¹H NMR (300 MHz, DMSO-*d*₆) δ 7.96 (s, 1H), 7.78 (s, 1H), 6.50 (s, 1H), 5.28 (s, 1H), 4.92 (d, *J* = 6.7 Hz, 1H), 4.76 (t, *J* = 5.4 Hz, 1H), 4.71 (s, 1H), 3.80-3.67 (m, 3H), 3.65-3.50 (m, 3H), 2.95-2.85 (m, 2H), 0.83 (s, 3H).; MS (ES⁺): 307.1.

Intermediate **93e** was prepared as follows.

a. To a solution of **42a** (27.85 g, 44.23 mmol) in pyridine (400 mL) was added 4-methoxytriphenylmethyl chloride (56.74 g, 178.24 mmol) and heated with stirring at 70 °C for 16 h. The reaction mixture was diluted with EtOAc (1.5 L), washed with water (2 x 700 mL) and brine (500 mL), dried, filtered, and concentrated. The residue was purified by flash column chromatography (silica gel eluting with hexanes/EtOAc, 1:0 to 4:1) to give **93a** (28.38 g, 71%),

as a light yellow solid; mp 78.6 °C. ¹H NMR (300 MHz, DMSO-d₆): δ 7.91 (s, 1H), 7.63 (s, 1H), 7.45-7.12 (m, 27H), 6.96 (s, 1H), 6.87 (d, *J* = 8.9 Hz, 2H), 5.56 (s, 1H), 4.74-4.50 (m, 6H), 4.20-4.12 (m, 1H), 4.02 (d, *J* = 8.5 Hz, 1H), 3.87-3.64 (m, 2H), 3.71 (s, 3H), 1.05 (s, 3H).

5 **b.** To a solution of **93a**, (26.1 g, 28.94 mmol) in DME (500 mL) was added potassium vinyltrifluoroborate (7.2 g, 53.75 mmol), NaHCO₃ (7.2 g, 85.70 mmol), Pd(PPh₃)₂Cl₂ (1.4 g, 98%, 1.99 mmol), H₂O (65 mL) and refluxed for 6 h. The reaction mixture was diluted with water (500 mL) and extracted with EtOAc (1.8 L and 0.5 L). The organic layers were combined and washed with brine (500 mL), dried, filtered, and concentrated in vacuo. The residue was
10 purified by flash column chromatography (silica gel eluting with hexanes/EtOAc, 1:0 to 6:1) to furnish **93b** (18.3 g, 74%) as a light yellow solid; mp 79.7 °C. ¹H NMR (300 MHz, DMSO-d₆) δ 7.56 (s, 1H), 7.44-7.12 (m, 28H), 7.01 (dd, *J* = 17.2, 11.0 Hz, 1H), 6.93 (s, 1H), 6.84 (d, *J* = 8.8 Hz, 2H), 5.57 (s, 1H), 5.31 (d, *J* = 17.2 Hz, 1H), 5.16 (d, *J* = 11.0 Hz, 1H), 4.76-4.52 (m, 6H), 4.22-4.13 (m, 1H), 4.04 (d, *J* = 8.4 Hz, 1H), 3.88-3.70 (m, 2H), 3.71 (s, 3H), 1.05 (s, 3H); MS
15 (ES⁺): 847.6.

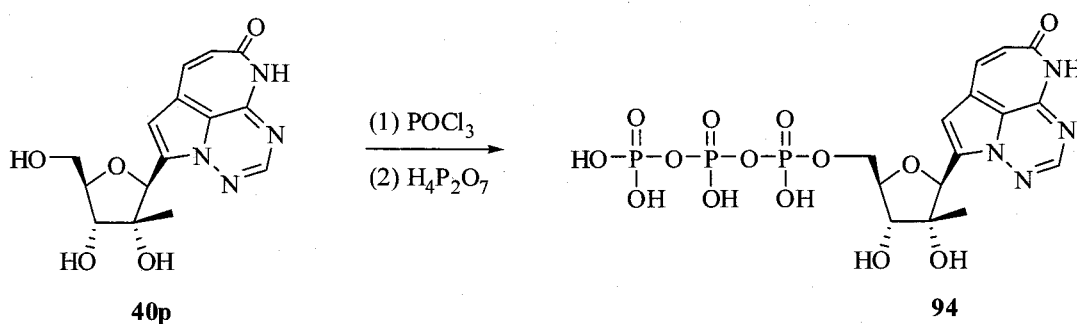
c. To a cold (ice water bath) solution of **93b** (20.5 g, 24.15 mmol) in THF (90 mL) was added dropwise borane dimethyl sulfide solution (2M in THF, 9.5 mL) and stirred at room temperature for 4 h. The reaction mixture was quenched with ethanol (19 mL), aqueous 3N
20 NaOH (6.0 mL), and cooled with ice/water. To the cold reaction mixture was added hydrogen peroxide (30% in water, 6 mL) and heated at reflux for 1 h. The reaction mixture was cooled to room temperature, diluted with ethyl acetate (1L), washed with water (2 x 500 mL), brine (300 ml), dried and concentrated in vacuo. The residue obtained was purified by flash column chromatography (silica gel, eluting with ethyl acetate in hexane 1:0 to 2:1) to give **93c** (11.17 g,
25 53%) as a yellow solid. ¹H NMR (300 MHz, DMSO-d₆) δ 8.95 (s, 1H), 7.45 (s, 1H), 7.42-7.22 (m, 27H), 6.81 (d, *J* = 9.0 Hz, 2H), 6.62 (s, 1H), 5.57 (s, 1H), 5.51 (t, *J* = 3.7 Hz, 1H), 4.76-4.48 (m, 6H), 4.20-4.10 (m, 1H), 4.04 (d, *J* = 8.4 Hz, 1H), 3.91-3.66 (m, 2H), 3.71 (s, 3H), 3.58-3.46 (m, 2H), 2.97-2.86 (s, 2H), 1.03 (s, 3H).

30 **d.** To a solution of **93c** (1.0 g, 1.15 mmol) and triphenylphosphine (610 mg, 2.30 mmol) in 1,4-dioxane (15 mL) was added dropwise a solution of DIAD (0.5 mL, 95%, 2.41 mmol) in 1,4-dioxane (2.5 mL) and stirred at room temperature for 16 h. The reaction mixture was concentrated in vacuo and the residue obtained was purified by flash column chromatography (silica gel 50 g, eluting with ethyl acetate in hexane 1:0 to 4:1) to give **93d** (730 mg, 75%) as a
35 white solid. ¹H NMR (300 MHz, DMSO-d₆): δ 7.68 (s, 1H), 7.49-7.15 (m, 27H), 6.86 (d, *J* = 9.0

Hz, 2H), 6.59 (s, 1H), 5.53 (s, 1H), 4.80–4.45 (m, 6H), 4.22–4.10 (m, 1H), 4.02 (d, $J = 7.9$ Hz, 1H), 3.86–3.64 (m, 2H), 3.72 (s, 3H), 3.60–3.34 (m, 2H), 3.18–2.92 (m, 2H), 1.08 (s, 3H).; MS (ES^+): 671.1 ($\text{M} + \text{Na}$).

- 5 e. To a solution of **93d** (618 mg, 0.73 mmol) in acetonitrile (35 mL) was added aqueous 1N HCl (3.5 mL) and stirred at room temperature for 17 h. The reaction mixture was neutralized with aqueous 0.5 N NaOH, diluted with water (50 mL), and concentrated in vacuo to remove acetonitrile. The aqueous layer was extracted with $\text{CHCl}_3/\text{MeOH}$ (5:1, 100 mL and 50 mL). The combined organic extracts were dried, filtered and concentrated in vacuo. The residue obtained
10 was purified by flash column chromatography (silica gel 30 g, eluting with hexane/ethyl acetate/methanol, 1:1:0 to 1:1:0.1) to give **93e** (362 mg, 86%) as a white solid. ^1H NMR (300 MHz, $\text{DMSO}-d_6$) δ 8.01 (s, 1H), 7.81 (s, 1H), 7.41–7.27 (m, 15H), 6.53 (s, 1H), 5.55 (s, 1H), 4.77–4.49 (m, 6H), 4.26–4.12 (m, 1H), 4.04 (d, $J = 8.1$ Hz, 1H), 3.85–3.65 (m, 2H), 3.60–3.48 (m, 2H), 2.83 (t, $J = 6.5$ Hz, 2H), 1.10 (s, 3H); MS (ES^+): 577.1.

Scheme 94 for the Synthesis of Example 9



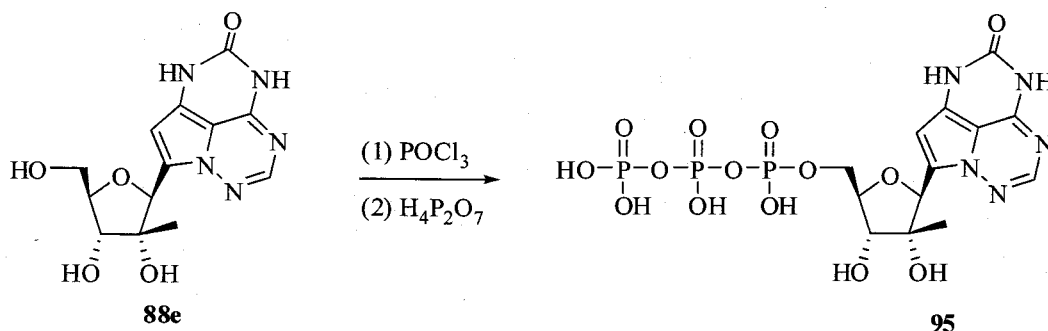
Example 9

Synthesis of 94

- To a suspension of **40p** (33 mg, 0.1 mmol) in trimethylphosphate (1 mL) at 0°C was added phosphorus oxychloride (19 μL , 0.21 mmol) and stirred at 0°C for 1 h. The reaction mixture was treated with *n*-tributylamine (70 μL , 0.29 mmol), acetonitrile (100 μL),
25 tributylammonium pyrophosphate ($\text{H}_4\text{P}_2\text{O}_7 \cdot 1.6 \text{ } n\text{-Bu}_3\text{N}$, 190 mg, 0.40 mmol) and stirred at room temperature for 0.5 h. The reaction mixture was quenched with 1M TEAB buffer (5 mL, pre-cooled with ice/water, pH = 8.0), diluted with water (20 mL), and washed with dichloromethane (2 x 15 mL). The aqueous solution was concentrated in vacuo to remove traces of CH_2Cl_2 and purified by DEAE ion exchange column chromatography with a linear gradient
30 of TEAB buffer (1M TEAB buffer, pH = 8.0/ H_2O , 0:1 to 1:0, total volume: 500 mL). The

fractions containing the desired triphosphate were combined and concentrated. The residue was re-dissolved in H₂O and purified by HPLC (CH₃CN/0.1 M TEAB buffer, pH = 8.0, 0-30 min; 0-35% CH₃CN; monitoring at 238 nm) to give **94** (t_R = 18.7 min). Fractions containing **94** were concentrated and re-dissolved in 2 mL of H₂O and the concentration of **94** was measured to be 0.34 mM (yield: 0.7%) by UV (240 nm, ϵ = 58,000 M⁻¹ cm⁻¹). ¹H NMR (300 MHz, D₂O) δ 7.79 (s, 1H), 7.19 (d, J = 12.0 Hz, 1H), 7.02 (s, 1H), 5.78 (d, J = 12.0 Hz, 1H), 5.46 (s, 1H), 4.04 (s, 2H), 4.50-3.50 (m, 2H), 0.91 (s, 3H). ³¹P NMR (121 MHz, D₂O): δ -8.8 (1P), -11.0 (1P), -22.3 (1P). MS (ES⁻): 570.9 (M-1).

Scheme 95 for the Synthesis of Example 10



Example 10

Synthesis of 95

To a suspension of **95e** (64 mg, 0.2 mmol) in trimethylphosphate (2 mL) at 0 °C was added phosphorus oxychloride (37 μ L, 0.4 mmol) and stirred at 0 °C for 1 h. The reaction mixture was treated with *n*-tributylamine (150 μ L, 0.62 mmol), acetonitrile (200 μ L), tributylammonium pyrophosphate (H₄P₂O₇•1.6 *n*-Bu₃N, 380 mg, 0.8 mmol) and stirred at room temperature for 0.5 h. The reaction mixture was quenched with 1M TEAB buffer (10 mL, pre-cooled with ice water, pH = 8.0), diluted with water (20 mL), and washed with dichloromethane (2 x 15 mL). The aqueous phase was concentrated in vacuo to remove the trace of CH₂Cl₂ and purified by DEAE ion exchange column chromatography with a linear gradient of TEAB buffer (1M TEAB buffer, pH = 8.0/H₂O, 0:1 to 1:0, total: 500 mL). The fractions containing the desired triphosphate were combined and concentrated. The residue was re-dissolved in H₂O and purified by HPLC (CH₃CN/0.1 M TEAB buffer, pH = 8.0, 0-40 min, 0-35% CH₃CN; monitoring at 244 nm) to give **95** (t_R = 17.2 min). Fractions containing **95** were concentrated and re-dissolved in 2 mL of H₂O and the concentration of **95** was measured to be 9.8 mM (yield: 10%) by UV (280 nm, ϵ = 6,400 M⁻¹ cm⁻¹). ¹H NMR (300 MHz, D₂O) δ 7.53 (s, 1H), 6.40 (s, 1H),

5.31 (s, 1H), 4.32-4.00 (m, 4H), 0.93 (s, 3H); ^{31}P NMR (D_2O) δ -10.69 (d, J = 19.4 Hz, 1P), -11.26 (d, J = 20.6 Hz, 1P), -23.24 (t, J = 19.4 Hz, 1P). MS (ES $^-$): 560.1 (M-1).

Example 11

5 The following illustrate representative pharmaceutical dosage forms, containing a compound of Formula I, or a pharmaceutically acceptable salt or prodrug thereof ('Compound X'), for therapeutic or prophylactic use in humans.

	<u>(i) Tablet 1</u>	<u>mg/tablet</u>
10	Compound X=	100.0
	Lactose	77.5
	Povidone	15.0
	Croscarmellose sodium	12.0
	Microcrystalline cellulose	92.5
15	Magnesium stearate	<u>3.0</u>
		300.0
	<u>(ii) Tablet 2</u>	<u>mg/tablet</u>
	Compound X=	20.0
20	Microcrystalline cellulose	410.0
	Starch	50.0
	Sodium starch glycolate	15.0
	Magnesium stearate	<u>5.0</u>
		500.0
25	<u>(iii) Capsule</u>	<u>mg/capsule</u>
	Compound X=	10.0
	Colloidal silicon dioxide	1.5
	Lactose	465.5
30	Pregelatinized starch	120.0
	Magnesium stearate	<u>3.0</u>
		600.0
	<u>(iv) Injection 1 (1 mg/ml)</u>	<u>mg/ml</u>
35	Compound X= (free acid form)	1.0
	Dibasic sodium phosphate	12.0
	Monobasic sodium phosphate	0.7
	Sodium chloride	4.5
	1.0 N Sodium hydroxide solution	
40	(pH adjustment to 7.0-7.5)	q.s.
	Water for injection	q.s. ad 1 mL

	(v) Injection 2 (10 mg/ml)	<u>mg/ml</u>
	Compound X= (free acid form)	10.0
	Monobasic sodium phosphate	0.3
	Dibasic sodium phosphate	1.1
5	Polyethylene glycol 400	200.0
	01 N Sodium hydroxide solution (pH adjustment to 7.0-7.5)	q.s.
	Water for injection	q.s. ad 1 mL
10	(vi) Aerosol	<u>mg/can</u>
	Compound X=	20.0
	Oleic acid	10.0
	Trichloromonofluoromethane	5,000.0
	Dichlorodifluoromethane	10,000.0
15	Dichlorotetrafluoroethane	5,000.0

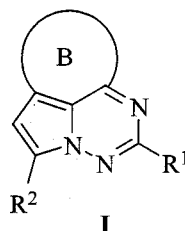
The above formulations may be obtained by conventional procedures well known in the pharmaceutical art.

All publications, patents, and patent documents are incorporated by reference herein, as though individually incorporated by reference. The invention has been described with reference to various specific and preferred embodiments and techniques. However, it should be understood that many variations and modifications may be made while remaining within the spirit and scope of the invention.

CLAIMS

What is claimed:

1. A compound of formula I:



wherein;

B represents a 5, 6, 7 or 8 membered carbocyclic or heterocyclic ring comprising one or more double bonds, wherein B is optionally substituted with one or more oxo, thioxo, NR_cR_d , F, Cl, Br, I, OR_z , SR_z , alkyl, $\text{C}\equiv\text{N}$, $\text{C}\equiv\text{C-R}$, N_3 or $\text{SO}_2\text{R}'$;

wherein:

R is H, alkyl or aryl;

R' is OH, NH_2 or alkyl;

R^1 is H, NR_aR_b , Cl, F, OR_a , SR_a , NHCOR_a , NHSO_2R_a , NHCONHR_a , CN, alkyl, aryl, ONR_aR_b , or $\text{NR}_a\text{C(O)OR}_b$;

R^2 is a nucleoside sugar group;

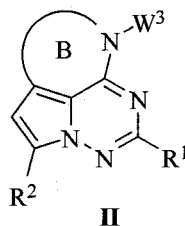
W^3 is absent, alkyl, or H;

R_a and R_b are independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, heterocyclic, aryl, substituted aryl, acyl, substituted acyl, SO_2 -alkyl, amino, substituted amino, and NO; or R_a and R_b together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring;

R_c and R_d are independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, acyl, substituted acyl and SO_2 -alkyl; or R_c and R_d together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring; and

each R_z is independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, acyl and substituted acyl; or a pharmaceutically acceptable salt or prodrug thereof.

2. The compound of claim 1 wherein the compound of formula I is a compound of formula II:



5 wherein;

B represents a 5, 6, 7 or 8 membered ring comprising one or more heteratatoms and one or more double bonds, wherein B is optionally substituted with one or more oxo, thioxo, NR_cR_d , F, Cl, Br, I, OR_z , SR_z , alkyl, $\text{C}\equiv\text{N}$, $\text{C}\equiv\text{C-R}$, N_3 or $\text{SO}_2\text{R}'$;

wherein:

10 R is H, alkyl or aryl;

R' is OH, NH_2 or alkyl;

R¹ is H, NR_aR_b , Cl, F, OR_a , SR_a , NHCOR_a , NHSO_2R_a , NHCONHR_a , CN, alkyl, aryl, ONR_aR_b , or $\text{NR}_a\text{C}(\text{O})\text{OR}_b$;

R² is a nucleoside sugar group;

15 W³ is absent, alkyl, or H;

R_a and R_b are independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, heterocyclic, aryl, substituted aryl, acyl, substituted acyl, SO_2 -alkyl, amino, substituted amino, and NO; or R_a and R_b together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring;

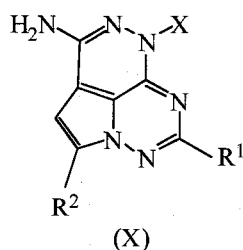
R_c and R_d are independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, acyl, substituted acyl and SO_2 -alkyl; or R_c and R_d together with the nitrogen to which they are attached form a pyrrolidino, piperidino, piperazino, azetidino, morpholino, or thiomorpholino ring; and

25 each R_z is independently selected from the group consisting of H, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, cycloalkyl, acyl and substituted acyl; or a pharmaceutically acceptable salt or prodrug thereof.

3. The compound of claim 2 wherein W³ is absent or H.

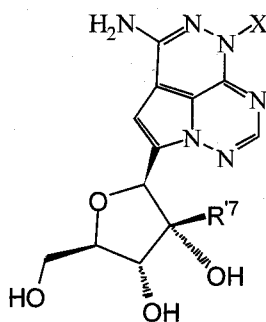
30

4. The compound of any one of claims 1-3 wherein the compound is not a compound of the following formula (X):



or a pharmaceutically acceptable salt or prodrug thereof; wherein X is H or alkyl.

5. The compound of any one of claims 1-3 wherein the compound is not a compound of the following formula:

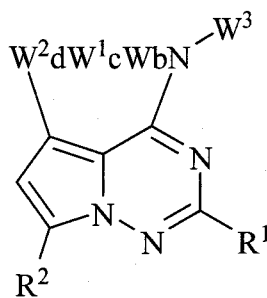


or a pharmaceutically acceptable salt or prodrug thereof; wherein X is H or methyl ; and R⁷ is H or methyl.

6. The compound of any one of claims 1-3 wherein the compound is not a 6 membered ring comprising two nitrogens and one double bond, wherein B is substituted with NR_cR_d.

7. The compound of any one of claims 1-3 wherein B is a 5, 7, or 8 membered ring comprising one or more heteratoms and one or more double bonds, wherein B is optionally substituted with one or more oxo, thioxo, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R'.

8. A compound of claim 1 which is a compound of formula III:



(III)

wherein:

5 each b, c and d is independently selected from a single and double bond provided that when b is a double bond, c is single bond, when c is a double bond, b and d are single bonds and when d is a double bond c is a single bond; or d is absent when W² is absent; and W² and d are not absent, when bNW³ is absent;

10 W is C=R_e, CH₂, CR_g or O, provided that when W is C=R_e, CH₂ or O, b and c are single bonds, or c is a single bond and bNW³ is absent; and provided when W is CR_g, one of b or c is a double bond, or bNW³ is absent and c is a double bond;

R_e is O or S;

R_g is H, NR_cR_d, OR_z or SR_z;

15 W¹ is C=R_h, CR_iR_{i'}, N, NR_n, CR_j or O provided that when W¹ is C=R_h, CR_iR_{i'}, NR_n or O, c and d are single bonds or c is a single bond and W²d is absent; and provided when W¹ is CR_j or N one of c or d is a double bond or W²d is absent and c is a double bond;

R_h is O or S;

R_i and R_{i'} are H, CH₃, NH₂ or Br;

R_j is CH₃, NH₂, or H;

20 W² is C=R_k, (CR_lR_{l'})_{p'}, CR_m, O, NR_s, absent or N provided that when W² is C=R_k, CR_lR_{l'}, O, or NR_s d is a single bond; when W² is N or CR_m d is a double bond; and provided when W² is absent, d is absent;

R_k is O or S;

R_l and R_{l'} are H, CH₃, OCH₃, NH₂ or SCH₃;

25 p' is 1 or 2;

R_m is H, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R';

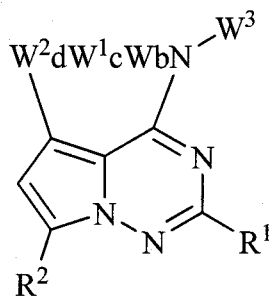
R_n is H, alkyl, or NR_qR_r wherein each R_q and R_r is H or alkyl;

R_s is H, CH₃, or NH₂; and

W³ is absent, H or alkyl; provided that when W³ is absent b is a double bond;

30 or a pharmaceutically acceptable salt or prodrug thereof.

9. A compound of claim 1 which is a compound of formula IV:



(IV)

wherein:

- 5 each b, c and d is independently selected from a single or double bond provided that when b is a double bond, c is single bond, when c is a double bond, b and d are single bonds and when d is a double bond c is a single bond; or d is absent when W² is absent;
- W is C=R_e, CR_fR_f, CR_g or O, provided that when W is C=R_e, CR_fR_f or O, b and c are single bonds and when W is CR_g, one of b or c is a double bond;
- 10 R_e is O or S;
R_f is H;
R_g is H, NR_cR_d, OR_z or SR_z;
- W¹ is C=R_h, CR_iR_i, NH, CR_j or O provided that when W¹ is C=R_h, CR_iR_i, or O, c and d are single bonds; when W¹ is CR_j, one of c or d is a double bond; and when W¹ is NH, W is not
- 15 O and W² is not O, NH, or N;
- R_h is O or S;
R_i and R_i' are H, CH₃ or Br;
R_j is CH₃ or H;
- W² is C=R_k, (CR_lR_l')_p, CR_m, O, NH, absent, or N provided that when W² is C=R_k, CR_lR_l', CR_m, O, or NH d is a single bond; when W² is N or CR_m d is a double bond; or when W² is absent, d is absent;
- 20 R_k is O or S;
R_l and R_l' are H, CH₃, OCH₃ or SCH₃;
p' is 1 or 2;
- 25 R_m is H, NR_cR_d, F, Cl, Br, I, OR_z, SR_z, alkyl, C≡N, C≡C-R, N₃ or SO₂R'; and
W³ is absent, H or alkyl; provided that when W³ is absent b is a double bond;
or a pharmaceutically acceptable salt or prodrug thereof.

10. The compound of formula IV as described in claim 9 wherein:

each b, c and d is independently selected from a single or double bond provided that when b is a double bond, c is single bond, when c is a double bond, b and d are single bonds and when d is a double bond c is a single bond;

5 W is $C=R_e$, CR_fR_f , CR_g or O, provided that when W is $C=R_e$, CR_fR_f or O, b and c are single bonds and when W is CR_g , one of b or c is a double bond;

R_e is O or S;

R_f is H;

R_g is H, NR_cR_d , OR_z or SR_z ;

10 W^1 is $C=R_h$, CR_iR_i , CR_j or O provided that when W^1 is $C=R_h$, CR_iR_i , or O, c and d are single bonds and when W^1 is CR_j , one of c or d is a double bond;

R_h is O or S;

R_i and R_i are H, CH_3 or Br;

R_j is CH_3 or H;

15 W^2 is $C=R_k$, $(CR_lR_l)_{p'}$, CR_m , O, NH or N provided that when W^2 is $C=R_k$, CR_lR_l , CR_m , O, or NH d is a single bond and when W^2 is N or CR_m d is a double bond;

R_k is O or S;

R_l and R_l are H, CH_3 , OCH_3 or SCH_3 ;

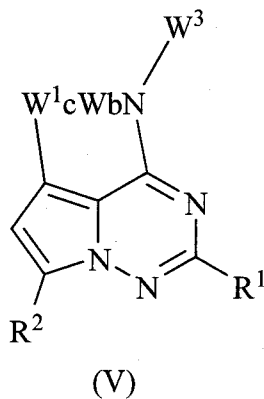
p' is 1 or 2;

20 R_m is H, NR_cR_d , F, Cl, Br, I, OR_z , SR_z , alkyl, $C\equiv N$, $C\equiv C-R$, N_3 or SO_2R' ; and

W^3 is absent or H, provided that when W^3 is absent b is a double bond;

or a pharmaceutically acceptable salt or prodrug thereof.

11. The compound of any one of claims 1-4 wherein the compound of formula I is a compound
25 of formula V:



wherein:

each of b and c is independently selected from a single or double bond provided that when b is a double bond, c is single bond and when c is a double bond b is a single bond;

W is C=R_e, CR_fR_f, CR_g or O, provided that when W is C=R_e, CR_fR_f or O, b and c are single bonds and when W is CR_g, one of b or c is a double bond;

5 R_e is O or S;

R_f is H;

R_g is H, NR_cR_d, OR_z or SR_z;

W¹ is C=R_h, CR_iR_i, NH, CR_j or O provided that when W¹ is C=R_h, CR_iR_i, or O, c is a single bond; when W¹ is CR_j, c is a double bond; and when W¹ is NH, W is not O;

10 R_h is O or S;

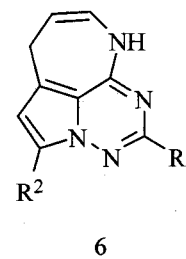
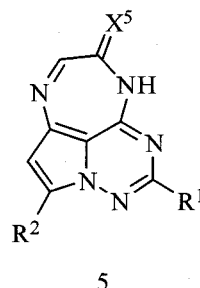
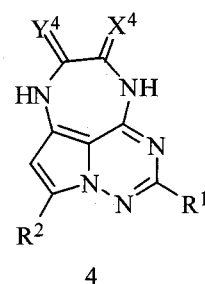
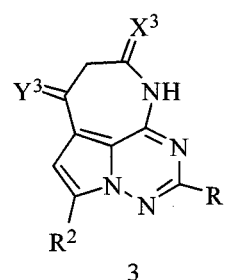
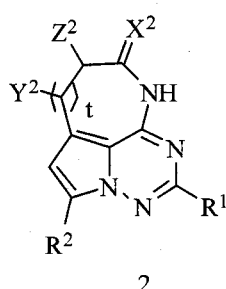
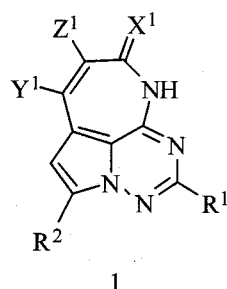
R_i and R_i are each independently H, CH₃ or Br;

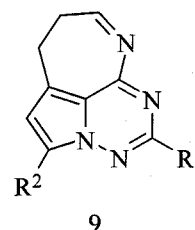
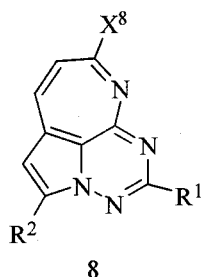
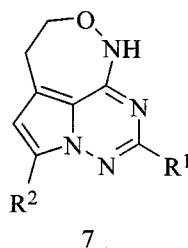
R_j is CH₃ or H; and

W³ is absent, H, or alkyl, provided that when W³ is absent b is a double bond; or a pharmaceutically acceptable salt or prodrug thereof.

15

12. A compound of claim 1 which is a compound of formula 1-9:





wherein:

X^1 is O, S, or two hydrogens;

X^2 is O, S, or two hydrogens;

5 X^3 is O or S;

X^4 is O, S, or two hydrogens;

X^5 is O, S, or two hydrogens;

X^8 is H, NH_2 , OCH_3 or SCH_3 ;

10 Y^1 is H, OH, NH_2 , $NHCH_3$, $N(CH_3)_2$, F, Cl, Br, I, alkoxy, alkyl SCH_3 , $C\equiv N$, $C\equiv C-R$, N_3 or SO_2R' ;

Y^2 is H, CH_3 , OCH_3 or SCH_3 ;

Y^3 is O or S;

Y^4 is O, S, or two hydrogens;

Z^1 is H or CH_3 ;

15 Z^2 is H, CH_3 or Br; and

t is 1 or 2;

or a pharmaceutically acceptable salt or prodrug thereof.

13. The compound of claim 12 which is a compound of formula 1 or a pharmaceutically acceptable salt or prodrug thereof.

14. The compound of claim 12 which is a compound of formula 2 or a pharmaceutically acceptable salt or prodrug thereof.

15. The compound of claim 12 which is a compound of formula 3 or a pharmaceutically acceptable salt or prodrug thereof.

16. The compound of claim 12 which is a compound of formula 4 or a pharmaceutically acceptable salt or prodrug thereof.

17. The compound of claim 12 which is a compound of formula 5 or a pharmaceutically acceptable salt or prodrug thereof.

18. The compound of claim 12 which is a compound of formula 6 or a pharmaceutically acceptable salt or prodrug thereof.

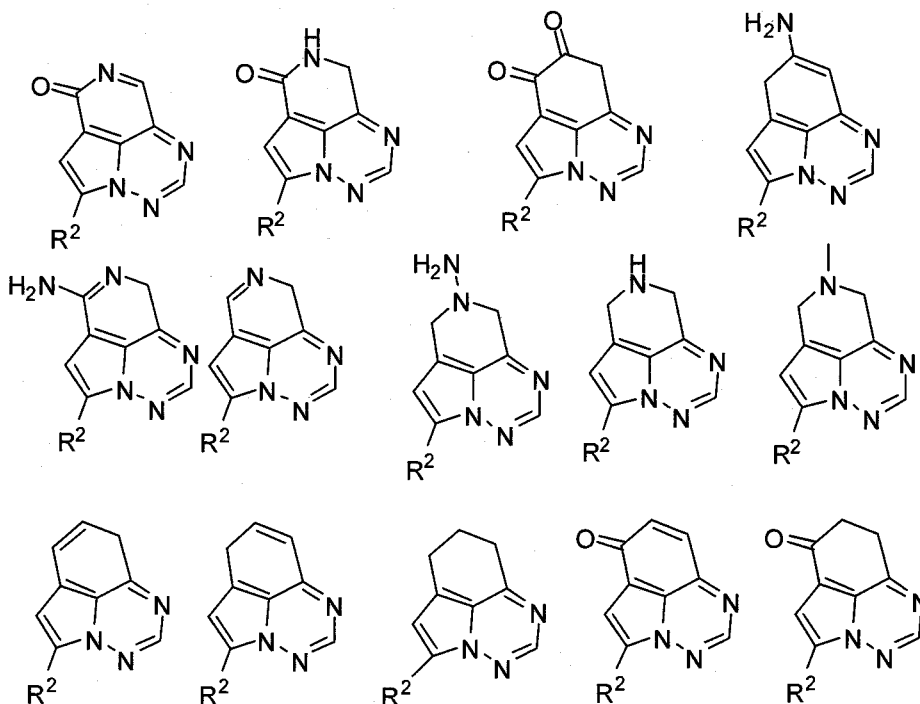
19. The compound of claim 12 which is a compound of formula 7 or a pharmaceutically acceptable salt or prodrug thereof.

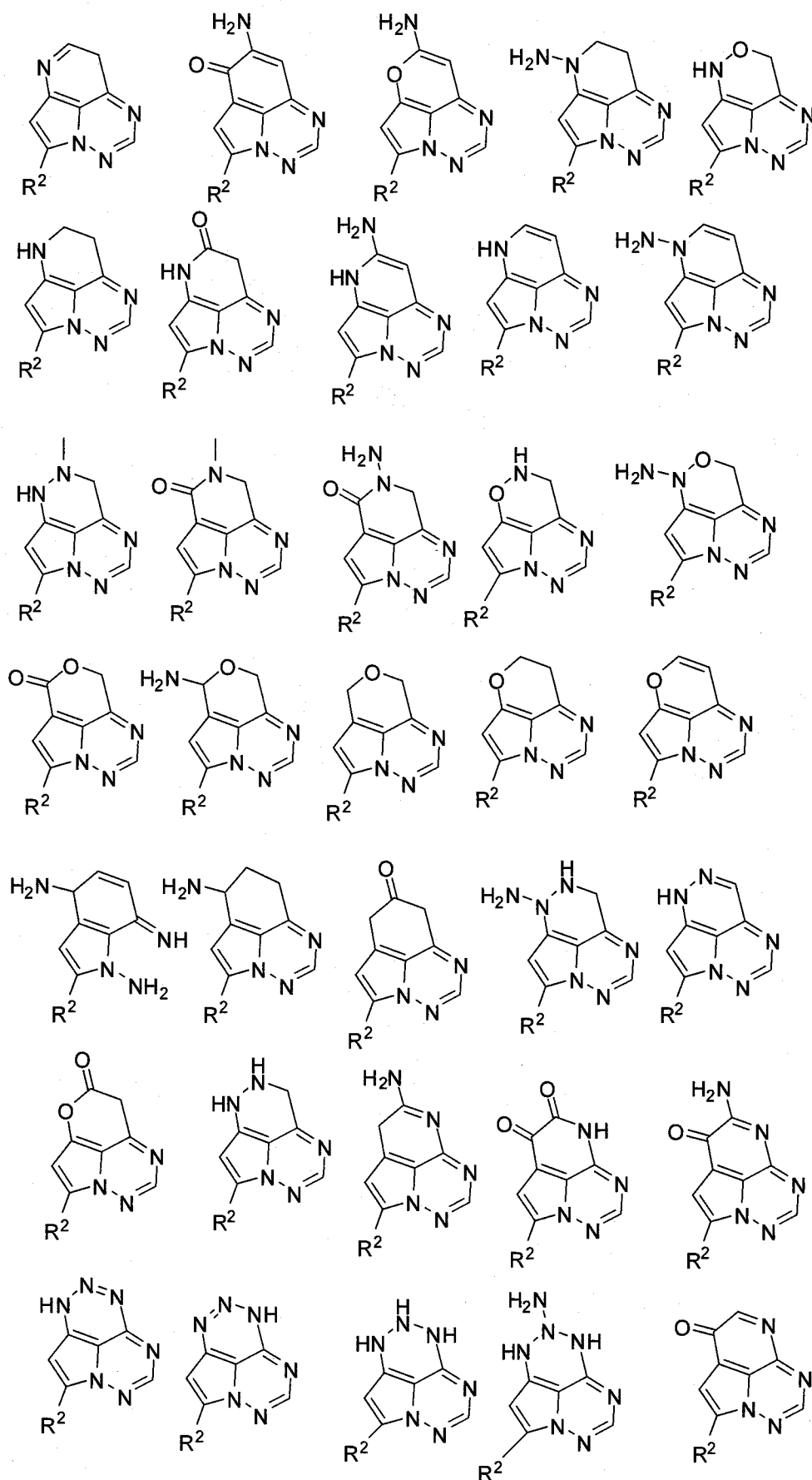
20. The compound of claim 12 which is a compound of formula 8 or a pharmaceutically acceptable salt or prodrug thereof.

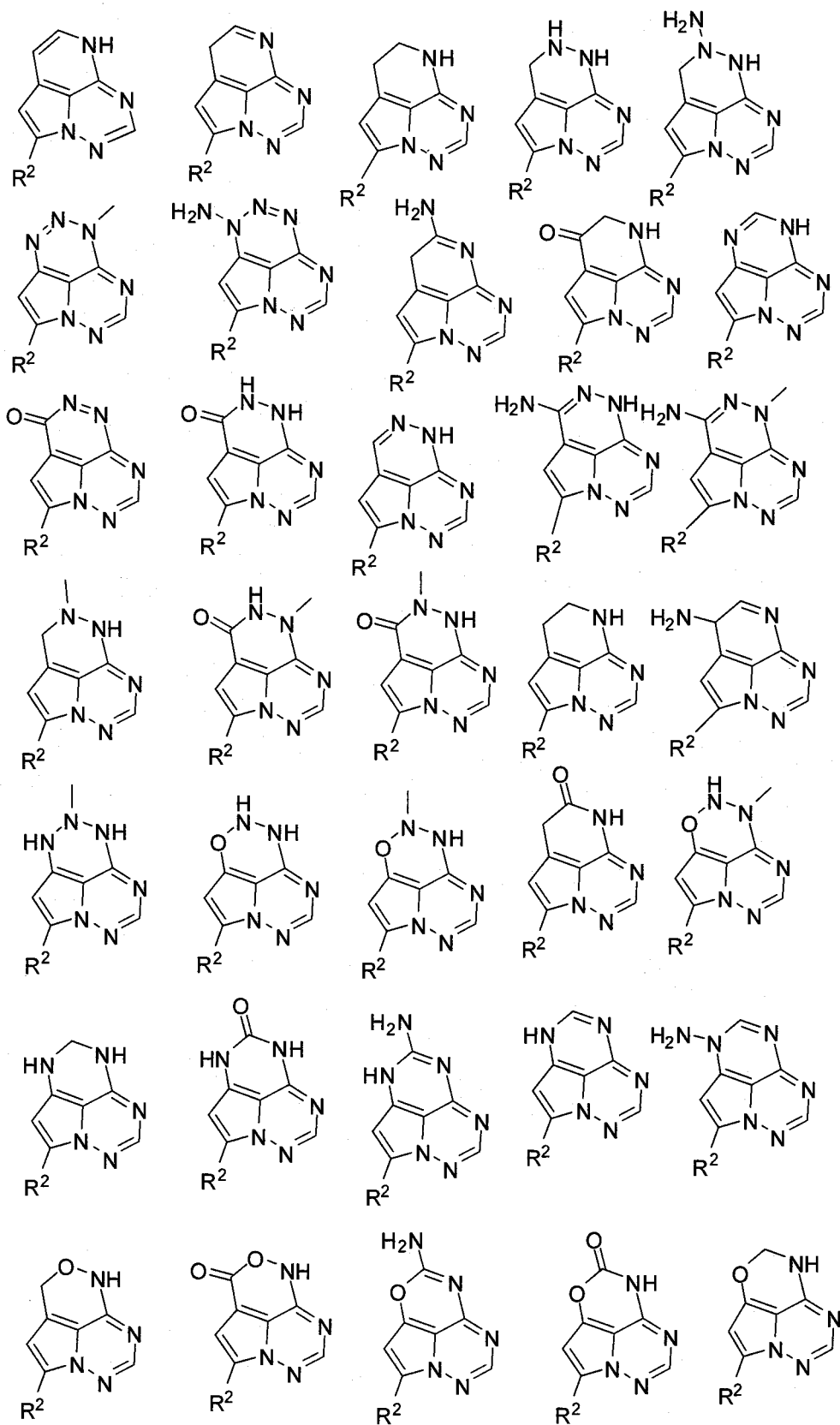
21. The compound of claim 12 which is a compound of formula 9 or a pharmaceutically acceptable salt or prodrug thereof.

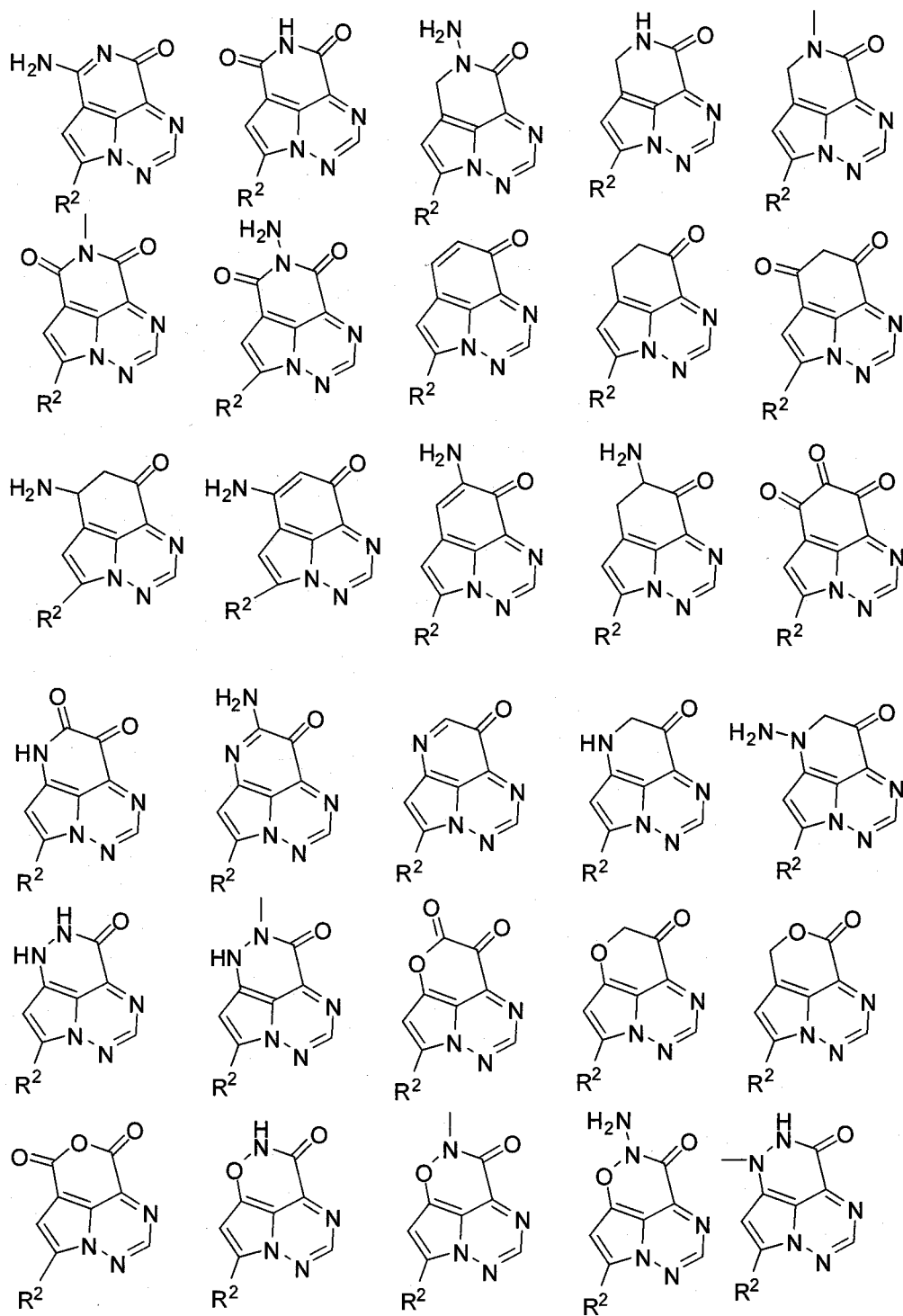
22. The compound of any one of claims 1-21 wherein R^1 is H or NR_aR_b .

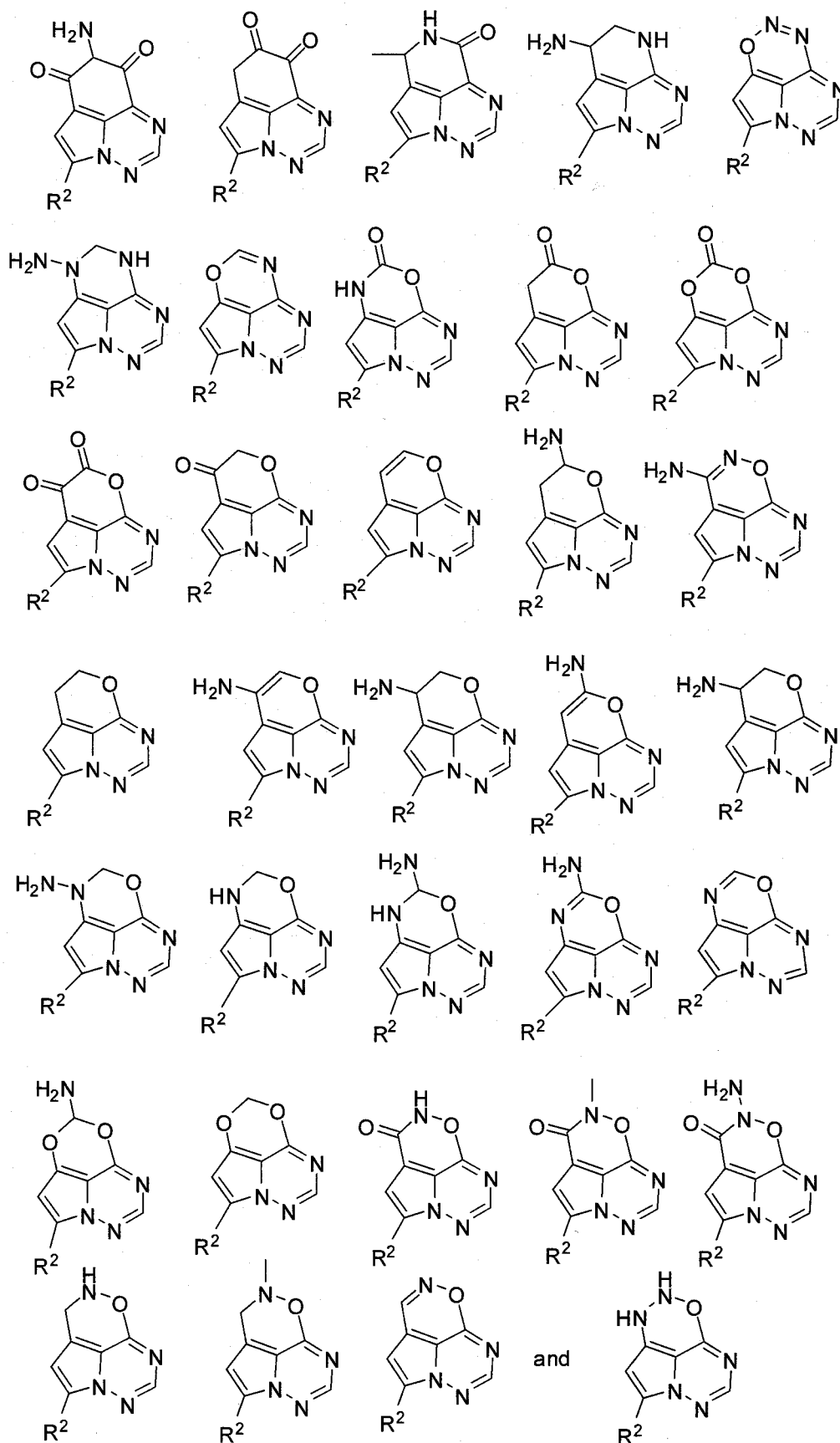
23. The compound of claim 1 which is selected from,





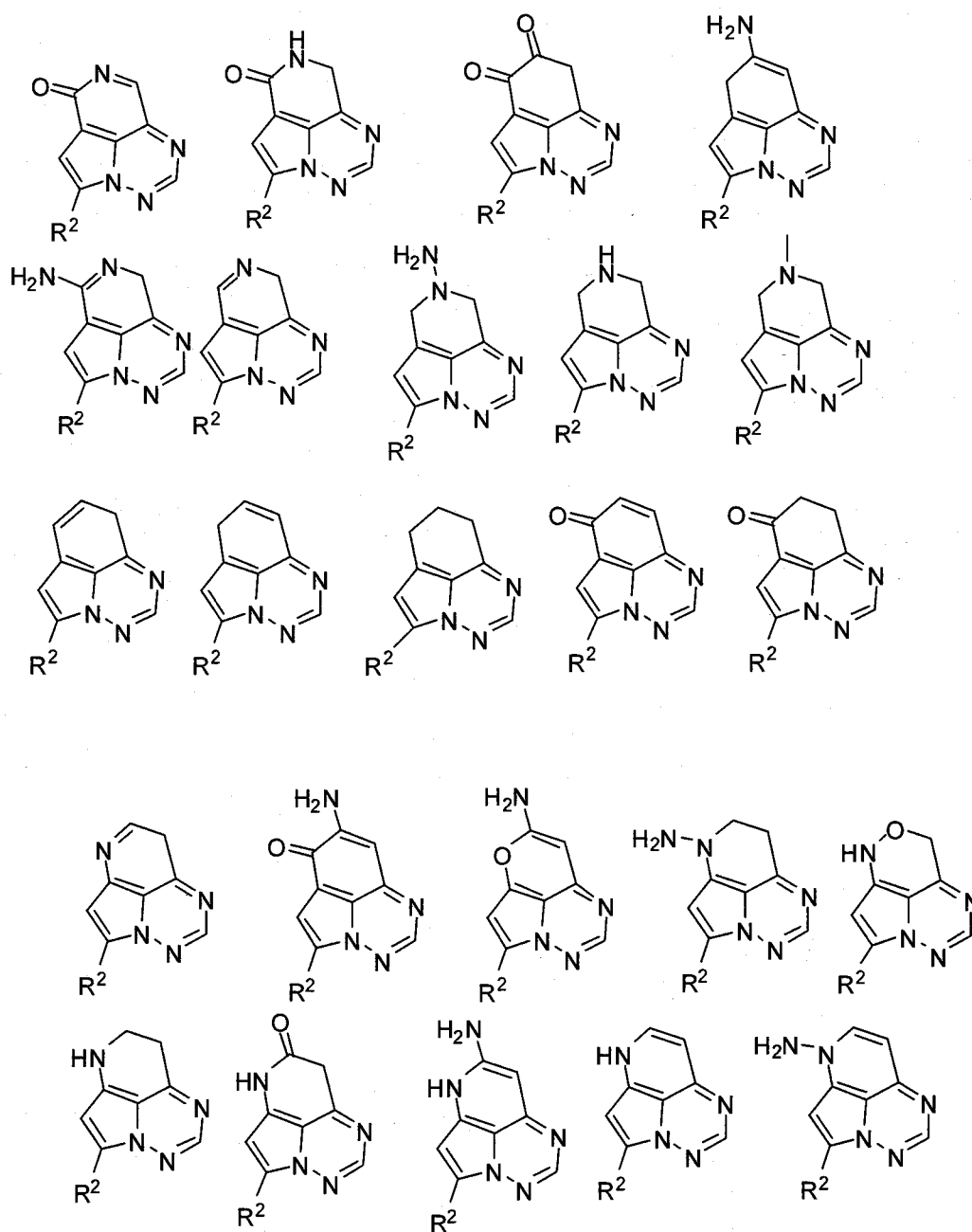


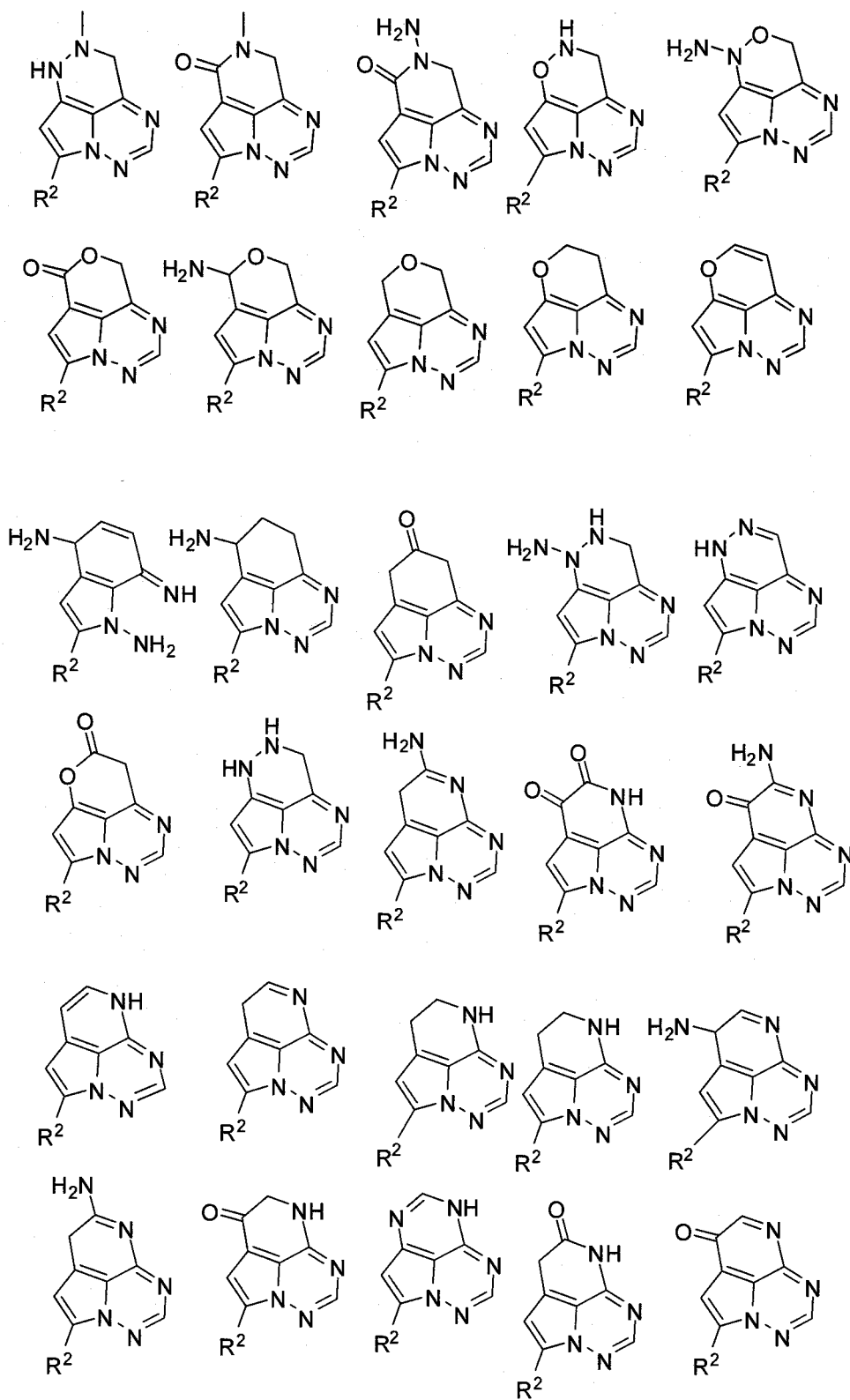


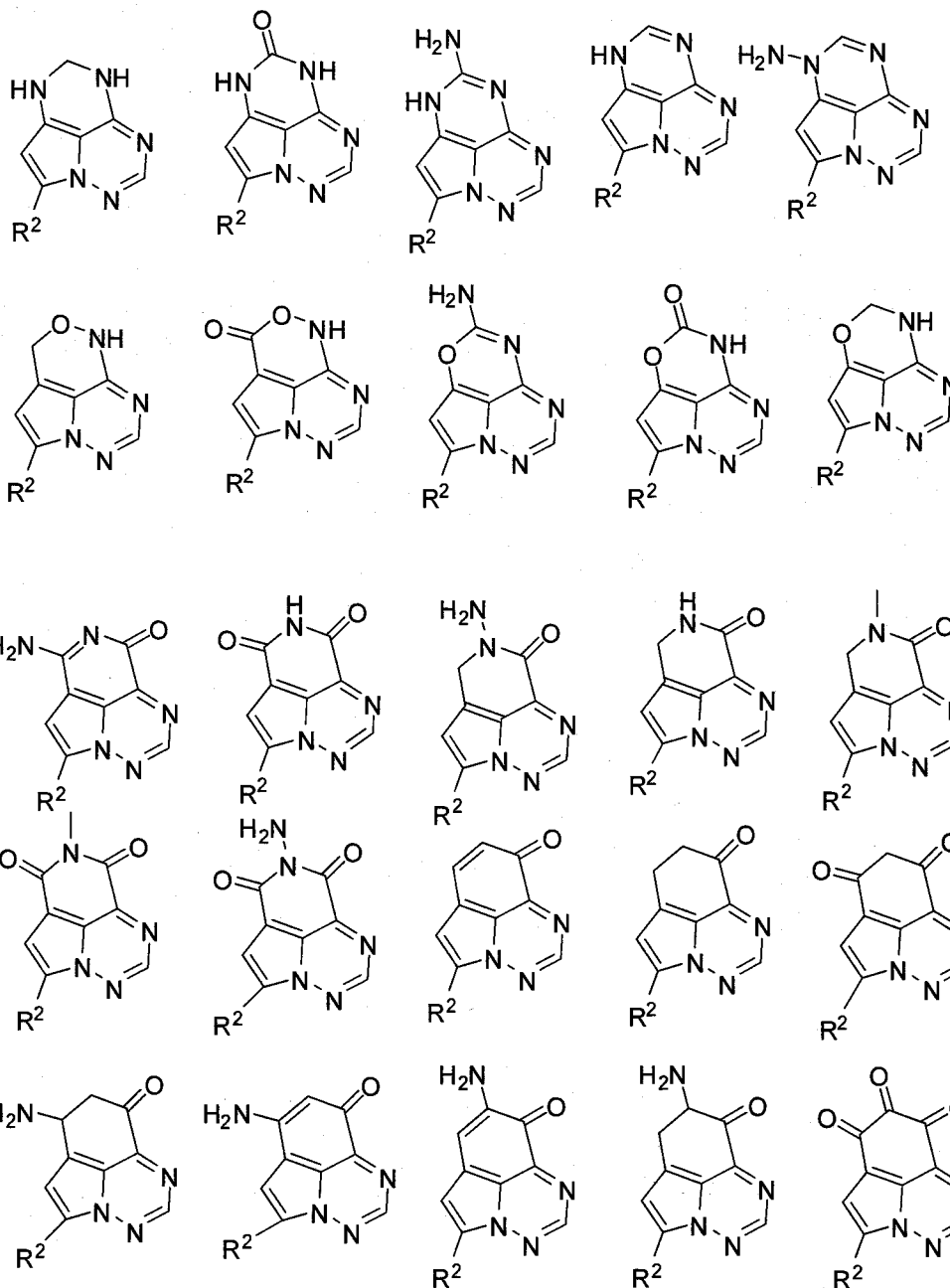


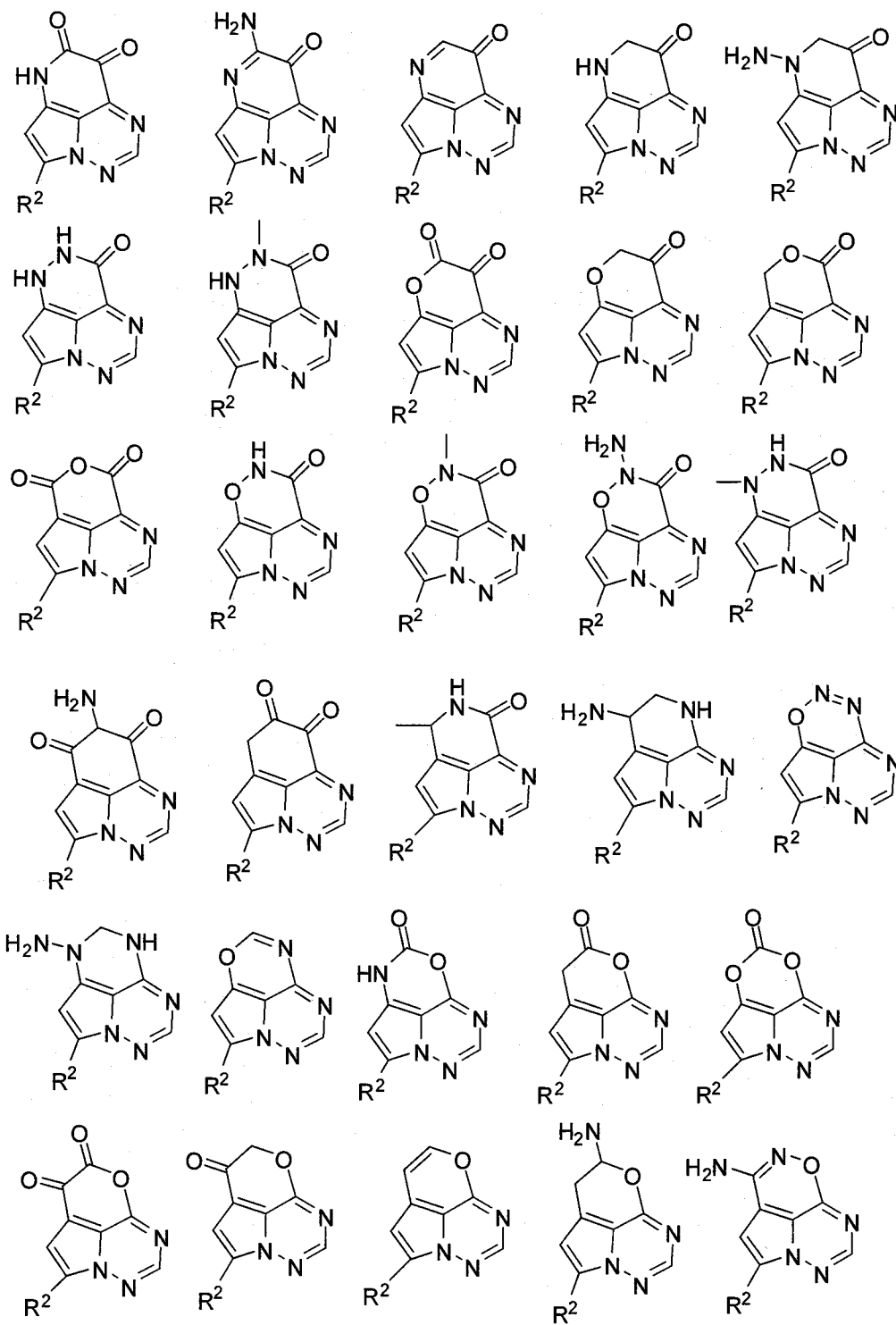
or a pharmaceutically acceptable salt or prodrug thereof.

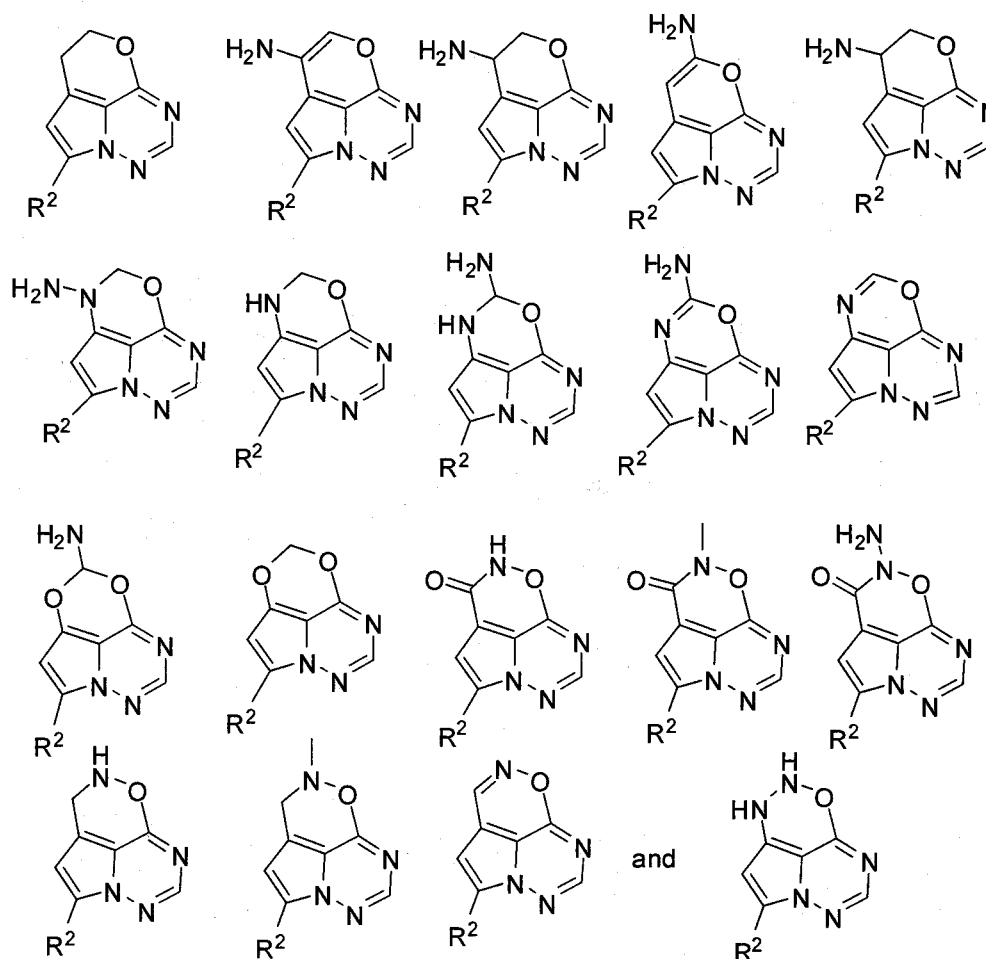
24. The compound of claim 23 which is selected from





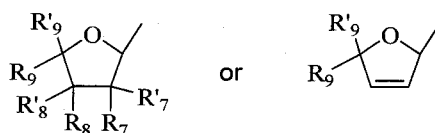






5 or a pharmaceutically acceptable salt or prodrug thereof.

25. The compound of any one of claims 1-24 wherein R^2 is

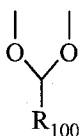


wherein:

10 R_7 is H, OR_{14} , N_3 , NH_2 , or F; and R'_7 is H, F, OH, O-alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_7 and R'_7 together may be $=CH_2$, $=CHF$; wherein both R_7 and R'_7 are not OH; and when one of R_7 and R'_7 is NH_2 , the other is not OH; and when one of R_7 and R'_7 is N_3 , the other is not OH;

15 R_8 is H, OR_{14} , N_3 , NH_2 , or F; and R'_8 is H, F, OH, O alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_8 and R'_8 together may be $=CH_2$, $=CHF$; wherein both R_8 and R'_8 are not OH; and when one of R_8 and R'_8 is NH_2 , the other is not OH; and when one of R_8 and R'_8 is N_3 , the other is not OH;

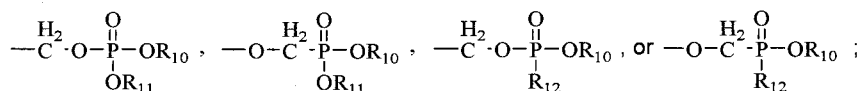
or R_7 and R_8 together can form



wherein: R_{100} is C_{1-12} alkyl C_{3-8} cycloalkyl, aryl or heteroaryl; wherein any C_{1-12} alkyl and C_{3-8} cycloalkyl of R_{100} is unsubstituted or is substituted with 1-3 substituents selected from halogen, hydroxy, carboxy, and C_{1-4} alkoxy; and wherein any aryl or heteroaryl of R_{100} is unsubstituted or is substituted with 1-5 substituents independently selected from R_{101} ;

each R_{101} is independently halo, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} alkylthio, C_{1-4} alkylsulfoyl, cyano, nitro, amino, phenyl, carboxy, trifluoromethyl, trifluoromethoxy, C_{1-4} alkylamino, di(C_{1-4} alkyl) amino, C_{1-4} alkanoyl, C_{1-4} alkanoyloxy, or C_{1-4} alkyloxycarbonyl; R_9 is H, CH_3 , C_2H_5 , or N_3 ;

R'_9 is CH_2OR_{14} , CH_2F , CH_2SH , $CHFOH$, CF_2OH , CH_2 -diphosphate, CH_2 -triphosphate,



R_{10} and R_{11} are each independently H, alkyl, aryl, substituted aryl, acyloxyalkyl, or $(CH_2)_n-O-(CH_2)_mCH_3$;

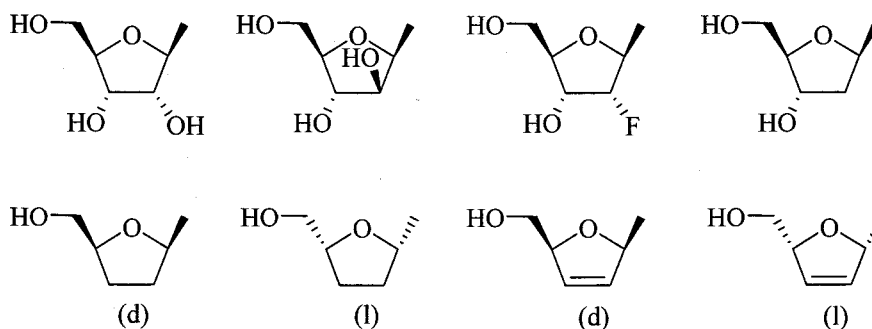
R_{12} is an N-linked amino acid residue (e.g. $-NH-CH(CH_3)CO_2alkyl$ or $-NH-CH(isopropyl)-CO_2alkyl$); and

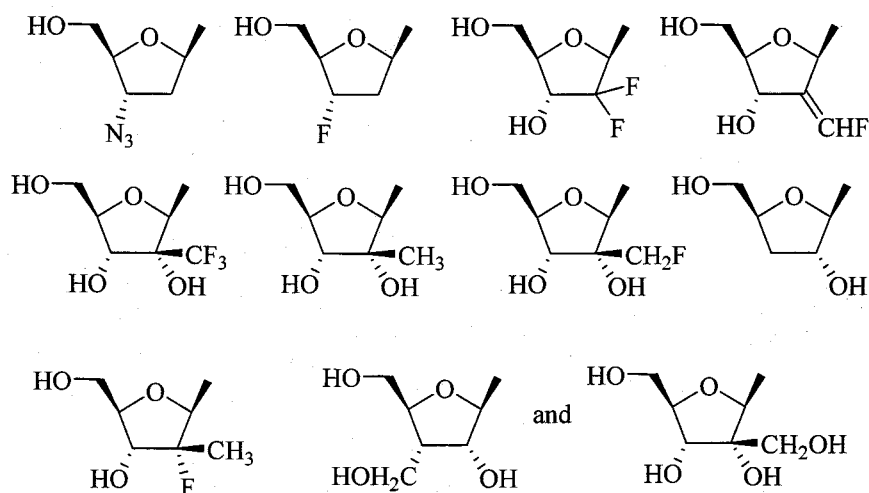
R_{14} is H;

n is 2-5; and

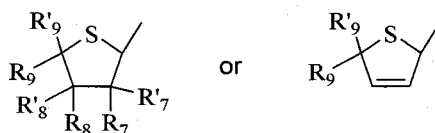
m is 10-20.

26. The compound of any one of claims 1-24 wherein R^2 is selected from:





27. The compound of any one of claims 1-24 wherein R^2 is:

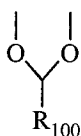


wherein:

R_7 is H, OR_{14} , N_3 , NH_2 , or F; and R'_7 is H, F, OH, O-alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_7 and R'_7 together may be $=CH_2$, $=CHF$; wherein both R_7 and R'_7 are not OH; and when one of R_7 and R'_7 is NH_2 , the other is not OH; and when one of R_7 and R'_7 is N_3 , the other is not OH;

R_8 is H, OR_{14} , N_3 , NH_2 , or F; and R'_8 is H, F, OH, O alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_8 and R'_8 together may be $=CH_2$, $=CHF$; wherein both R_8 and R'_8 are not OH; and when one of R_8 and R'_8 is NH_2 , the other is not OH; and when one of R_8 and R'_8 is N_3 , the other is not OH;

or R_7 and R_8 together can form

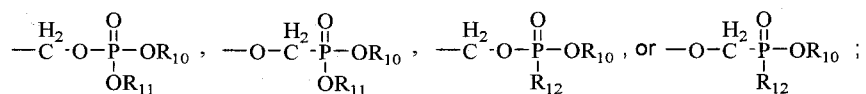


wherein: R_{100} is C_{1-12} alkyl C_{3-8} cycloalkyl, aryl or heteroaryl; wherein any C_{1-12} alkyl and C_{3-8} cycloalkyl of R_{100} is unsubstituted or is substituted with 1-3 substituents selected from halogen, hydroxy, carboxy, and C_{1-4} alkoxy; and wherein any aryl or heteroaryl of R_{100} is unsubstituted or is substituted with 1-5 substituents independently selected from R_{101} ;

each R_{101} is independently halo, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} alkylthio, C_{1-4} alkylsulfoyl, cyano, nitro, amino, phenyl, carboxy, trifluoromethyl, trifluoromethoxy, C_{1-4} alkylamino, di(C_{1-4} alkyl) amino, C_{1-4} alkanoyl, C_{1-4} alkanoyloxy, or C_{1-4} alkyloxycarbonyl;

R₉ is H, CH₃, C₂H₅, or N₃;

R₉ is CH₂OR₁₄, CH₂F, CH₂SH, CHFOH, CF₂OH, CH₂-diphosphate, CH₂-triphosphate,



R₁₀ and R₁₁ are each independently H, alkyl, aryl, substituted aryl,

10 acyloxyalkyl, or $(\text{CH}_2)_n\text{-O-(CH}_2)_m\text{CH}_3$;

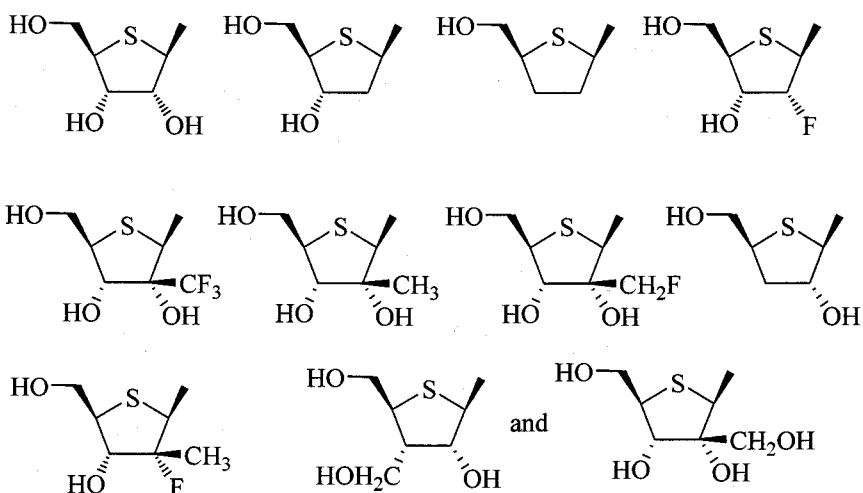
R₁₂ is an N-linked amino acid residue (e.g. -NH-CH(CH₃)CO₂alkyl or -NH-CH(isopropyl)-CO₂alkyl); and

R_{14} is H;

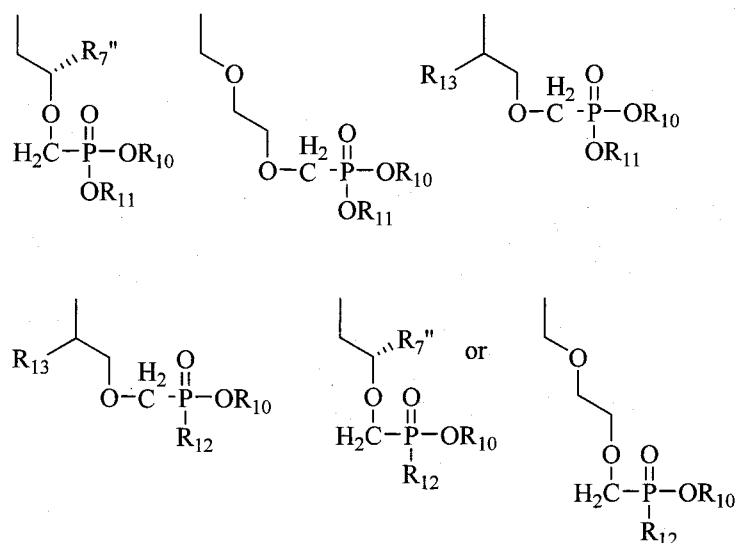
n is 2-5; and

15 m is 10-20.

28. The compound of any one of claims 1-24 wherein R² is selected from:



29. The compound of any one of claims 1-24 wherein R^2 is:



wherein

R_7'' is alkyl or substituted alkyl;

5 R_{10} and R_{11} are each independently H, alkyl, aryl, substituted aryl, acyloxyalkyl, or $(CH_2)_n-O-(CH_2)_mCH_3$;

R_{12} is an N-linked amino acid residue (e.g. $-NH-CH(CH_3)CO_2alkyl$ or $-NH-CH(isopropyl)-CO_2alkyl$);

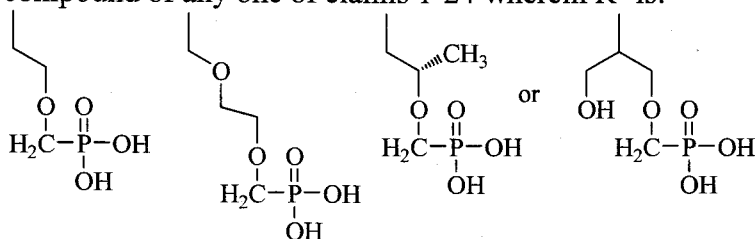
10 R_{13} is H, CH_3 , C_2H_5 , CH_2F , CH_2OH , CH_2CH_2F , CH_2CH_2OH , CH_2N_3 , $CH_2CH_2N_3$, CH_2NH_2 , or $CH_2CH_2NH_2$;

R_{14} is H;

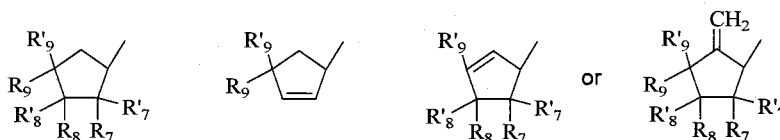
n is 2-5; and

m is 10-20.

30. The compound of any one of claims 1-24 wherein R^2 is:



31. The compound of any one of claims 1-24 wherein R^2 is:

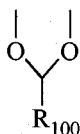


wherein:

R_7 is H, OR_{14} , N_3 , NH_2 , or F; and R'_7 is H, F, OH, O-alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_7 and R'_7 together may be $=CH_2$, $=CHF$; wherein both R_7 and R'_7 are not OH; and when one of R_7 and R'_7 is NH_2 , the other is not OH; and when one of R_7 and R'_7 is N_3 , the other is not OH;

R_8 is H, OR_{14} , N_3 , NH_2 , or F; and R'_8 is H, F, OH, O alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_8 and R'_8 together may be $=CH_2$, $=CHF$; wherein both R_8 and R'_8 are not OH; and when one of R_8 and R'_8 is NH_2 , the other is not OH; and when one of R_8 and R'_8 is N_3 , the other is not OH;

or R_7 and R_8 together can form

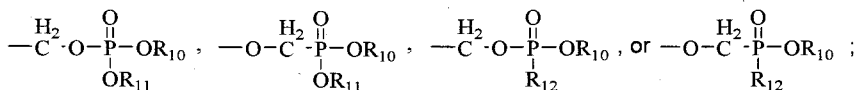


wherein: R_{100} is C_{1-12} alkyl C_{3-8} cycloalkyl, aryl or heteroaryl; wherein any C_{1-12} alkyl and C_{3-8} cycloalkyl of R_{100} is unsubstituted or is substituted with 1-3 substituents selected from halogen, hydroxy, carboxy, and C_{1-4} alkoxy; and wherein any aryl or heteroaryl of R_{100} is unsubstituted or is substituted with 1-5 substituents independently selected from R_{101} ;

each R_{101} is independently halo, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} alkylthio, C_{1-4} alkylsulfoyl, cyano, nitro, amino, phenyl, carboxy, trifluoromethyl, trifluoromethoxy, C_{1-4} alkylamino, di(C_{1-4} alkyl) amino, C_{1-4} alkanoyl, C_{1-4} alkanoyloxy, or C_{1-4} alkyloxycarbonyl;

R_9 is H, CH_3 , C_2H_5 , or N_3 ;

R'_9 is CH_2OR_{14} , CH_2F , CH_2SH , $CHFOH$, CF_2OH , CH_2 -diphosphate, CH_2 -triphosphate,



R_{10} and R_{11} are each independently H, alkyl, aryl, substituted aryl,

acyloxyalkyl, or $(CH_2)_n-O-(CH_2)_mCH_3$;

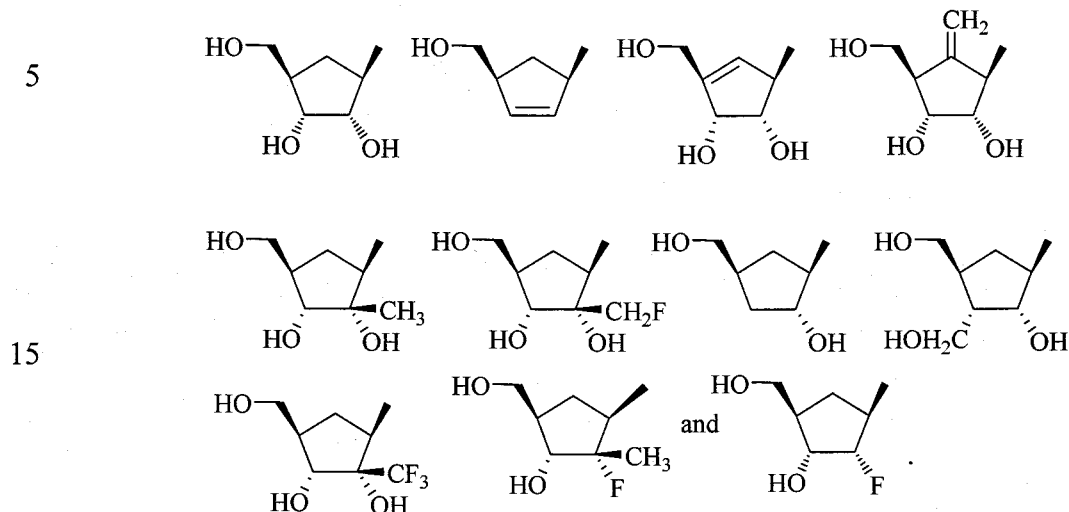
R_{12} is an N-linked amino acid residue (e.g. $-NH-CH(CH_3)CO_2$ alkyl or $-NH-CH(isopropyl)-CO_2$ alkyl);

R_{14} is H;

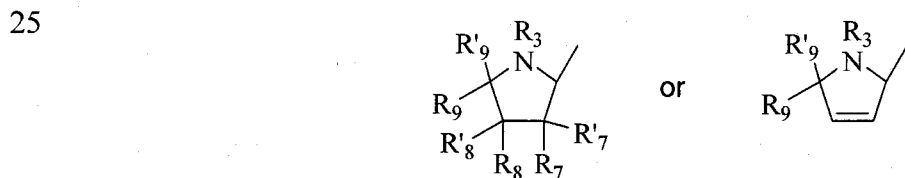
n is 2-5; and

m is 10-20.

32. The compound of any one of claims 1-24 wherein R^2 is selected from:



33. The compound of any one of claims 1-24 wherein R^2 is:



wherein:

R_7 is H, OR_{14} , N_3 , NH_2 , or F; and R'_7 is H, F, OH, O-alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_7 and R'_7 together may be $=CH_2$, $=CHF$; wherein both R_7 and R'_7 are not OH; and when one of R_7 and R'_7 is NH_2 , the other is not OH; and when one of R_7 and R'_7 is N_3 , the other is not OH;

R_8 is H, OR_{14} , N_3 , NH_2 , or F; and R'_8 is H, F, OH, O alkyl, alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, or substituted alkynyl; or R_8 and R'_8 together may be $=CH_2$, $=CHF$; wherein both R_8 and R'_8 are not OH; and when one of R_8 and R'_8 is NH_2 , the other is not OH; and when one of R_8 and R'_8 is N_3 , the other is not OH;

or R_7 and R_8 together can form

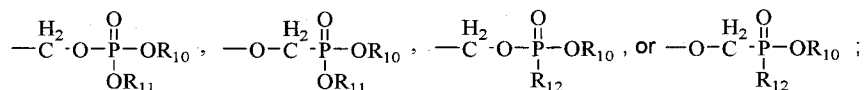


wherein: R_{100} is C_{1-12} alkyl C_{3-8} cycloalkyl, aryl or heteroaryl; wherein any C_{1-12} alkyl and C_{3-8} cycloalkyl of R_{100} is unsubstituted or is substituted with 1-3 substituents selected from halogen, hydroxy, carboxy, and C_{1-4} alkoxy; and wherein any aryl or heteroaryl of R_{100} is unsubstituted or is substituted with 1-5 substituents independently selected from R_{101} ;

each R_{101} is independently halo, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} alkylthio, C_{1-4} alkylsulfoyl, cyano, nitro, amino, phenyl, carboxy, trifluoromethyl, trifluoromethoxy, C_{1-4} alkylamino, di(C_{1-4} alkyl) amino, C_{1-4} alkanoyl, C_{1-4} alkanoyloxy, or C_{1-4} alkyloxycarbonyl;

R_9 is H, CH_3 , C_2H_5 , or N_3 ;

5 R'_9 is CH_2OR_{14} , CH_2F , CH_2SH , $CHFOH$, CF_2OH , CH_2 -diphosphate, CH_2 -triphosphate,



R_{10} and R_{11} are each independently H, alkyl, aryl, substituted aryl, acyloxyalkyl, or $(CH_2)_n-O-(CH_2)_mCH_3$;

15 R_{12} is an N-linked amino acid residue (e.g. $-NH-CH(CH_3)CO_2$ alkyl or $-NH-CH(isopropyl)-CO_2$ alkyl); and

R_{14} is H;

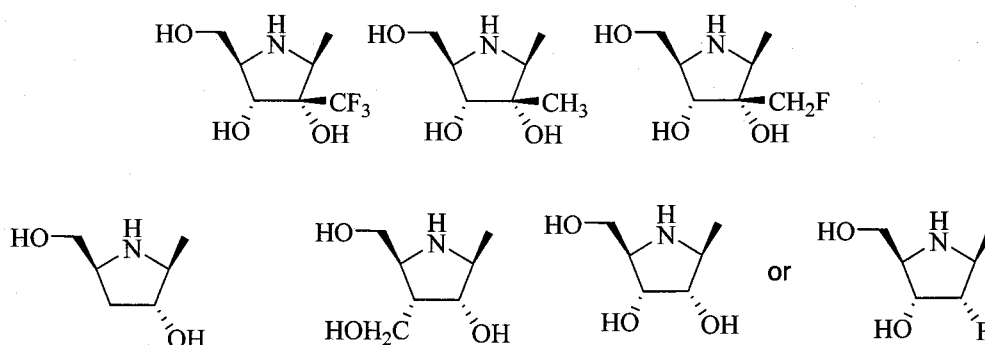
n is 2-5; and

m is 10-20.

20

34. The compound of any one of claims 1-24 wherein R^2 is:

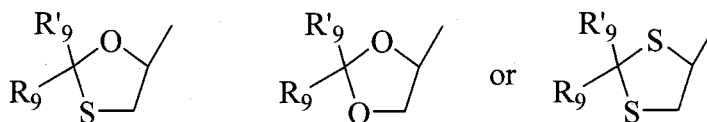
25



35

35. The compound of any one of claims 1-24 wherein R^2 is:

40

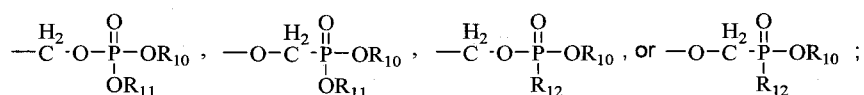


45

wherein

R_9 is H, CH_3 , C_2H_5 , or N_3 ;

R'_9 is CH_2OR_{14} , CH_2F , CH_2SH , $CHFOH$, CF_2OH , CH_2 -diphosphate, CH_2 -triphosphate,



R_{10} and R_{11} are each independently H, alkyl, aryl, substituted aryl, acyloxyalkyl, or $(\text{CH}_2)_n\text{-O-(CH}_2)_m\text{CH}_3$;

R_{12} is an N-linked amino acid residue (e.g. $-\text{NH-CH}(\text{CH}_3)\text{CO}_2\text{alkyl}$ or $-\text{NH-}$

5 $\text{CH}(\text{isopropyl})\text{-CO}_2\text{alkyl}$);

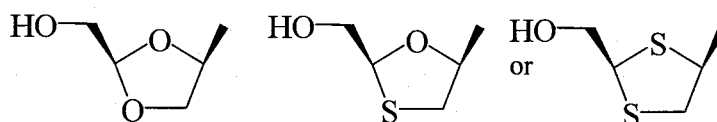
R_{13} is H, CH_3 , C_2H_5 , CH_2F , CH_2OH , $\text{CH}_2\text{CH}_2\text{F}$, $\text{CH}_2\text{CH}_2\text{OH}$, CH_2N_3 , $\text{CH}_2\text{CH}_2\text{N}_3$, CH_2NH_2 , or $\text{CH}_2\text{CH}_2\text{NH}_2$;

R_{14} is H;

n is 2-5; and

10 m is 10-20.

36. The compound of any one of claims 1-24 wherein R^2 is:



20 37. The compound of any one of claims 1-24 wherein R^2 is ribose, 2-methylribose, 2-deoxyribose; 2-deoxy-2-fluororibose; arabinose; 2-deoxy-2-fluoroarabinose; 2,3-dideoxyribose; 2,3-dideoxy-2-fluoroarabinose; 2,3-dideoxy-3-fluororibose; 2,3-dideoxy-2,3-didehydroribose; 2,3-dideoxy-3-azidoribose; 2,3-dideoxy-3-thiaribose; or 2,3-dideoxy-3-oxaribose; or a pharmaceutically acceptable salt or prodrug thereof.

25 38. The compound of any one of claims 1-24 wherein R^2 is thioribose, 2-deoxythioribose; 2-deoxy-2-fluorothioribose; thioarabinose; 2-deoxy-2-fluorothioarabinose; 2,3-dideoxythioribose; 2,3-dideoxy-2-fluorothioarabinose; 2,3-dideoxy-3-fluorothioribose; 2,3-dideoxy-2,3-didehydrothioribose; or 2,3-dideoxy-3-azidothioribose; or a pharmaceutically acceptable salt or prodrug thereof.

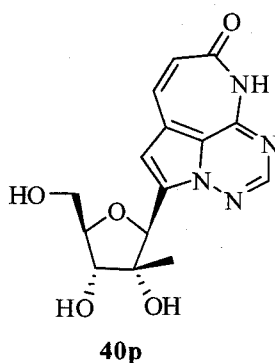
35 39. The compound of any one of claims 1-24 wherein R^2 is 4-hydroxymethyl-cyclopent-2-ene; 2,3-dihydroxy-4-hydroxymethylcyclopent-4-ene; 3-hydroxy-4-hydroxymethylcyclopentane; 2-hydroxy-4-hydroxymethylcyclopentene; 2-fluoro-3-hydroxy-4-hydroxymethylcyclopentane; 2,3-dihydroxy-4-hydroxymethyl-5-methylenecyclopentane; 4-

hydroxymethylcyclopentane, 2,3-dihydroxy-4-hydroxymethylcyclopentane; or 2,3-dihydroxymethylcyclobutane; or a pharmaceutically acceptable salt or prodrug thereof.

40. The compound of any one of claims 1-24 wherein R² is 4-hydroxymethyl-pyrrolidine;

5 2,3-dihydroxy-4-hydroxymethylpyrrolidine; 2/3-hydroxy-4-hydroxymethylpyrrolidine; 2-fluoro-3-hydroxy-4-hydroxymethylpyrrolidine; or 3-fluoro-2-hydroxy-4-hydroxymethyl-pyrrolidine; or a pharmaceutically acceptable salt or prodrug thereof.

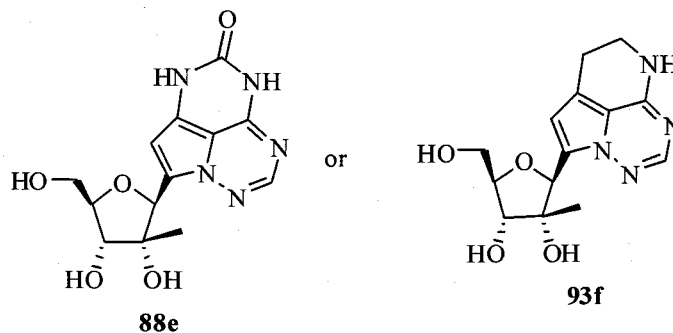
41. The compound of claim 1 which is:



10

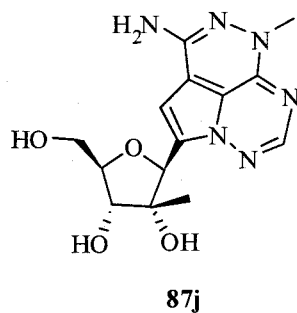
or a pharmaceutically acceptable salt or prodrug thereof.

42. The compound of claim 1 which is:



15 or a pharmaceutically acceptable salt or prodrug thereof.

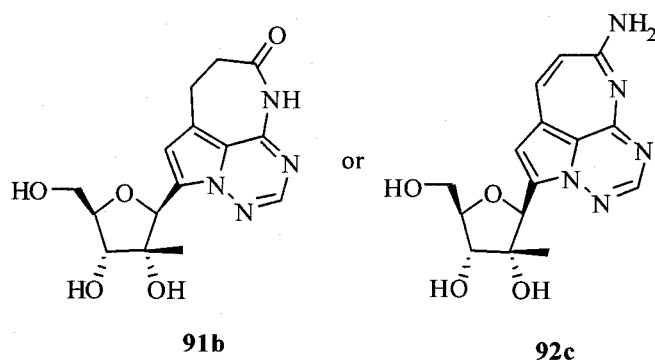
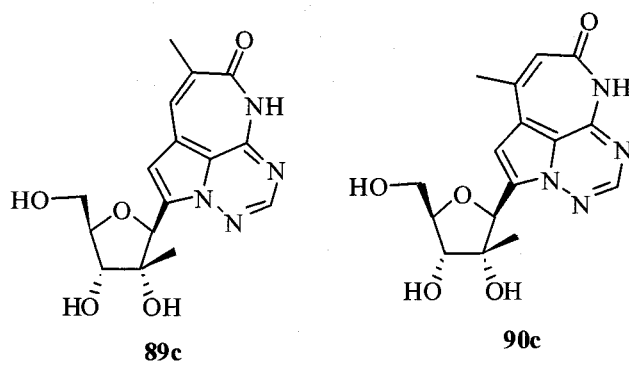
43. The compound of claim 1 which is:



or a pharmaceutically acceptable salt or prodrug thereof.

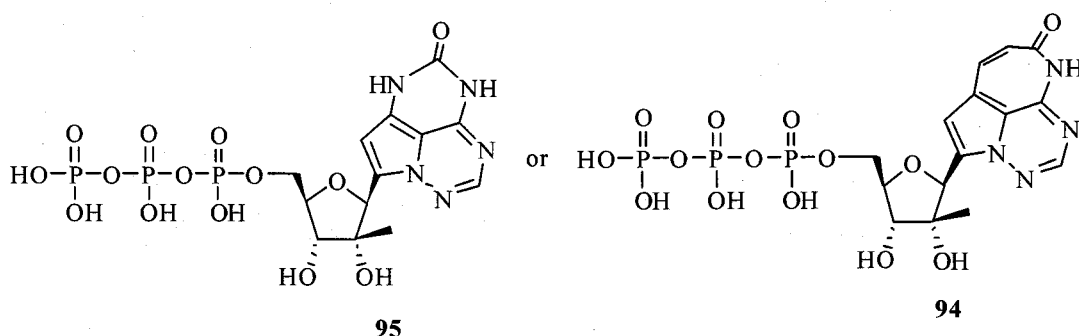
5

44. The compound of claim 1 which is:



or a pharmaceutically acceptable salt or prodrug thereof.

45. The compound of claim 1 which is:



or a pharmaceutically acceptable salt or prodrug thereof.

5 46. The compound of any one of claims 1-45 which is a prodrug.

47. The compound of any one of claims 1-45 which comprises one or more mono-, di-, or tri-phosphate groups.

10 48. The compound of any one of claims 1-45 which comprises one or more mono-phosphate groups.

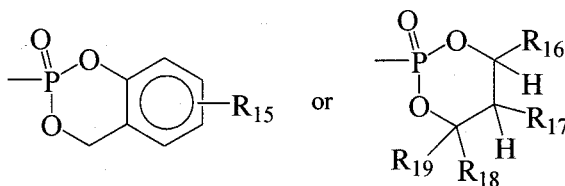
49. The compound of claim 47 wherein one or more pendent hydroxyl groups from the mono-, di-, or tri-phosphate group has been converted to an alkoxy, substituted alkoxy, aryloxy, or substituted aryloxy group.

50. The compound of claim 47 wherein one or more pendent hydroxyl groups from the mono-, di-, or tri-phosphate group has been converted to a group R_y-O-; wherein each R_y is independently a 1-20 carbon branched or unbranched, saturated or unsaturated chain, wherein one or more of the carbon atoms is optionally replaced with -O- or -S- and wherein one or more of the carbon atoms is optionally substituted with oxo (=O) or thioxo (=S).

51. The compound of claim 47 wherein one or more pendent hydroxyl groups from the
mono-, di-, or tri-phosphate group has been converted to a group R_z-N- ; wherein each R_z is a
25 residue of an amino acid.

52. The compound of claim 51 wherein the amino acid is a natural amino acid.

53. The compound of any one of claims 1-45 which is a prodrug that comprises one or more groups of formula:



wherein:

R_{15} is H, alkyl, substituted alkyl, aryl, substituted aryl, cycloalkyl, substituted cycloalkyl, heteroaryl, substituted heteroaryl, heterocyclic, substituted heterocyclic, or an amino acid;

R_{16} is H, optionally substituted monocyclic aryl, or optionally substituted monocyclic heteroaryl; and R_{17} is H, halogen, CN, $-\text{CO}-R_{20}$, $-\text{CON}(\text{R}_{21})_2$, $-\text{CO}_2\text{R}_{20}$, $-\text{SO}_2\text{R}_{20}$, $-\text{SO}_2\text{N}(\text{R}_{21})_2$, $-\text{OR}_{21}$, $-\text{SR}_{21}$, $-\text{R}_{21}$, $-\text{N}(\text{R}_{21})_2$, $-\text{O}-\text{COR}_{20}$, $-\text{O}-\text{CO}_2\text{R}_{20}$, $-\text{SCOR}_{20}$, $-\text{S}-\text{CO}_2\text{R}_{20}$, $-\text{NHCOR}_{21}$, $-\text{NHCO}_2\text{R}_{21}$, $-(\text{CH}_2)_p-\text{OR}_{22}$, or $-(\text{CH}_2)_p-\text{SR}_{22}$; or R_{16} and R_{17} are connected via an additional 3-5 atoms to form a cyclic group, optionally containing one heteroatom, that is fused to an aryl group at the beta and gamma position to the O attached to the phosphorus; or R_{17} and R_{18} are connected as described below;

R_{18} and R_{19} are each independently H, alkyl, aryl, heterocycloalkyl, aralkyl, optionally substituted monocyclic aryl or optionally substituted monocyclic heteroaryl; or R_{18} and R_{19} are connected via an additional 2-5 atoms to form a cyclic group, optionally containing 0-2 heteroatoms; or R_{17} and R_{18} are connected via an additional 3-5 atoms to form a cyclic group, optionally containing one heteroatom and R_{19} is H, alkyl, aryl, heterocycloalkyl, aralkyl, optionally substituted monocyclic aryl or optionally substituted monocyclic heteroaryl;

R_{20} is alkyl, aryl, heterocycloalkyl, or arylalkyl;

R_{21} is H, alkyl, aryl, heterocycloalkyl, or arylalkyl;

R_{22} is H or lower acyl; and

p is an integer from 2-3.

54. A pharmaceutical composition comprising a compound as described in any one of claims 1-53 and a pharmaceutically acceptable carrier.

55. The composition of claim 54 which further comprises one or more additional anti-viral agents.

56. The composition of claim 55 wherein the one or more anti-viral agents are selected from ribavirin, levovirin, viramidine, thymosin alpha-1, an inhibitor of a serine proteases, an inhibitor

of inosine monophosphatedehydrogenase, interferon- α , and pegylated interferon- α (peginterferon- α).

57. The composition of any one of claims 54-56 which further comprises one or more additional HCV polymerase inhibitors.

58. The composition of any one of claims 54-57 which further comprises one or more protease inhibitors.

59. The composition of any one of claims 54-58 which further comprises ribavirin.

60. The composition of any one of claims 54-59 which further comprises interferon- α or pegylated interferon- α (peginterferon- α).

61. The composition of claim 54 which further comprises one or more anti-cancer agents.

62. The composition of claim 61 wherein the one or more anti-cancer agents are selected from alkylating agents, antimetabolites, natural products, and hormonal agents.

63. A method for treating a viral infection in an animal comprising administering to the animal an effective amount of a compound as described in any one of claims 1-53, or a composition as described in any one of claims 54-62.

64. The method of claim 63 wherein the viral infection is selected from the group consisting of: hepatitis B, hepatitis C, human immunodeficiency virus, Polio, Coxsackie A and B, Rhino, Echo, small pox, Ebola, and West Nile virus.

65. The method of claim 63 wherein the viral infection is HCV.

66. The method of any one of claims 63-65 which further comprises administering to the animal one or more additional HCV polymerase inhibitors.

67. The method of any one of claims 63-66 which further comprises administering to the animal, one or more protease inhibitors.

68. The method of any one of claims 63-67 which further comprises administering ribavirin to the animal.

69. The method of any one of claims 63-68 which further comprises administering
5 interferon- α or pegylated interferon- α (peginterferon- α) to the animal.

70. A method for treating cancer in an animal comprising administering to the animal an effective amount of a compound as described in any one of claims 1-53, or a composition as described in any one of claims 54 and 61-62.

10 71. The method of claim 70 wherein one or more additional anti-cancer compounds are administered.

72. The method of any one of claims 63-71 wherein the animal is a human.

15 73. A method for inhibiting a viral RNA or DNA polymerase comprising contacting the polymerase *in vitro* or *in vivo* with an effective inhibitory amount of a compound as described in any one of claims 1-53.

20 74. The method of claim 73 wherein the viral polymerase is an RdRp.

75. A compound as described in any one of claims 1-53 for use in medical therapy.

76. The use of a compound as described in any one of claims 1-53 to prepare a medicament
25 useful for treating a viral infection in an animal.

77. The use of a compound as described in any one of claims 1-53 to prepare a medicament useful for treating cancer in an animal.

30 78. A compound as described in any one of claims 1-53 for the prophylactic or therapeutic treatment of a viral infection.

79. A compound as described in any one of claims 1-53 for the prophylactic or therapeutic treatment of cancer.