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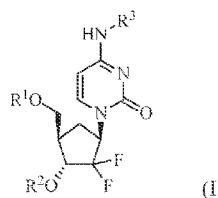
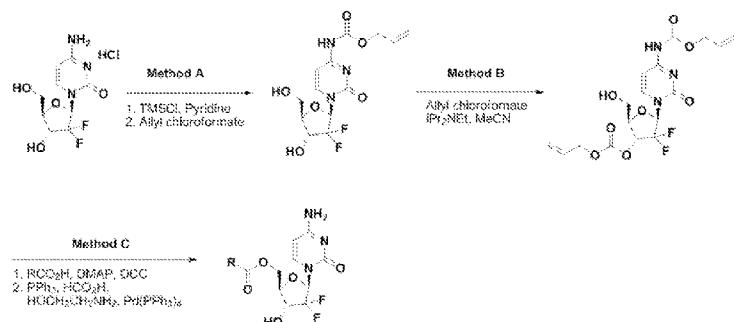
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(54) Title: GEMCITABINE PRODRUGS AND USES THEREOF**Figure 1**

(57) Abstract: The present invention provides compounds according to formula I and pharmaceutically acceptable salts thereof. For compounds of formula I, R¹ and R² are independently selected from the group consisting of H, -C(=O)-(CH₂)₂-aryl, and C(=O)-(CH₂)_nC(=O)-NH-aryl. The subscript n is from 2 to 6. R³ is selected from the group consisting of H and -C(=O)-O-R⁴; and R⁴ is selected from the group consisting of alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, arylalkyl, substituted arylalkyl, cycloheteroalkyl, substituted cycloheteroalkyl, heteroalkyl and substituted heteroalkyl. Compounds are provided wherein at least one of R¹ and R² is other than H. Pharmaceutical compositions, methods for inhibiting the growth of cancer cells, and methods for the treatment of cancer are also provided.

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GEMCITABINE PRODRUGS AND USES THEREOF

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Patent Application No. 61/725,643, filed Nov. 13, 2012, which application is herein 10 incorporated by reference in its entirety.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

[0002] NOT APPLICABLE

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REFERENCE TO A "SEQUENCE LISTING," A TABLE, OR A COMPUTER PROGRAM LISTING APPENDIX SUBMITTED ON A COMPACT DISK

[0003] NOT APPLICABLE

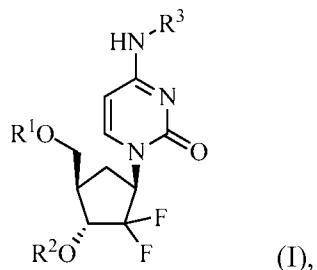
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BACKGROUND OF THE INVENTION

[0004] Gemcitabine is a nucleoside analogue that has been effectively used for the treatment of cancers including non-small cell lung cancer, pancreatic cancer, bladder cancer, ovarian cancer and breast cancer. Despite gemcitabine's demonstrated efficacy in a number of clinical situations, the drug is also associated with side effects 25 such as flu-like symptoms, diarrhea, weakness, mouth sores, and shortness of breath. In order to maximize the benefits of gemcitabine-based chemotherapy regimens and improve safety and tolerability, new forms of gemcitabine are needed. The present invention, providing surprisingly effective gemcitabine derivatives, meets this and other needs.

BRIEF SUMMARY OF THE INVENTION

[0005] In one aspect, the invention provides compounds according to formula I:



5 and pharmaceutically acceptable salts thereof. For compounds of formula I, R¹ and R² are independently selected from H, -C(=O)-(CH₂)₂-aryl, and -C(=O) - (CH₂)_n-C(=O) -NH-aryl, and at least one of R¹ and R² is other than H. The subscript n is from 2 to 6. R³ is selected from H and -C(=O)-O-R⁴; and R⁴ is selected from alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, 10 arylalkyl, substituted arylalkyl, cycloheteroalkyl, substituted cycloheteroalkyl, heteroalkyl and substituted heteroalkyl.

[0006] In a second aspect, the invention provides pharmaceutical compositions containing a pharmaceutically acceptable carrier and one or more compounds according to formula I as described above, prodrugs thereof, or pharmaceutically acceptable salts of the compounds and prodrugs.

[0007] In a third aspect, the invention provides methods for inhibiting the growth of cancer cells. The methods include contacting the cells with an effective amount of a compound of the invention.

[0008] In a fourth aspect, the invention provides methods for treating cancer. The methods include administering to the subject an effective amount of a pharmaceutical composition of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 shows a synthetic route for the preparation of 5'-O-derivatized gemcitabine prodrugs.

[0010] Figure 2 shows a synthetic route for the preparation of *N*4-5'*O*-derivatized gemcitabine prodrugs.

[0011] Figure 3 shows a synthetic route for the preparation of 3'*O*-*N*4-derivatized gemcitabine prodrugs.

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DETAILED DESCRIPTION OF THE INVENTION

I. Definitions

[0012] As used herein, the term “prodrug” refers to a precursor compound that, following administration, releases a biologically active compound *in vivo* via a

10 chemical or physiological process (e.g., a prodrug on reaching physiological pH or through enzyme action is converted to the biologically active compound). A prodrug itself may either lack or possess the desired biological activity.

[0013] As used herein, the term “salt” refers to an acid or base salt of a compound of the invention. Illustrative examples of pharmaceutically acceptable salts are

15 mineral acid salts (prepared using hydrochloric acid, hydrobromic acid, phosphoric acid, and the like), organic acid salts (prepared using acetic acid, propionic acid, glutamic acid, citric acid, methanesulfonic acid, maleic acid, and the like), and quaternary ammonium salts (prepared using methyl iodide, ethyl iodide, and the like). It is understood that the pharmaceutically acceptable salts are non-toxic. Additional 20 information on suitable pharmaceutically acceptable salts can be found in *Remington: The Science & Practice of Pharmacy*, 20th ed., Lippincott Williams & Wilkins, Philadelphia, Pa., 2000, which is incorporated herein by reference.

[0014] Salts of acidic compounds are formed with bases, namely cationic species such as alkali and alkaline earth metal cations (e.g., sodium, lithium, potassium,

25 calcium, and magnesium ions), as well as ammonium cations (e.g., ammonium, trimethylammonium, diethylammonium, and *tris*-(hydroxymethyl)-methyl-ammonium ions). Salts of basic compounds are salts formed with mineral acids, organic carboxylic acids, organic sulfonic acids, and the like. The neutral forms of the compounds can be regenerated by contacting the salt 30 with a base or acid and isolating the parent compound in the conventional manner. The parent form of the compound differs from the various salt forms in certain

physical properties, such as solubility in polar solvents, but otherwise the salts are equivalent to the parent form of the compound for the purposes of the present invention.

[0015] As used herein, the term “aryl” refers to an aromatic ring system having any 5 suitable number of ring atoms and any suitable number of rings. Aryl groups can include any suitable number of ring atoms, such as, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 or 16 ring atoms, as well as from 6 to 10, 6 to 12, or 6 to 14 ring members. Aryl groups can be monocyclic, fused to form bicyclic or tricyclic groups, or linked by a bond to form a biaryl group. Representative aryl groups include phenyl, naphthyl and 10 biphenyl. Other aryl groups include benzyl, having a methylene linking group. Some aryl groups have from 6 to 12 ring members, such as phenyl, naphthyl or biphenyl. Other aryl groups have from 6 to 10 ring members, such as phenyl or naphthyl. Some other aryl groups have 6 ring members, such as phenyl. “Substituted aryl” groups can be substituted with one or more groups selected from halo, hydroxy, amino, 15 alkylamino, amido, acyl, nitro, cyano, and alkoxy.

[0016] Aryl groups also include heteroaryl groups. “Heteroaryl” refers to a monocyclic or fused bicyclic or tricyclic aromatic ring assembly containing 5 to 16 ring atoms, where from 1 to 5 of the ring atoms are a heteroatom such as N, O or S. Additional heteroatoms can also be useful, including, but not limited to, B, Al, Si and 20 P. The heteroatoms can also be oxidized, such as in groups including, but not limited to, -S(O)- and -S(O)₂- . Heteroaryl groups can include any number of ring atoms, such as, 3 to 6, 4 to 6, 5 to 6, 3 to 8, 4 to 8, 5 to 8, 6 to 8, 3 to 9, 3 to 10, 3 to 11, or 3 to 12 ring members. Any suitable number of heteroatoms can be included in the heteroaryl groups, such as 1, 2, 3, 4, or 5, or 1 to 2, 1 to 3, 1 to 4, 1 to 5, 2 to 3, 2 to 4, 2 to 5, 3 to 25 4, or 3 to 5. Heteroaryl groups can have from 5 to 8 ring members and from 1 to 4 heteroatoms, or from 5 to 8 ring members and from 1 to 3 heteroatoms, or from 5 to 6 ring members and from 1 to 4 heteroatoms, or from 5 to 6 ring members and from 1 to 3 heteroatoms. The heteroaryl group can include groups such as pyrrolyl, pyridinyl (2-, 3-, and 4-isomers), imidazolyl, pyrazolyl, triazolyl, tetrazolyl, pyrazinyl, 30 pyrimidinyl, pyridazinyl, triazinyl (1,2,3-, 1,2,4- and 1,3,5-isomers), thiophenyl, furanyl, thiazolyl, isothiazolyl, oxazolyl, and isoxazolyl. The heteroaryl groups can also be fused to aromatic ring systems, such as a phenyl ring, to form members including, but not limited to, benzopyrroles such as indolyl and isoindolyl,

benzopyridines such as quinolinyl and isoquinolinyl, benzopyrazinyl (quinoxaline), benzopyrimidinyl (quinazoline), benzopyridazines such as phthalazinyl and cinnolinyl, benzothiophenyl, and benzofuranyl. Other heteroaryl groups include heteroaryl rings linked by a bond, such as bipyridinyl. “Substituted heteroaryl” groups can be

5 substituted with one or more groups selected from halo, hydroxy, amino, alkylamino, amido, acyl, nitro, cyano, and alkoxy.

[0017] As used herein, the term “alkyl” refers to a straight or branched, saturated, aliphatic radical having from 1 to about 10 carbon atoms. Alkyl can include any number of carbons, such as C₁₋₂, C₁₋₃, C₁₋₄, C₁₋₅, C₁₋₆, C₁₋₇, C₁₋₈, C₁₋₉, C₁₋₁₀, C₂₋₃, C₂₋₄,

10 C₂₋₅, C₂₋₆, C₃₋₄, C₃₋₅, C₃₋₆, C₄₋₅, C₄₋₆ and C₅₋₆. For example, C₁₋₆ alkyl includes, but is not limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *sec*-butyl, *tert*-butyl, pentyl, isopentyl, hexyl, etc. Alkyl can also refer to alkyl groups having up to 20 carbons atoms including, but not limited to, heptyl, octyl, nonyl, decyl, etc.

“Substituted alkyl” groups can be substituted with one or more groups selected from 15 halo, hydroxy, amino, alkylamino, amido, acyl, nitro, cyano, and alkoxy.

[0018] As used herein, the term “alkenyl” refers to a straight chain or branched hydrocarbon having at least 2 carbon atoms and at least one carbon-carbon double bond. Alkenyl can include any number of carbons, such as C₂, C₂₋₃, C₂₋₄, C₂₋₅, C₂₋₆, C₂₋₇, C₂₋₈, C₂₋₉, C₂₋₁₀, C₃, C₃₋₄, C₃₋₅, C₃₋₆, C₄, C₄₋₅, C₄₋₆, C₅, C₅₋₆, and C₆. Alkenyl

20 groups can have any suitable number of double bonds, including, but not limited to, 1, 2, 3, 4, 5 or more. Examples of alkenyl groups include, but are not limited to, vinyl (ethenyl), propenyl, isopropenyl, 1-butenyl, 2-butenyl, isobutenyl, butadienyl, 1-pentenyl, 2-pentenyl, isopentenyl, 1,3-pentadienyl, 1,4-pentadienyl, 1-hexenyl, 2-hexenyl, 3-hexenyl, 1,3-hexadienyl, 1,4-hexadienyl, 1,5-hexadienyl, 2,4-hexadienyl, 25 or 1,3,5-hexatrienyl. “Substituted alkenyl” groups can be substituted with one or more groups selected from halo, hydroxy, amino, alkylamino, amido, acyl, nitro, cyano, and alkoxy.

[0019] As used herein, the term “alkynyl” refers to either a straight chain or branched hydrocarbon having at least 2 carbon atoms and at least one carbon-carbon

30 triple bond. Alkynyl can include any number of carbons, such as C₂, C₂₋₃, C₂₋₄, C₂₋₅, C₂₋₆, C₂₋₇, C₂₋₈, C₂₋₉, C₂₋₁₀, C₃, C₃₋₄, C₃₋₅, C₃₋₆, C₄, C₄₋₅, C₄₋₆, C₅, C₅₋₆, and C₆.

Examples of alkynyl groups include, but are not limited to, acetylenyl, propynyl,

1-butynyl, 2-butynyl, isobutynyl, *sec*-butynyl, butadiynyl, 1-pentynyl, 2-pentynyl, isopentynyl, 1,3-pentadiynyl, 1,4-pentadiynyl, 1-hexynyl, 2-hexynyl, 3-hexynyl, 1,3-hexadiynyl, 1,4-hexadiynyl, 1,5-hexadiynyl, 2,4-hexadiynyl, or 1,3,5-hexatriynyl. “Substituted alkynyl” groups can be substituted with one or more groups selected

5 from halo, hydroxy, amino, alkylamino, amido, acyl, nitro, cyano, and alkoxy.

[0020] As used herein, the term “arylalkyl” refers to a radical having an alkyl component and an aryl component, where the alkyl component links the aryl component to the point of attachment. The alkyl component is as defined above, except that the alkyl component is at least divalent (*i.e.*, an alkylene), to link to the 10 aryl component to the point of attachment. The alkyl component can include any number of carbons, such as C₁₋₆, C₁₋₂, C₁₋₃, C₁₋₄, C₁₋₅, C₁₋₆, C₂₋₃, C₂₋₄, C₂₋₅, C₂₋₆, C₃₋₄, C₃₋₅, C₃₋₆, C₄₋₅, C₄₋₆ and C₅₋₆. The aryl component is as defined above. Examples of arylalkyl groups include, but are not limited to, benzyl and ethyl-benzene. “Substituted arylalkyl” groups can be substituted with one or more groups selected

15 from halo, hydroxy, amino, alkylamino, amido, acyl, nitro, cyano, and alkoxy.

[0021] As used herein, the term “cycloheteroalkyl” refers to a saturated ring system having from 3 to 12 ring members and from 1 to 4 heteroatoms of N, O and S. Additional heteroatoms can also be useful, including, but not limited to, B, Al, Si and P. The heteroatoms can also be oxidized, such as is groups including, but not limited 20 to, -S(O)- and -S(O)₂- . Cycloheteroalkyl groups can include any number of ring atoms, such as, 3 to 6, 4 to 6, 5 to 6, 3 to 8, 4 to 8, 5 to 8, 6 to 8, 3 to 9, 3 to 10, 3 to 11, or 3 to 12 ring members. Any suitable number of heteroatoms can be included in the cycloheteroalkyl groups, such as 1, 2, 3, or 4, or 1 to 2, 1 to 3, 1 to 4, 2 to 3, 2 to 4, or 3 to 4. The cycloheteroalkyl group can include groups such as aziridinyl, azetidinyl, 25 pyrrolidinyl, piperidinyl, azepanyl, azocanyl, quinuclidinyl, pyrazolidinyl, imidazolidinyl, piperazinyl (1,2-, 1,3- and 1,4-isomers), oxiranyl, oxetanyl, tetrahydrofuranyl, oxanyl (tetrahydropyranyl), oxepanyl, thiiranyl, thietanyl, thiolanyl (tetrahydrothiophenyl), thianyl (tetrahydrothiopyranyl), oxazolidinyl, isoxazolidinyl, thiazolidinyl, isothiazolidinyl, dioxolanyl, dithiolanyl, morpholino, thiomorpholino, 30 dioxanyl, or dithianyl. The cycloheteroalkyl groups can also be fused to aromatic or non-aromatic ring systems to form members including, but not limited to, indolinyl. Cycloheteroalkyl groups can be unsubstituted or substituted. “Substituted

cycloheteroalkyl" groups can be substituted with one or more groups selected from halo, hydroxy, amino, alkylamino, amido, acyl, nitro, cyano, alkoxy, and oxo.

[0022] As used herein, the term "heteroalkyl" refers to an alkyl group of any suitable length and having from 1 to 3 heteroatoms such as N, O and S. Additional 5 heteroatoms can also be useful, including, but not limited to, B, Al, Si and P. The heteroatoms can also be oxidized, such as in groups including, but not limited to, -S(O)- and -S(O)₂-⁻. For example, heteroalkyl can include ethers, thioethers and alkyl-amines. The heteroatom portion of the heteroalkyl can replace a hydrogen of the alkyl group to form a hydroxy, thio or amino group. Alternatively, the heteroatom 10 portion can be the connecting atom, or be inserted between two carbon atoms. "Substituted heteroalkyl" groups can be substituted with one or more groups selected from halo, hydroxy, amino, alkylamino, amido, acyl, nitro, cyano, and alkoxy.

[0023] As used herein, the term "alkoxy" refers to an alkyl group, as defined herein, having an oxygen atom that connects the alkyl group to the point of attachment (*i.e.*, 15 alkyl-O-). Alkoxy groups can have any suitable number of carbon atoms, such as C₁₋₆. Alkoxy groups include, for example, methoxy, ethoxy, propoxy, isopropoxy, butoxy, 2-butoxy, isobutoxy, *sec*-butoxy, *tert*-butoxy, pentoxy, hexoxy, etc.

[0024] As used herein, the term "acyl," by itself or as part of another substituent, refers to a radical containing an alkyl group, as defined herein, bound to the carbon 20 atom of a carbonyl group, the carbonyl carbon atom further being the point of attachment of the radical.

[0025] As used herein, the term "amino," by itself or as a part of another substituent, refers to a radical containing a nitrogen atom bound to two or three atoms selected 25 from hydrogen and carbon, the nitrogen atom further being the point of attachment of the radical.

[0026] As used herein, the term "amido," by itself or as part of another substituent, refers to a radical containing an acyl group, as defined herein, bound to the nitrogen atom of an amino group, the carbonyl carbon atom or the nitrogen atom further being the point of attachment of the radical.

30 **[0027]** As used herein, the term "composition" is intended to encompass a product comprising the specified ingredients in the specified amounts, as well as any product,

which results, directly or indirectly, from combination of the specified ingredients in the specified amounts. By “pharmaceutically acceptable” it is meant the carriers, diluents or excipients in the composition must be compatible with other ingredients and not deleterious to the recipient thereof.

5 **[0028]** As used herein, the term “pharmaceutically acceptable carrier” refers to a substance that aids the administration of an active agent to and absorption by a subject. Pharmaceutical carriers useful in the present invention include, but are not limited to, binders, fillers, disintegrants, lubricants, coatings, sweeteners, flavors and colors. One of skill in the art will recognize that other pharmaceutical carriers are useful in
10 the present invention.

[0029] As used herein, the terms “treat”, “treating” and “treatment” refer to any indicia of success in the treatment or amelioration of cancer or an injury, pathology, condition, or symptom (*e.g.*, pain) related to cancer, including any objective or subjective parameter such as abatement; remission; diminishing of symptoms or
15 making the symptom, injury, pathology or condition more tolerable to the patient; decreasing the frequency or duration of the symptom or condition; or, in some situations, preventing the onset of the symptom or condition. The treatment or amelioration of symptoms can be based on any objective or subjective parameter, including, *e.g.*, the result of a physical examination.

20 **[0030]** As used herein, the term “cancer” refers to conditions including solid cancers, lymphomas, and leukemias. Examples of different types of cancer include, but are not limited to, lung cancer (*e.g.*, non-small cell lung cancer or NSCLC), ovarian cancer, prostate cancer, colorectal cancer, liver cancer (*i.e.*, hepatocarcinoma), renal cancer (*i.e.*, renal cell carcinoma), bladder cancer, breast cancer, thyroid cancer, pleural cancer, pancreatic cancer, uterine cancer, cervical cancer, testicular cancer, anal cancer, bile duct cancer, gastrointestinal carcinoid tumors, esophageal cancer, gall bladder cancer, appendix cancer, small intestine cancer, stomach (gastric) cancer, cancer of the central nervous system, skin cancer, choriocarcinoma, head and neck cancer, blood cancer, osteogenic sarcoma, fibrosarcoma, neuroblastoma, glioma,
25 melanoma, B-cell lymphoma, non-Hodgkin's lymphoma, Burkitt's lymphoma, Small Cell lymphoma, Large Cell lymphoma, monocytic leukemia, myelogenous leukemia, acute lymphocytic leukemia, acute myelocytic leukemia, and multiple myeloma.

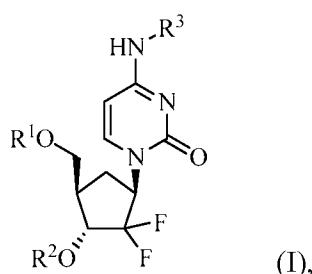
[0031] As used herein, the term “subject” refers to animals such as mammals, including, but not limited to, primates (e.g., humans), cows, sheep, goats, horses, dogs, cats, rabbits, rats, mice and the like. In certain embodiments, the subject is a human.

[0032] As used herein, the term “administering” refers to oral, topical, parenteral, 5 intraperitoneal, intramuscular, intralesional, intranasal, subcutaneous, or intrathecal administration of a compound or composition of the invention to a subject, as well as administration via suppository or implantation of a slow-release device, e.g., a mini-osmotic pump.

[0033] As used herein, the term “effective amount” refers to a dose of a compound 10 or composition that produces therapeutic effects for which it is administered. The exact dose will depend on the purpose of the treatment, and will be ascertainable by one skilled in the art using known techniques (see, e.g., Lieberman, *Pharmaceutical Dosage Forms* (vols. 1-3, 1992); Lloyd, *The Art, Science and Technology of Pharmaceutical Compounding* (1999); Pickar, *Dosage Calculations* (1999); and 15 Remington: *The Science and Practice of Pharmacy*, 20th Edition, 2003, Gennaro, Ed., Lippincott, Williams & Wilkins). In sensitized cells, the therapeutically effective dose can often be lower than the conventional therapeutically effective dose for non-sensitized cells.

II. Gemcitabine Prodrugs

20 **[0034]** In one aspect, the invention provides compounds according to formula I:



and pharmaceutically acceptable salts thereof. For compounds of formula I, R¹ and R² are independently selected from H, -C(=O)-(CH₂)₂-Ar and -C(=O)-(CH₂)_n-C(=O)-NH-Ar, wherein Ar is aryl or heteroaryl and at least one of R¹ and R² is other than H. The subscript n is from 2 to 6. R³ is selected from H and -C(=O)-O-R⁴; and R⁴ is selected from alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, arylalkyl, substituted arylalkyl, cycloheteroalkyl, 25

substituted cycloheteroalkyl, heteroalkyl and substituted heteroalkyl. In some embodiments, the invention provides prodrugs of compounds of formula I and pharmaceutically acceptable salts of the prodrugs.

[0035] In some embodiments, R¹ and R² are independently selected from

5 H, -C(=O)-(CH₂)₂-Ar and -C(=O)-(CH₂)_n-C(=O)-NH-phenyl, wherein Ar is phenyl or 3-pyridyl; and the subscript n is 2, 4 or 6. In some embodiments, R² and R³ are H. In some embodiments, R² is H and R¹ and R³ are other than H. In some embodiments, R¹ is H and R² and R³ are other than H. In some embodiments, R⁴ is selected from alkyl and substituted alkyl when R³ is other than H. In some embodiments, R⁴ is 10 C₁-C₈ alkyl when R³ is other than H. In some embodiments, R⁴ is C₃-C₈ heteroalkyl when R³ is other than H.

[0036] In some embodiments, R² is H and R³ is C₁₋₈ alkyloxycarbonyl or

C₃₋₈ heteroalkyloxycarbonyl. In such embodiments, R¹ can be aryl-acyl, heteroaryl-acyl, arylamido-acyl, or heteroaryl amido-acyl. In some embodiments, R¹ is selected 15 from (3-aryl)propanoyl, (3-heteroaryl)propanoyl, 4-arylamino-4-oxo-butanoyl, 6-arylamino-6-oxo-hexanoyl, 8-arylamino-8-oxo-octanoyl, 4-heteroaryl amido-4-oxo-butanoyl, 6-heteroaryl amido-6-oxo-hexanoyl, and 8-heteroaryl amido-8-oxo-octanoyl.

[0037] In some embodiments, R² is H and R³ is alkyloxycarbonyl. In such

embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-20 oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

[0038] In some embodiments, R² is H and R³ is ethoxycarbonyl. In such

embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

[0039] In some embodiments, R² is H and R³ is *n*-butyloxycarbonyl. In such

25 embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

[0040] In some embodiments, R² is H and R³ is isobutyloxycarbonyl. In such

embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

[0041] In some embodiments, R² is H and R³ is *n*-pentyloxycarbonyl. In such embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

5 **[0042]** In some embodiments, R² is H and R³ is *n*-hexyloxycarbonyl. In such embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

[0043] In some embodiments, R² is H and R³ is *n*-heptyloxycarbonyl. In such embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

10 **[0044]** In some embodiments, R² is H and R³ is C₃₋₈ heteroalkylcarbonyl. In such embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

15 **[0045]** In some embodiments, R² is H and R³ is (2-methoxy)ethyloxycarbonyl. In such embodiments, R¹ can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

20 **[0046]** In some embodiments, R¹ is H and R³ is C₁₋₈ alkyloxycarbonyl or C₃₋₈ heteroalkyloxycarbonyl. In such embodiments, R² can be aryl-acyl, heteroaryl-acyl, arylamido-acyl, or heteroaryl amido-acyl. In some embodiments, R² is selected from (3-aryl)propanoyl, (3-heteroaryl)propanoyl, 4-aryl amino-4-oxo-butanoyl, 6-aryl amino-6-oxo-hexanoyl, 8-aryl amino-8-oxo-octanoyl, 4-heteroaryl amino-4-oxo-butanoyl, 6-heteroaryl amino-6-oxo-hexanoyl, and 8-heteroaryl amino-8-oxo-octanoyl.

[0047] In some embodiments, R¹ is H and R³ is C₁₋₈ alkyloxycarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

25 **[0048]** In some embodiments, R¹ is H and R³ is ethoxycarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

30 **[0049]** In some embodiments, R¹ is H and R³ is *n*-butyloxycarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

[0050] In some embodiments, R¹ is H and R³ is isobutyloxycarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

5 **[0051]** In some embodiments, R¹ is H and R³ is *n*-pentyloxycarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

[0052] In some embodiments, R¹ is H and R³ is *n*-hexyloxycarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

10 **[0053]** In some embodiments, R¹ is H and R³ is *n*-heptyloxycarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

15 **[0054]** In some embodiments, R¹ is H and R³ is C₃₋₈ heteroalkylcarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

[0055] In some embodiments, R¹ is H and R³ is (2-methoxy)ethyloxycarbonyl. In such embodiments, R² can be 3-phenyl-propanoyl, 3-(3-pyridyl)-propanoyl, 4-anilino-4-oxo-butanoyl, 6-anilino-6-oxo-hexanoyl, or 8-anilino-8-oxo-octanoyl.

20 **[0056]** Compounds of the invention can be made by the methods depicted in Figures 1, 2, and 3. These schemes are merely illustrative of some methods by which the compounds of the invention can be synthesized, and various modifications to these schemes can be made and will be suggested to one skilled in the art having referred to this disclosure.

25 **[0057]** The starting materials and reagents used in preparing these compounds are either available from commercial suppliers or are prepared by methods known to those skilled in the art following procedures set forth in references such as Fieser and Fieser's *Reagents for Organic Synthesis*, Volumes 1-17 (John Wiley and Sons, 1991); Rodd's *Chemistry of Carbon Compounds*, Volumes 1-5 and Supplements (Elsevier Science Publishers, 1989); *Organic Reactions*, Volumes 1-40 (John Wiley and Sons, 1991), March's *Advanced Organic Chemistry*, (John Wiley and Sons, 4th Edition) and Larock's *Comprehensive Organic Transformations* (VCH Publishers Inc., 1989).

[0058] The starting materials and the intermediates of the reaction can be isolated and purified if desired using conventional techniques including, but not limited to, filtration, distillation, crystallization, chromatography and the like. Such materials can be characterized using conventional means, including measuring physical constants and obtaining spectral data.

[0059] Unless specified to the contrary, the reactions described herein take place at atmospheric pressure over a temperature range of from about -78 °C to about 150 °C. For example, reactions can be conducted at from about 0 °C to about 125 °C, or at about room (or ambient) temperature, e.g., about 20 °C.

10 **[0060]** In the reactions described hereinafter, it may be necessary to protect reactive functional groups, for example hydroxy, amino, imino, thio or carboxy groups, where these are desired in the final product, to avoid their unwanted participation in the reactions. Conventional protecting groups can be used in accordance with standard practice, for examples see T.W. Greene and P. G. M. Wuts in "*Protective Groups in Organic Chemistry*" John Wiley and Sons, 1999.

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III. Pharmaceutical Compositions

[0061] In a second aspect, the invention provides pharmaceutical compositions containing one or more compounds according to formula I as described above, prodrugs thereof, or pharmaceutically acceptable salts of the compounds and prodrugs.

20 **[0062]** Accordingly, some embodiments of the invention provide pharmaceutical compositions containing any of the compounds of formula I described herein, or pharmaceutical salts thereof, as well as a pharmaceutically acceptable carrier. The compositions can also include prodrugs of compounds of formula I, or pharmaceutically acceptable salts of the prodrugs. For compositions containing compounds of formula (I), R¹ and R² are independently selected from H, –

25 C(=O)-(CH₂)₂-Ar and –C(=O)-(CH₂)_n-C(=O)-NH-Ar, wherein Ar is aryl or heteroaryl and at least one of R¹ and R² is other than H. The subscript n is from 2 to 6. R³ is selected from H and –C(=O)-O-R⁴; and R⁴ is selected from alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, arylalkyl, substituted arylalkyl, cycloheteroalkyl, substituted cycloheteroalkyl, heteroalkyl and substituted heteroalkyl.

30

[0063] In some embodiments, R¹ and R² are independently selected from H, –C(=O)-(CH₂)₂-Ar and –C(=O)-(CH₂)_n-C(=O)-NH-phenyl, wherein Ar is phenyl or 3-pyridyl; and the subscript n is 2, 4 or 6. In some embodiments, R² and R³ are H. In some embodiments, R² is H and R¹ and R³ are other than H. In some embodiments, R¹ is H and R² and R³ is other than H. In some embodiments, R⁴ is selected from alkyl and substituted alkyl when R³ is other than H.

[0064] The pharmaceutical compositions for the administration of the compounds of the invention can be prepared by any of the methods well known in the art of pharmacy and drug delivery. The compositions can be conveniently prepared and/or packaged in unit dosage form. Methods of preparing the compositions include the step of bringing the active ingredient into association with a carrier containing one or more accessory ingredients. In general, the pharmaceutical compositions are prepared by uniformly and intimately bringing the active ingredient into association with a liquid carrier or a finely divided solid carrier or both, and then, if necessary, shaping the product into the desired formulation.

[0065] The pharmaceutical compositions can be in the form of a sterile injectable aqueous or oleaginous suspension. This suspension can be formulated according to the known art using those suitable dispersing or wetting agents and suspending agents which have been mentioned above. The sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally-acceptable diluent or solvent, for example as a solution in 1,3-butane diol. Among the acceptable vehicles and solvents that can be employed are water, Ringer's solution and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil can be employed including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid find use in the preparation of injectables.

[0066] Aqueous suspensions contain the active materials in admixture with excipients suitable for the manufacture of aqueous suspensions. Such excipients include, but are not limited to: suspending agents such as sodium carboxymethylcellulose, methylcellulose, oleagino-propylmethylcellulose, sodium alginate, polyvinyl-pyrrolidone, gum tragacanth and gum acacia; dispersing or

wetting agents such as lecithin, polyoxyethylene stearate, and polyethylene sorbitan monooleate; and preservatives such as ethyl, *n*-propyl, and *p*-hydroxybenzoate.

[0067] Oily suspensions can be formulated by suspending the active ingredient in a vegetable oil, for example, arachis oil, olive oil, sesame oil or coconut oil, or in a 5 mineral oil such as liquid paraffin. The oily suspensions may contain a thickening agent, for example beeswax, hard paraffin or cetyl alcohol. These compositions can be preserved by the addition of an anti-oxidant such as ascorbic acid.

[0068] Dispersible powders and granules suitable for preparation of an aqueous suspension by the addition of water provide the active ingredient in admixture with a 10 dispersing or wetting agent, suspending agent and one or more preservatives. Suitable dispersing or wetting agents and suspending agents are exemplified by those already mentioned above. Additional excipients, can also be present.

[0069] The pharmaceutical compositions of the invention may also be in the form of oil-in-water emulsions. The oily phase can be a vegetable oil, for example olive oil 15 or arachis oil, or a mineral oil, for example liquid paraffin or mixtures of these. Suitable emulsifying agents can be naturally-occurring gums, for example gum acacia or gum tragacanth, naturally-occurring phosphatides, for example soy bean, lecithin, and esters or partial esters derived from fatty acids and hexitol anhydrides, for example sorbitan monooleate, and condensation products of the said partial esters 20 with ethylene oxide, for example polyoxyethylene sorbitan monooleate. The emulsions may also contain sweetening and flavoring agents.

[0070] The pharmaceutical compositions containing the active ingredient can be in a form suitable for oral use, for example, as tablets, troches, lozenges, aqueous or oily suspensions, dispersible powders or granules, emulsions, hard or soft capsules, syrups, 25 elixirs, solutions, buccal patches, oral gels, chewing gums, chewable tablets, effervescent powder and effervescent tablets. Compositions intended for oral use can be prepared according to any method known to the art for the manufacture of pharmaceutical compositions and such compositions may contain one or more agents selected from sweetening agents, flavoring agents, coloring agents, antioxidants and 30 preserving agents in order to provide pharmaceutically elegant and palatable preparations. Tablets contain the active ingredient in admixture with non-toxic pharmaceutically acceptable excipients, which are suitable for the manufacture of

tablets. These excipients include, but are not limited to: inert diluents such as cellulose, silicon dioxide, aluminum oxide, calcium carbonate, sodium carbonate, glucose, mannitol, sorbitol, lactose, calcium phosphate and sodium phosphate; granulating and disintegrating agents such as corn starch and alginic acid; binding agents such as PVP, cellulose, PEG, starch, gelatin and acacia; and lubricating agents such as magnesium stearate, stearic acid, and talc. The tablets can be uncoated or coated, enterically or otherwise, by known techniques to delay disintegration and absorption in the gastrointestinal tract and thereby provide a sustained action over a longer period. For example, a time delay material such as glyceryl monostearate or 10 glyceryl distearate can be employed. They may also be coated by the techniques described in the U.S. Pat. Nos. 4,256,108; 4,166,452; and 4,265,874 to form osmotic therapeutic tablets for control release.

15 **[0071]** Formulations for oral use may also be presented as hard gelatin capsules wherein the active ingredient is mixed with an inert solid diluent (such as calcium carbonate, calcium phosphate, or kaolin), or as soft gelatin capsules wherein the active ingredient is mixed with water or an oil medium (such as peanut oil, liquid paraffin, or olive oil). Additionally, emulsions can be prepared with a non-water miscible ingredients such as oils and stabilized with surfactants such as mono-diglycerides, PEG esters, and the like.

20 **[0072]** The compounds of the present invention may also be administered in the form of suppositories for rectal administration of the drug. These compositions can be prepared by mixing the drug with a suitable non-irritating excipient which is solid at ordinary temperatures but liquid at the rectal temperature and will therefore melt in the rectum to release the drug. Such materials include cocoa butter and polyethylene glycols. Additionally, the compounds can be administered via ocular delivery by means of solutions or ointments. Still further, transdermal delivery of the subject compounds can be accomplished by means of iontophoretic patches and the like. For topical use, creams, ointments, jellies, solutions or suspensions, etc., containing the compounds of the present invention are employed. As used herein, topical application 25 is also meant to include the use of mouth washes and gargles, as well as eye-drops for ophthalmological use.

[0073] The compounds of the invention can be formulated for depositing into a medical device, which may include any of variety of conventional grafts, stents, including stent grafts, catheters, balloons, baskets or other device that can be deployed or permanently implanted within a body lumen. As a particular example, it would be 5 desirable to have devices and methods which can deliver compounds of the invention to the region of a body which has been treated by interventional technique. The term “deposited” means that the inhibitory agent is coated, adsorbed, placed, or otherwise incorporated into the device by methods known in the art. For example, the inhibitory agent can be embedded and released from within (“matrix type”) or surrounded by 10 and released through (“reservoir type”) polymer materials that coat or span the medical device. In the later example, the inhibitory agent can be entrapped within the polymer materials or coupled to the polymer materials using one or more the techniques for generating such materials known in the art. In other formulations, the inhibitory agent can be linked to the surface of the medical device without the need 15 for a coating by means of detachable bonds and release with time, can be removed by active mechanical or chemical processes, or are in a permanently immobilized form that presents the inhibitory agent at the implantation site.

IV. Methods of Inhibiting Cancer

[0074] In a third aspect, the invention provides methods for treating cancer in a 20 subject. The methods include administering to the subject an effective amount of a compound or pharmaceutical composition of the invention. In therapeutic use for the treatment of cancer, the compounds and compositions of the present invention can be administered such that the initial dosage of a gemcitabine prodrug ranges from about 0.001 mg/kg to about 1000 mg/kg daily. A daily dose of about 0.01-500 mg/kg, or 25 about 0.1-200 mg/kg, or about 1-100 mg/kg, or about 10-50 mg/kg, or about 10 mg/kg, or about 5 mg/kg, or about 2.5 mg/kg, or about 1 mg/kg can be used.

[0075] The dosages can be varied depending upon the requirements of the patient, the severity of the cancer being treated, and the gemcitabine prodrug being employed. For example, dosages can be empirically determined considering the type and stage of 30 cancer diagnosed in a particular patient. The dose administered to a patient should be sufficient to result in a beneficial therapeutic response in the patient over time. The size of the dose will also be determined by the existence, nature, and extent of any

adverse side-effects that accompany the administration of a particular gemcitabine prodrug in a particular patient. Determination of the proper dosage for a particular situation is within the skill of the typical practitioner. Generally, treatment is initiated with smaller dosages which are less than the optimum dose of the gemcitabine

5 prodrug. Thereafter, the dosage is increased by small increments until the optimum effect under the circumstances is reached. The total daily dosage can be divided and administered in portions during the day.

[0076] The compositions can be administered alone in the methods of the invention, or in combination with other therapeutic agents. In some embodiments, the methods 10 further include administering to the subject an anti-cancer agent. In certain instances, the methods include a combination of anti-cancer agents. Any suitable anti-cancer agent can be used in the methods of the invention. In some embodiments, the anti-cancer agent is selected from a conventional chemotherapeutic agent, a targeted therapeutic agent, and a radiotherapeutic agent.

15 **[0077]** Suitable conventional chemotherapeutic agents include, but are not limited to, anthracycline antibiotics, DNA synthesis inhibitors, alkylating agents, antifolate agents, metabolic inhibitors and combinations thereof. Examples of anthracycline antibiotics include, but are not limited to, doxorubicin, epirubicin, mitoxantrone and the like. Examples of DNA synthesis inhibitors include, but are not limited to, 20 mitomycin C, 5FU (5-fluorouracil), capecitabine, irinotecan hydrochloride, thymitaq and the like. Examples of alkylating agents include, but are not limited to, cisplatin, carboplatin, oxaliplatin, mitoxantrone and the like. Examples of metabolic inhibitors include, but are not limited to, etoposide,rottlerin and the like. Examples of antifolate agents include, but are not limited to, nolatrexed and the like.

25 **[0078]** Targeted cancer therapies are medications which inhibit the growth of cancer cells by interfering with specific targeted molecules needed for carcinogenesis and cancer growth, rather than by simply interfering with rapidly dividing cells (e.g. with conventional chemotherapeutic agent). Targeted cancer therapy can include kinase inhibitors, angiogenesis inhibitors, epidermal growth factor receptor (EGFR) 30 inhibitors, HER2/neu receptors, or combinations thereof. Examples of kinase inhibitors include, but are not limited to, lapatinib, sorafenib, sunitinib, erlotinib, ABT-869, ARQ 197 and the like. Examples of angiogenesis inhibitors include, but are not

limited to, Avastin, Brivanib, Bevacizumab, Ramucirumab and the like. Examples of EGFR inhibitor include, but are not limited to, Cetuximab, Gefitinib and the like. Examples of HER2/neu receptor include, but are not limited to, Trastuzumab and the like.

5 **[0079]** Radiotherapeutic agents are those conventionally adopted in the therapeutic field of cancer treatment and include photons having enough energy for chemical bond ionization such as, for instance, alpha (α), beta (β), and gamma (γ) rays from radioactive nuclei as well as x-rays. The radiation may be high-LET (linear energy transfer) or low-LET. LET is the energy transferred per unit length of the distance.

10 High LET is said to be densely ionizing radiation and Low LET is said to be sparsely ionizing radiation. Representative examples of high-LET are neutrons and alpha particles. Representative examples of low-LET are x-ray and gamma rays. Low LET radiation including both x-rays and γ rays is most commonly used for radiotherapy of cancer patients. The radiation may be used for external radiation therapy that is

15 usually given on an outpatient basis or for internal radiation therapy that uses radiation that is placed very close to or inside the tumor. In case of internal radiation therapy, the radiation source is usually sealed in a small holder called an implant. Implants may be in the form of thin wires, plastic tubes called catheters, ribbons, capsules, or seeds. The implant is put directly into the body. Internal radiation

20 therapy may require a hospital stay. The ionizing radiation source is provided as a unit dose of radiation and is preferably an x-ray tube since it provides many advantages, such as convenient adjustable dosing where the source may be easily turned on and off, minimal disposal problems, and the like. A unit dose of radiation is generally measured in gray (Gy). The ionizing radiation source may also comprise a

25 radioisotope, such as a solid radioisotopic source (*e.g.*, wire, strip, pellet, seed, bead, or the like), or a liquid radioisotopic filled balloon. In the latter case, the balloon has been specially configured to prevent leakage of the radioisotopic material from the balloon into the body lumen or blood stream. Still further, the ionizing radiation source may comprise a receptacle in the catheter body for receiving radioisotopic

30 materials like pellets or liquids. The radioisotopic material may be selected to emit α , β and γ . Usually, α and β radiations are preferred since they may be quickly absorbed by the surrounding tissue and will not penetrate substantially beyond the wall of the body lumen being treated. Accordingly, incidental irradiation of the heart and other

organs adjacent to the treatment region can be substantially eliminated. The total number of units provided will be an amount determined to be therapeutically effective by one skilled in treatment using ionizing radiation. This amount will vary with the subject and the type of malignancy or neoplasm being treated. The amount may vary 5 but a patient may receive a dosage of about 30-75 Gy over several weeks.

[0080] Additional anti-cancer agents can include, but are not limited to, 20-epi-1,25 dihydroxyvitamin D3,4-ipomeanol, 5-ethynyluracil, 9-dihydrotaxol, abiraterone, acivicin, aclarubicin, acodazole hydrochloride, acronine, acylfulvene, adecyphenol, adozelesin, aldesleukin, all-tk antagonists, altretamine, ambamustine, ambomycin, 10 ametantrone acetate, amidox, amifostine, aminoglutethimide, aminolevulinic acid, amrubicin, amsacrine, anagrelide, anastrozole, andrographolide, angiogenesis inhibitors, antagonist D, antagonist G, antarelix, anthramycin, anti-dorsalizing morphogenetic protein-1, antiestrogen, antineoplaston, antisense oligonucleotides, aphidicolin glycinate, apoptosis gene modulators, apoptosis regulators, apurinic acid, 15 ARA-CDP-DL-PTBA, arginine deaminase, asparaginase, asperlin, asulacrine, atamestane, atrimustine, axinastatin 1, axinastatin 2, axinastatin 3, azacitidine, azasetron, azatoxin, azatyrosine, azetepa, azotomycin, baccatin III derivatives, balanol, batimastat, benzochlorins, benzodepa, benzoylstaurosporine, beta lactam derivatives, beta-alethine, betaclamycin B, betulinic acid, BFGF inhibitor, bicalutamide, 20 bisantrene, bisantrene hydrochloride, bisaziridinylspermine, bisnafide, bisnafide dimesylate, bistratene A, bizelesin, bleomycin, bleomycin sulfate, BRC/ABL antagonists, breflate, brequinar sodium, bropirimine, budotitane, busulfan, buthionine sulfoximine, cactinomycin, calcipotriol, calphostin C, calusterone, camptothecin derivatives, canarypox IL-2, capecitabine, caracemide, carbetimer, carboplatin, 25 carboxamide-amino-triazole, carboxyamidotriazole, carest M3, carmustine, cam 700, cartilage derived inhibitor, carubicin hydrochloride, carzelesin, casein kinase inhibitors, castanospermine, cecropin B, cedefingol, cetrorelix, chlorambucil, chlorins, chloroquinoxaline sulfonamide, cicaprost, cirolemycin, cisplatin, cis-porphyrin, cladribine, clomifene analogs, clotrimazole, collismycin A, collismycin B, 30 combretastatin A4, combretastatin analog, conagenin, crambescidin 816, crisnatol, crisnatol mesylate, cryptophycin 8, cryptophycin A derivatives, curacin A, cyclopentanthraquinones, cyclophosphamide, cycloplatam, cypemycin, cytarabine, cytarabine ocfosfate, cytolytic factor, cytostatin, dacarbazine, daclizimab,

dactinomycin, daunorubicin hydrochloride, decitabine, dehydrodidemnin B, deslorelin, dexifosfamide, dexormaplatin, dexrazoxane, dexverapamil, dezaguanine, dezaguanine mesylate, diaziquone, didemnin B, didox, diethylnorspermine, dihydro-5-azacytidine, dioxamycin, diphenyl spiromustine, docetaxel, docosanol, dolasetron, doxifluridine, 5 doxorubicin, doxorubicin hydrochloride, droloxifene, droloxifene citrate, dromostanolone propionate, dronabinol, duazomycin, duocarmycin SA, ebselen, ecomustine, edatrexate, edelfosine, edrecolomab, eflomithine, eflomithine hydrochloride, elemene, elsamitracin, emitefur, enloplatin, enpromate, epipropidine, epirubicin, epirubicin hydrochloride, epristeride, erbulazole, erythrocyte gene therapy 10 vector system, esorubicin hydrochloride, estramustine, estramustine analog, estramustine phosphate sodium, estrogen agonists, estrogen antagonists, etanidazole, etoposide, etoposide phosphate, etoprine, exemestane, fadrozole, fadrozole hydrochloride, fazarabine, fenretinide, filgrastim, finasteride, flavopiridol, flezelastine, floxuridine, fluasterone, fludarabine, fludarabine phosphate, fluorodaunorubicin 15 hydrochloride, fluorouracil, fluorocitabine, forfenimex, formestane, fosquidone, fostriecin, fostriecin sodium, fotemustine, gadolinium texaphyrin, gallium nitrate, galocitabine, ganirelix, gelatinase inhibitors, glutathione inhibitors, hepsulfam, heregulin, hexamethylene bisacetamide, hydroxyurea, hypericin, ibandronic acid, idarubicin, idarubicin hydrochloride, idoxifene, idramantone, ifosfamide, ilmofosine, 20 ilomastat, imidazoacridones, imiquimod, immunostimulant peptides, insulin-like growth factor-1 receptor inhibitor, interferon agonists, interferon alpha-2A, interferon alpha-2B, interferon alpha-N1, interferon alpha-N3, interferon beta-1A, interferon gamma-1B, interferons, interleukins, iobenguane, iododoxorubicin, iproplatin, irinotecan, irinotecan hydrochloride, iroplact, irsogladine, isobengazole, 25 isohomohalicondrin B, itasetron, jasplakinolide, kahalalide F, lamellarin-N triacetate, lanreotide, lanreotide acetate, leinamycin, lenograstim, lentinan sulfate, leptolstatin, letrozole, leukemia inhibiting factor, leukocyte alpha interferon, leuprolide acetate, leuprolide/estrogen/progesterone, leuprorelin, levamisole, liarozole, liarozole hydrochloride, linear polyamine analog, lipophilic disaccharide peptide, lipophilic 30 platinum compounds, lissoclinamide 7, lobaplatin, lombricine, lometrexol, lometrexol sodium, lomustine, lonidamine, losoxantrone, losoxantrone hydrochloride, lovastatin, loxoribine, lurtotecan, lutetium texaphyrin, lysofylline, lytic peptides, maitansine, mannostatin A, marimastat, masoprolol, maspin, matrilysin inhibitors, matrix metalloproteinase inhibitors, maytansine, mechlorethamine hydrochloride, megestrol

acetate, melengestrol acetate, melphalan, menogaril, merbarone, mercaptoperine, meterelin, methioninase, methotrexate, methotrexate sodium, metoclopramide, metoprine, meturedopa, microalgal protein kinase C inhibitors, MIF inhibitor, mifepristone, miltefosine, mirimostim, mismatched double stranded RNA,

5 mitindomide, mitocarcin, mitocromin, mitogillin, mitoguazone, mitolactol, mitomalcin, mitomycin, mitomycin analogs, mitonafide, mitosper, mitotane, mitotoxin fibroblast growth factor-saporin, mitoxantrone, mitoxantrone hydrochloride, mofarotene, molgramostim, monoclonal antibody, human chorionic gonadotrophin, monophosphoryl lipid a/myobacterium cell wall SK, mopidamol, multiple drug

10 resistance gene inhibitor, multiple tumor suppressor 1-based therapy, mustard anticancer agent, mycaperoxide B, mycobacterial cell wall extract, mycophenolic acid, myriaporone, n-acetyldinaline, nafarelin, nagrestip, naloxone/pentazocine, napavin, naphterpin, nartograstim, nedaplatin, nemorubicin, neridronic acid, neutral endopeptidase, nilutamide, nisamycin, nitric oxide modulators, nitroxide antioxidant,

15 nitrullyn, nocodazole, nogalamycin, n-substituted benzamides, 06-benzylguanine, octreotide, okicenone, oligonucleotides, onapristone, ondansetron, oracin, oral cytokine inducer, ormaplatin, osaterone, oxaliplatin, oxaunomycin, oxisuran, paclitaxel, paclitaxel analogs, paclitaxel derivatives, palauamine, palmitoylrhizoxin, pamidronic acid, panaxytriol, panomifene, parabactin, pazelliptine, pegaspargase,

20 peldesine, peliomycin, pentamustine, pentosan polysulfate sodium, pentostatin, pentrozole, peplomycin sulfate, perflubron, perfosfamide, perillyl alcohol, phenazinomycin, phenylacetate, phosphatase inhibitors, picibanil, pilocarpine hydrochloride, pipobroman, piposulfan, pirarubicin, piritrexim, piroxantrone hydrochloride, placetin A, placetin B, plasminogen activator inhibitor, platinum

25 complex, platinum compounds, platinum-triamine complex, plicamycin, plomestane, porfimer sodium, porfiromycin, prednimustine, procarbazine hydrochloride, propyl bis-acridone, prostaglandin J2, prostatic carcinoma antiandrogen, proteasome inhibitors, protein A-based immune modulator, protein kinase C inhibitor, protein tyrosine phosphatase inhibitors, purine nucleoside phosphorylase inhibitors,

30 puromycin, puromycin hydrochloride, purpurins, pyrazofurin, pyrazoloacridine, pyridoxylated hemoglobin polyoxyethylene conjugate, RAF antagonists, raltitrexed, ramosetron, RAS farnesyl protein transferase inhibitors, RAS inhibitors, RAS-GAP inhibitor, retelliptine demethylated, rhenium RE 186 etidronate, rhizoxin, riboprime, ribozymes, RII retinamide, RNAi, rogletimide, rohitukine, romurtide, roquinimex,

rubiginone B1, ruboxyl, safingol, safingol hydrochloride, saintopin, sarcnu, sarcophytol A, sargramostim, SDI 1 mimetics, semustine, senescence derived inhibitor 1, sense oligonucleotides, signal transduction inhibitors, signal transduction modulators, simtrazene, single chain antigen binding protein, sizofuran, sobuzoxane,

5 sodium borocaptate, sodium phenylacetate, solverol, somatomedin binding protein, sonermin, sparfosate sodium, sparfosic acid, sparsomycin, spicamycin D, spirogermanium hydrochloride, spiomustine, spiroplatin, splenopentin, spongistatin 1, squalamine, stem cell inhibitor, stem-cell division inhibitors, stipiamide, streptonigrin, streptozocin, stromelysin inhibitors, sulfinosine, sulofenur, superactive vasoactive

10 intestinal peptide antagonist, suradista, suramin, swainsonine, synthetic glycosaminoglycans, talisomycin, tallimustine, tamoxifen methiodide, tauromustine, tazarotene, tecogalan sodium, tegafur, tellurapyrylium, telomerase inhibitors, teloxantrone hydrochloride, temoporfin, temozolomide, teniposide, teroxirone, testolactone, tetrachlorodecaoxide, tetrazomine, thaliblastine, thalidomide,

15 thiamiprime, thiocoraline, thioguanine, thiopeta, thrombopoietin, thrombopoietin mimetic, thymalfasin, thymopoietin receptor agonist, thymotrinan, thyroid stimulating hormone, tiazofurin, tin ethyl etiopurpurin, tirapazamine, titanocene dichloride, topotecan hydrochloride, topsentin, toremifene, toremifene citrate, totipotent stem cell factor, translation inhibitors, trestolone acetate, tretinoin, triacetyluridine, triciribine,

20 triciribine phosphate, trimetrexate, trimetrexate glucuronate, triptorelin, tropisetron, tubulozole hydrochloride, turosteride, tyrosine kinase inhibitors, tyrophostins, UBC inhibitors, ubenimex, uracil mustard, uredepa, urogenital sinus-derived growth inhibitory factor, urokinase receptor antagonists, vapreotide, variolin B, velaresol, veramine, verdins, verteporfin, vinblastine sulfate, vincristine sulfate, vindesine,

25 vindesine sulfate, vinepidine sulfate, vinglycinate sulfate, vinleurosine sulfate, vinorelbine, vinorelbine tartrate, vinrosidine sulfate, vinxaltine, vinzolidine sulfate, vitaxin, vorozole, zanoterone, zeniplatin, zilascorb, zinostatin, zinostatin stimalamer, or zorubicin hydrochloride. In some embodiments, the anti-cancer agent is selected from methotrexate, taxol, L-asparaginase, mercaptopurine, thioguanine, hydroxyurea,

30 cytarabine, cyclophosphamide, ifosfamide, nitrosoureas, cisplatin, carboplatin, mitomycin, dacarbazine, procarbazine, topotecan, nitrogen mustards, cytoxan, etoposide, 5-fluorouracil, BCNU, irinotecan, camptothecins, bleomycin, doxorubicin, idarubicin, daunorubicin, dactinomycin, plicamycin, mitoxantrone, asparaginase, vinblastine, vincristine, vinorelbine, paclitaxel, and docetaxel. In some embodiments,

the anti-cancer agent is selected from cisplatin, oxaliplatin, carboplatin, erlotinib, gefitinib, lapatinib, cetuximab, zalutumumab, minotuzumab, and matuzumab.

[0081] Compounds and compositions as described above can be administered via any suitable route when used in the methods of the invention. In some embodiments, 5 administering the compound or composition is conducted orally. In some embodiments, administering the compound or composition is conducted parenterally. Other routes of administration can be useful in the methods of the invention.

[0082] A number of cancers can be treated according to the methods of the invention. Cancers contemplated for treatment using the methods of the invention 10 include solid tumors such as fibrosarcoma, myxosarcoma, liposarcoma, chondrosarcoma, osteogenic sarcoma, chordoma, angiosarcoma, endotheliosarcoma, lymphangiosarcoma, lymphangioendotheliosarcoma, synovioma, mesothelioma, Ewing's tumor, leiomyosarcoma, rhabdomyosarcoma, non-small cell lung cancer, colon cancer, colorectal cancer, kidney cancer, pancreatic cancer, bone cancer, breast 15 cancer, ovarian cancer, prostate cancer, esophageal cancer, stomach cancer, oral cancer, nasal cancer, throat cancer, squamous cell carcinoma, basal cell carcinoma, adenocarcinoma, sweat gland carcinoma, sebaceous gland carcinoma, papillary carcinoma, papillary adenocarcinomas, cystadenocarcinoma, medullary carcinoma, bronchogenic carcinoma, renal cell carcinoma, hepatoma, bile duct carcinoma, 20 choriocarcinoma, seminoma, embryonal carcinoma, Wilms' tumor, cervical cancer, uterine cancer, testicular cancer, small cell lung carcinoma, bladder carcinoma, lung cancer, epithelial carcinoma, glioma, glioblastoma multiforme, astrocytoma, medulloblastoma, craniopharyngioma, ependymoma, pinealoma, hemangioblastoma, acoustic neuroma, oligodendrogioma, meningioma, skin cancer, melanoma, 25 neuroblastoma, and retinoblastoma. Cancers also include blood-borne cancers, such as acute lymphoblastic leukemia (ALL), acute lymphoblastic B-cell leukemia, acute lymphoblastic T-cell leukemia, acute myeloblastic leukemia (AML), acute promyelocytic leukemia (APL), acute monoblastic leukemia, acute erythroleukemic leukemia, acute megakaryoblastic leukemia, acute myelomonocytic leukemia, acute 30 nonlymphocytic leukemia, acute undifferentiated leukemia, chronic myelocytic leukemia (CML), chronic lymphocytic leukemia (CLL), hairy cell leukemia, and multiple myeloma. Cancer also includes acute and chronic leukemias such as lymphoblastic, myelogenous, lymphocytic, and myelocytic leukemias. Cancer also

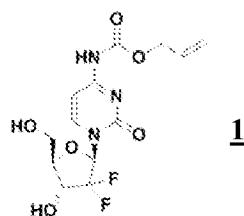
includes lymphomas such as Hodgkin's disease, non-Hodgkin's Lymphoma, Waldenström's macroglobulinemia, heavy chain disease, and polycythemia vera. Some embodiments of the invention provide methods for treating cancer as described above, wherein the cancer is selected from pancreatic cancer, non-small cell lung cancer, breast cancer, ovarian cancer, and bladder cancer.

[0083] In a related aspect, the invention provides methods for inhibiting the growth of cancer cells. The methods include contacting the cells with an effective amount of any of the compounds of the invention. In some embodiments, the methods further include contacting the cells with an anti-cancer agent. In some embodiments, the 10 anti-cancer agent is selected from a conventional chemotherapeutic agent, a targeted therapeutic agent, a radiotherapeutic agent, and a mixture thereof. In some embodiments, the anti-cancer agent is selected from cisplatin, oxaliplatin, carboplatin, erlotinib, gefitinib, lapatinib, cetuximab, zalutumumab, minotuzumab, and matuzumab. In some embodiments, the cancer cells are selected from the group 15 consisting of pancreatic cancer cells, non-small cell lung cancer cells, breast cancer cells, ovarian cancer cells, and bladder cancer cells.

V. Examples

Example 1

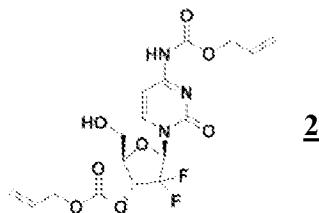
[0084] 5 'O-derivatized gemcitabine prodrugs can be prepared according to Figure 20 1.



[0085] Method A: Preparation of 4-Allyloxycarbonylamo-1-[(2R,4R,5R)-3,3-difluoro-4-hydroxy-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydropyrimidin-2-one

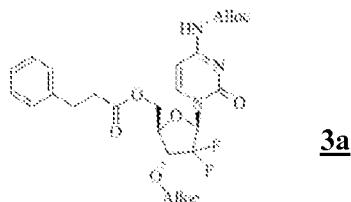
(**1**). To a solution of gemcitabine hydrochloride (1.2 g, 4 mmol) in 12 mL pyridine, 25 chlorotrimethylsilane (2.54 mL, 20 mmol) was added at 0 °C; after stirring for 2 h, allyl chloroformate (0.43 mL, 4 mmol) was added at 0 °C. The reaction mixture was allowed to warm to RT, and heated at 45 °C overnight, then cooled to 30-35 °C when 12 mL of absolute EtOH was added. The reaction mixture was reheated at 45 °C for

0.5 h, and following the addition of 6 mL of H₂O, was heated at 45 °C for 5 h, then cooled to RT and concentrated in vacuo. The residue was partitioned between EtOAc and water; The organic layer was separated, and the aqueous layer was again extracted with EtOAc. The organic extracts were combined and washed with saturated aqueous CuSO₄ solution, saturated aqueous NaHCO₃ solution and brine, dried over Na₂SO₄ and concentrated in vacuo. Purification by flash column chromatography (5:1 → 10:1 EtOAc/Hexane) afforded **1** (white solid, 70% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 11.00 (s, 1H), 8.26-8.28 (d, 1H), 7.13-7.15 (d, 1H), 6.34-6.37 (d, 1H), 6.18-6.22 (t, 1H), 5.95-6.02 (m, 1H), 5.38-5.43 (d, 1H), 5.34 (t, 1H), 5.27-5.30 (d, 1H), 4.67-4.69 (d, 2H), 4.20-4.25 (m, 1H), 3.90-3.95 (m, 1H), 3.82-3.86 (m, 1H), 3.66-3.72 (m, 1H); MS (HR-ESI): m/z 346.0857 [M-H]⁻.



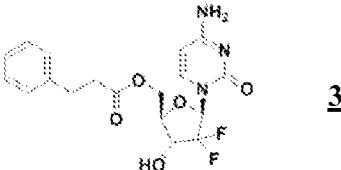
[0086] **Method B: Preparation of 4-Allyloxycarbonylamo-1-[(2R,4R,5R)-4-allyloxycarbonyloxy-3,3-difluoro-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydropyrimidin-2-one (2).** Allyl chloroformate (0.23 mL, 2.2 mmol) was added to a solution of **1** (694 mg, 2 mmol), N,N-diisopropylethylamine (0.7 mL, 4 mmol) in 20 mL MeCN at 0 °C. The reaction mixture was stirred at 0 °C for 4 h and concentrated in vacuo. The crude residue was purified by flash column chromatography (2:1 → 4:1 EtOAc/Hexane) to give **2** (white solid, 65% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 11.05 (s, 1H), 8.19-8.22 (d, 1H), 7.16-7.18 (d, 1H), 6.32-6.37 (t, 1H), 5.93-6.05 (m, 2H), 5.43 (s, 1H), 5.27-5.39 (m, 5H), 4.74-4.75 (d, 2H), 4.67-4.69 (d, 2H), 4.31-4.33 (m, 1H), 3.82-3.84 (m, 1H), 3.73-3.76 (m, 1H).

[0087] **Method C: Preparation of 4-Amino-1-[(2R,4R,5R)-3,3-difluoro-4-hydroxy-5-(3-phenylpropanoyloxymethyl)oxolan-2-yl]-1,2-dihydropyrimidin-2-one (3).**



[0088] **((2R,3R,5R)-5-(4-(Allyloxycarbonylamino)-2-oxo- pyrimidin-1(2H)-yl)-3-(allyloxycarbonyloxy)-4,4-difluorotetrahydrofuran-2-yl)methyl 3-phenylpropanoate (3a).** A solution of **2** (150 mg, 0.35 mmol), 3-phenylpropanoic

5 acid (57 mg, 0.38 mmol), 4-dimethylaminopyridine (8 mg, 0.07 mmol) in 4 mL dimethoxyethane, N,N'-dicyclohexylcarbodiimide (158 mg, 0.77 mmol) was added at 0 °C, the reaction mixture was stirred overnight at RT, and after filtering off the resulting precipitates was then concentrated in vacuo. Purification by flash column chromatography (1:2 → 1:1 EtOAc/Hexane) provided **3a** (colorless oil, 51% yield):
10 ^1H NMR (400 MHz, DMSO-d₆) δ 11.05 (s, 1H), 8.06-8.08 (d, 1H), 7.16-7.33 (m, 6H), 6.35 (t, 1H), 5.95-6.02 (m, 2H), 5.43-5.44 (dd, 2H), 5.38-5.40 (dd, 1H), 5.27-5.33 (t, 2H), 4.73-4.74 (d, 2H), 4.68-4.70 (d, 2H), 4.47-4.51 (d, 2H), 4.43-4.45 (m, 1H), 2.87-2.92 (t, 2H), 2.70-2.75 (t, 2H).



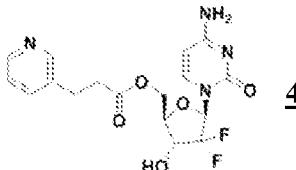
15 [0089] **4-Amino-1-[(2R,4R,5R)-3,3-difluoro-4-hydroxy-5-(3-phenylpropanoyloxy)methyl]oxolan-2-yl]-1,2-dihydropyrimidin-2-one (3).** A

solution of **3a** (100 mg, 0.18 mmol), triphenylphosphine (19 mg, 0.07 mmol), ethanolamine (0.02 mL, 0.36 mmol) and formic acid (0.03 mL, 0.67 mmol) in 5 mL of 2:2:1 THF/MeCN/H₂O was degassed by bubbling under N₂ for 1 min, palladium 20 tetrakis(triphenylphosphine) (41 mg, 0.04 mmol) was added; Then the resulting reaction mixture was stirred 1 h at RT, concentrated in vacuo, extracted with EtOAc. The organic extracts were washed with brine, dried over Na₂SO₄, concentrated, then purified by flash column chromatography (1:1 Acetone/CH₂Cl₂) afforded **3** (colorless solid, 33% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 7.52-7.55 (d, 1H), 7.42-7.45 (d, 2H), 7.22-7.31 (m, 5H), 6.41-6.44 (d, 1H), 6.19-6.23 (t, 1H), 5.80-5.84 (d, 1H), 4.34-

25

4.43 (m, 1H), 4.29-4.33 (m, 1H), 4.22 (s, 1H), 3.99-4.05 (m, 1H), 2.89-2.91 (t, 2H), 2.72-2.75 (t, 2H); MS (HR-ESI): m/z 396.1373 [M+H]⁺.

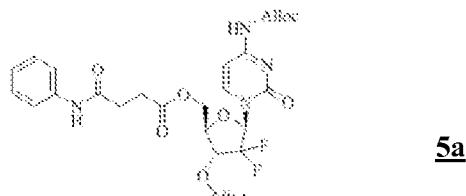
Example 2



5 [0090] **Preparation of 4-Amino-1-[(2R,4R,5R)-3,3-difluoro-4-hydroxy-5-(3-(3-pyridyl)propanoyloxymethyl)oxolan-2-yl]-1,2-dihydropyrimidin-2-one (4).** Using Method C and 3-(3-pyridyl)propanoic acid, **2** was converted to **4** (white solid, 53% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 8.51 (s, 1H), 8.43-8.44 (d, 1H), 7.69-7.71 (d, 1H), 7.53-7.55 (d, 1H), 7.45-7.47 (d, 2H), 7.31-7.34 (m, 1H), 6.46 (s, 1H), 6.20 (s, 1H), 5.82-5.84 (d, 1H), 4.39-4.42 (d, 1H), 4.30-4.34 (m, 1H), 4.21 (m, 1H), 4.00-4.03 (t, 1H), 2.90-2.93 (t, 2H), 2.76-2.80 (t, 2H).

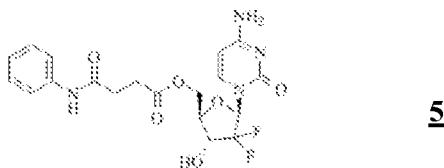
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Example 3



15 [0091] **Preparation of ((2R,3R,5R)-5-(4-(Allyloxycarbonylamino)-2-oxopyrimidin-1(2H)-yl)-3-(allyloxycarbonyloxy)-4,4-difluorotetrahydrofuran-2-yl)methyl-4-oxo-4-(phenylamino)-Butanoate (5a).** Using Method C and N-phenylsuccinic acid, **2** was converted to **5a** (colorless oil, 84% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 11.06 (s, 1H), 10.02 (s, 1H), 8.09-8.11 (d, 1H), 7.59-7.61 (d, 2H), 7.28-7.32 (t, 2H), 7.04 (t, 1H), 5.96-6.00 (m, 4H), 5.30-5.43 (m, 5H), 4.73-4.75 (m, 2H), 4.67-4.69 (d, 2H), 4.54 (s, 2H), 4.40-4.42 (m, 1H), 2.69 (s, 4H).

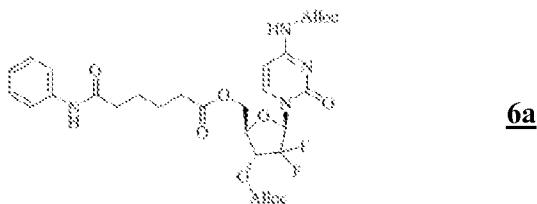
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[0092] Preparation of 4-Amino-1-[(2R,4R,5R)-5-((4-anilino-4-oxo-butanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydropyrimidin-2-one (5). Using Method C, **5a** was converted to **5** (yellow solid, 10% yield): ¹H

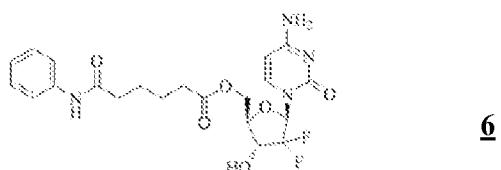
5 NMR (400 MHz, DMSO-d₆) δ10.02 (s, 1H), 7.48-7.53 (t, 3H), 7.42-7.45 (d, 2H), 7.29-7.37 (t, 2H), 7.03-7.08 (t, 1H), 6.42-6.45 (d, 1H), 6.20-6.23 (t, 1H), 5.80-5.85 (d, 1H), 4.42-4.47 (dd, 1H), 4.30-4.35 (m, 1H), 4.23 (s, 1H), 4.01-4.06 (m, 1H), 2.67-2.69 (m, 4H); MS (HR-ESI): m/z 461.1248 [M+Na]⁺.

Example 4



10

[0093] Preparation of ((2R,3R,5R)-5-(4-(Allyloxycarbonylamino)-2-oxopyrimidin-1(2H)-yl)-3-(allyloxycarbonyloxy)-4,4-difluorotetrahydrofuran-2-yl)methyl 6-oxo-6- (phenylamino)hexanoate (6a). Using Method C and adipanilic acid, **2** was converted to **6a** (colorless oil, 61% yield): ¹H NMR (400 MHz, DMSO-d₆) δ11.04 (s, 1H), 9.87 (s, 1H), 8.08-8.10 (d, 1H), 7.59-7.62 (d, 2H), 7.28-7.33 (t, 2H), 7.17-7.19 (d, 1H), 7.02-7.04 (t, 1H), 6.35-6.39 (t, 1H), 5.94-6.02 (m, 2H), 5.38-5.43 (d, 3H), 5.26-5.34 (dd, 2H), 4.72-4.75 (d, 2H), 4.67-4.69 (d, 2H), 4.52-4.54 (d, 2H), 4.43-4.50 (m, 1H), 2.41-2.45 (t, 2H), 2.32-2.36 (t, 2H), 1.63 (s, 4H).

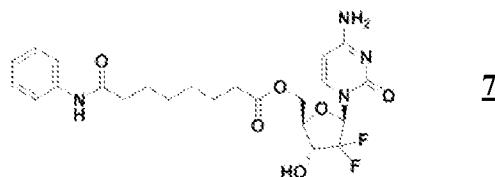


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[0094] Preparation of 4-Amino-1-[(2R,4R,5R)-5-((6-anilino-6-oxohexanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydropyrimidin-2-one (6). Using Method C, **6a** was converted to **6** (white solid, 38% yield): ¹H NMR (400 MHz, DMSO-d₆) δ9.88 (s, 1H), 7.60-7.63 (d, 2H), 7.54-7.57 (d, 1H), 7.41-

7.44 (d, 2H), 7.29-7.34 (t, 2H), 7.03-7.07 (t, 1H), 6.42-6.44 (d, 1H), 6.19-6.21 (t, 1H), 5.83-5.85 (d, 1H), 4.40-4.45 (dd, 1H), 4.30-4.35 (m, 1H), 4.22 (s, 1H), 4.01-4.07 (m, 1H), 2.43-2.47 (t, 2H), 2.33-2.37 (t, 2H), 1.62-1.65 (t, 4H); MS (HR-ESI): m/z 489.1558 [M+Na]⁺.

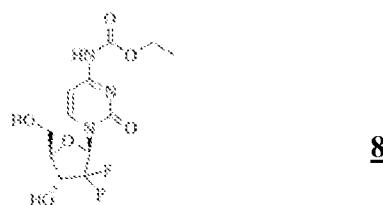
5 Example 5



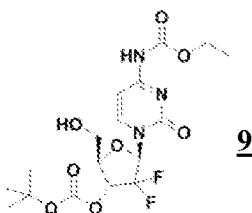
[0095] **Preparation of 4-Amino-1-[(2R,4R,5R)-5-((8-anilino-8-oxo-octanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydropyrimidin-2-one (7).** Using Method C and 8-anilino-8-oxo-octanoic acid, **2** was converted to **7** (white solid, 53% yield): ¹H NMR (200 MHz, DMSO-d₆) δ 9.88 (s, 1H), 7.59-7.64 (d, 2H), 7.53-7.57 (d, 1H), 7.45 (s, 2H), 7.27-7.35 (t, 2H), 7.01-7.08 (t, 1H), 6.44-6.47 (d, 1H), 6.16-6.25 (t, 1H), 5.81-5.85 (d, 1H), 4.38-4.40 (d, 1H), 4.33-4.36 (d, 1H), 4.26 (s, 1H), 4.01-4.08 (m, 1H), 2.36-2.44 (t, 2H), 2.29-2.36 (t, 2H) 1.58-1.61 (d, 4H), 1.34 (s, 4H).

15 Example 6

[0096] *N*4-5' *O*-derivatized gemcitabine prodrugs can be synthesized according to Figure 2.

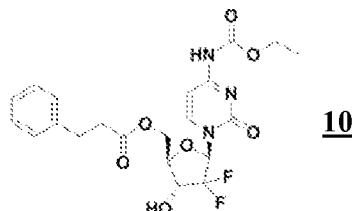


[0097] **Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)pyrimidin-2-one (8).** Using Method A and ethyl chloroformate, gemcitabine hydrochloride was converted to **8** (white solid, 64% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 10.88 (s, 1H), 8.24-8.27 (d, 1H), 7.13-7.16 (d, 1H), 6.34-6.37 (d, 1H), 6.18-6.22 (t, 1H), 5.32-5.36 (t, 1H), 4.17-4.23 (m, 3H), 3.90-3.94 (m, 1H), 3.82-3.86 (m, 1H), 3.65-3.72 (m, 1H), 1.25-1.29 (t, 3H); MS (HR-ESI): m/z 334.0853 [M-H]⁻.



[0098] Method D: Preparation of 1-[(2R,4R,5R)-4-tert-Butyloxycarbonyloxy-3,3-difluoro-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (9).

To a solution of **8** (2 g, 5.97 mmol) in 20 mL of MeCN, Et₃N (2.5 mL, 17.90 mmol) and di-tert-butyl dicarbonate (1.51 mL, 6.56 mmol) were added. The resulting reaction mixture was stirred for 6 h at RT and concentrated in vacuo. The crude residue was purified by flash column chromatography (1:2 → 2:1 EtOAc/Hexane) to give 1.84 g of **9** (white solid, 70% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 10.90 (s, 1H), 8.17-8.19 (d, 1H), 7.16-7.18 (d, 1H), 6.29-6.34 (t, 1H), 5.34-5.37 (t, 1H), 5.23-5.25 (m, 1H), 4.27-4.29 (m, 1H), 4.20-4.23 (m, 2H), 3.81-3.84 (m, 1H), 3.68-3.73 (m, 1H), 1.50 (s, 9H), 1.26-1.29 (t, 3H).



[0099] Method E: Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-phenylpropanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (10).

To a mixture of **9** (150 mg, 0.35 mmol), 3-phenylpropanoic acid (57 mg, 0.38 mmol), 4-dimethylaminopyridine (8 mg, 0.07 mmol) and 4 mL of dimethoxyethane, N,N'-dicyclohexylcarbodiimide (158 mg, 0.77 mmol) was added at 0 °C. The reaction mixture was stirred overnight at RT and, after filtering off the resulting precipitates, was then concentrated in vacuo. Purification by flash column chromatography (1:1 EtOAc/Hexane) provided 109 mg of colorless oil. To a solution of this colorless oil (109 mg, 0.19 mmol) in 2 mL of CH₂Cl₂, 2 mL of trifluoroacetic acid was added. Then the resulting reaction mixture was stirred for 1 h at RT, concentrated in vacuo and extracted with EtOAc. The organic extract was washed with brine, dried over Na₂SO₄, concentrated, then purified by flash column

chromatography (2:1 EtOAc/Hexane) to give 83 mg of **10** (colorless oil, 92% yield):

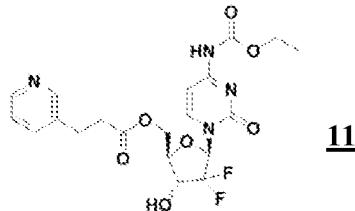
¹H NMR (400 MHz, DMSO-d₆) δ 10.89 (s, 1H), 7.99-8.02 (d, 1H), 7.15-7.33 (m, 6H),

6.49-6.52 (d, 1H), 6.21-6.26 (t, 1H), 4.34-4.46 (m, 2H), 4.17-4.28 (m, 3H), 4.04-4.13

(m, 1H), 2.88-2.93 (t, 2H), 2.74-2.77 (t, 2H), 1.26-1.29 (t, 3H); MS (HR-ESI) m/z

5 490.1405 [M+H]⁺.

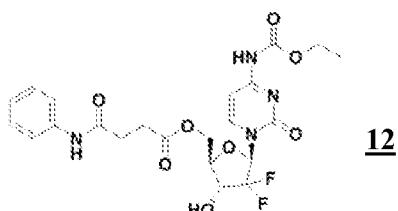
Example 7



[0100] Preparation of 1-[2R,4R,5R]-3,3-Difluoro-4-hydroxy-5-(3-(3-pyridyl)propanoyloxy)methyl]oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)pyrimidin-2-one (11**).**

Using Method E and 3-(3-pyridyl)propanoic acid, **9** was converted to **11** (yellow solid, 73% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 10.89 (s, 1H), 8.50 (s, 1H), 8.42-8.45 (m, 1H), 7.99-8.02 (d, 1H), 7.69-7.72 (d, 1H), 7.31-7.35 (m, 1H), 7.15-7.18 (d, 1H), 6.50-6.52 (d, 1H), 6.21-6.26 (t, 1H), 4.34-4.46 (m, 2H), 4.17-4.24 (m, 3H), 4.04-4.12 (m, 1H), 2.90-2.95 (t, 2H), 2.78-2.82 (t, 2H), 1.25-1.29 (t, 3H); MS (FAB) m/z 469.1528 [M+H]⁺.

Example 8

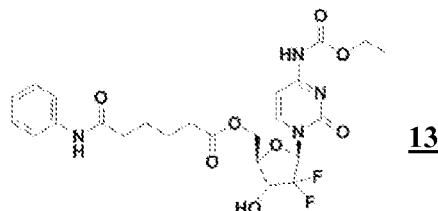


[0101] Preparation of 1-[2R,4R,5R]-5-((4-Anilino-4-oxo-butanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)pyrimidin-2-one (12**).**

Using Method E and 4-anilino-4-oxo-butanoic acid, **9** was converted to **12** (white solid, 88% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 10.89 (s, 1H), 10.03 (s, 1H), 8.04-8.06 (d, 1H), 7.59-7.61 (d, 2H), 7.28-7.32 (t, 2H), 7.18-7.21 (d, 1H), 7.02-7.06 (t, 1H), 6.52-6.54 (d, 1H), 6.21-6.26 (t, 1H), 4.47-4.51 (d, 1H),

4.37-4.40 (m, 1H), 4.34 (s, 1H), 4.11-4.23 (m, 3H), 2.66-2.73 (m, 4H), 1.24-1.29 (t, 3H).

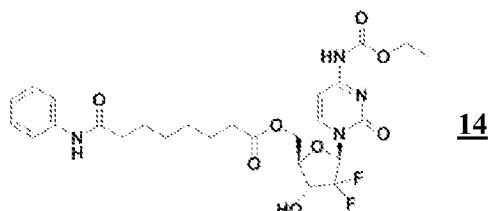
Example 9



5 [0102] **Preparation of 1-[(2R,4R,5R)-5-((6-Anilino-6-oxo-hexanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (13).** Using Method E and 6-anilino-6-oxo-hexanoic acid, **9** was converted to **13** (white solid, 56% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.88 (s, 1H), 9.88 (s, 1H), 8.02-8.05 (d, 1H), 7.59-7.65 (d, 2H), 7.29-7.35 (t, 2H), 7.16-7.19 (d, 1H), 7.03-7.07 (t, 1H), 6.50-6.53 (d, 1H), 6.23-6.26 (t, 1H), 4.35-4.47 (m, 2H), 4.18-4.35 (m, 3H), 4.05-4.08 (d, 1H), 2.44-2.46 (t, 2H), 2.34-2.36 (t, 2H), 1.63 (s, 4H), 1.24-1.28 (t, 3H); MS (HR-ESI) m/z 561.1762 [M+Na]⁺.

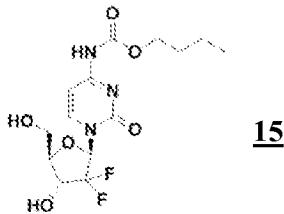
10

Example 10

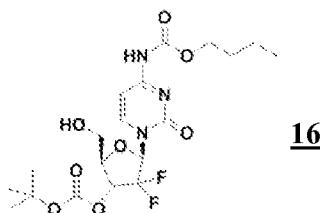


15 [0103] **Preparation of 1-[(2R,4R,5R)-5-((8-Anilino-8-oxo-octanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (14).** Using Method E and 8-anilino-8-oxo-octanoic acid, **9** was converted to **14** (white solid, 66% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.88 (s, 1H), 9.85 (s, 1H), 8.02-8.04 (d, 1H), 7.60-7.63 (d, 2H), 7.28-7.33 (t, 2H), 7.16-7.19 (d, 1H), 7.02-7.07 (t, 1H), 6.50-6.53 (d, 1H), 6.22-6.27 (t, 1H), 4.34-4.47 (m, 2H), 4.11-4.30 (m, 4H), 2.39-2.44 (t, 2H), 2.30-2.34 (t, 2H), 1.57-1.64 (m, 4H), 1.33-1.36 (t, 4H), 1.24-1.28 (t, 3H); MS (HR-ESI) m/z 565.2112 [M-H]⁻.

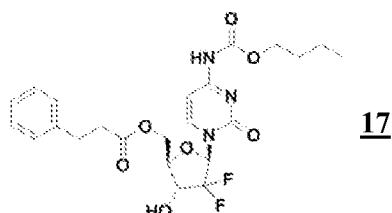
20

Example 11**[0104] Preparation of 4-(Butyloxycarbonylamino)-1-[(2R,4R,5R)-3,3-difluoro-4-hydroxy-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydropyrimidin-2-one (15).**

5 Using Method A and butyl chloroformate, gemcitabine hydrochloride was converted to **15** (white solid, 91% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.87 (s, 1H), 8.23-8.27 (d, 1H), 7.11-7.15 (d, 1H), 6.37 (s, 1H), 6.16-6.23 (t, 1H), 5.33 (s, 1H), 4.12-4.18 (t, 2H), 3.65-3.95 (m, 4H), 1.44-1.66 (m, 2H), 1.33-1.40 (m, 2H), 0.93-0.97 (t, 3H).



10 **[0105] Preparation of 4-(Butyloxycarbonylamino)-1-[(2R,4R,5R)-4-tert-butyloxycarbonyloxy-3,3-difluoro-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydropyrimidin-2-one (16).** Using Method D, **15** was converted to **16** (white solid, 62% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.92 (s, 1H), 8.16-8.20 (d, 1H), 7.14-7.19 (d, 1H), 6.27-6.36 (t, 1H), 5.33-5.40 (t, 1H), 5.17-5.30 (m, 1H), 4.24-4.31 (m, 1H), 4.12-4.19 (t, 2H), 3.64-3.88 (m, 2H), 1.54-1.70 (m, 2H), 1.49 (s, 9H), 1.33-1.48 (m, 2H), 0.90-0.98 (t, 3H).

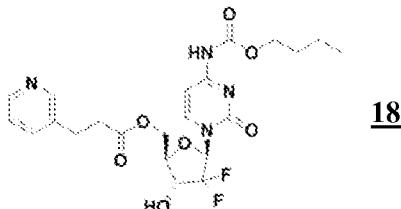


15 **[0106] Preparation of 4-(Butyloxycarbonylamino)-1-[(2R,4R,5R)-3,3-difluoro-4-hydroxy-5-(3-phenylpropanoyloxymethyl)oxolan-2-yl]-1,2-dihydropyrimidin-2-one (17).** Using Method E and 3-phenylpropanoic acid, **16** was converted to **17** (yellow oil, 72% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.92 (s, 1H), 7.99-8.03 (d,

1H), 7.25-7.31 (t, 5H), 7.14-7.18 (d, 1H), 6.51 (s, 1H), 6.19-6.28 (t, 1H), 4.38-4.40 (d, 2H), 4.01-4.19 (m, 4H), 2.87-2.94 (t, 2H), 2.71-2.78 (t, 2H), 1.59-1.66 (m, 2H), 1.33-1.45 (m, 2H), 0.90-0.97 (t, 3H).

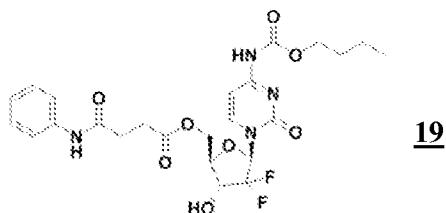
Example 12

5

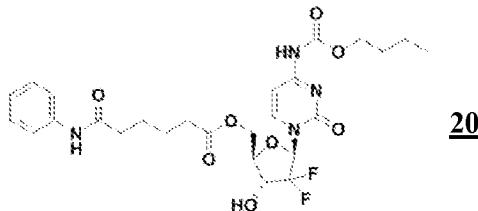


[0107] **Preparation of 4-(Butyloxycarbonylamino)-1-[(2R,4R,5R)-3,3-difluoro-4-hydroxy-5-(3-(3-pyridyl)propanoyloxy)methyl]oxolan-2-yl]-1,2-dihydro-pyrimidin-2-one (18).** Using Method E and 3-(3-pyridyl)propanoic acid, **16** was converted to **18** (white solid, 77% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.50-8.51 (d, 1H), 8.41-8.45 (m, 1H), 7.99-8.03 (d, 1H), 7.67-7.74 (m, 1H), 7.29-7.36 (m, 1H), 7.13-7.17 (d, 1H), 6.51-6.54 (d, 1H), 6.19-6.27 (t, 1H), 4.40 (s, 2H), 4.12-4.19 (t, 4H), 2.89-2.92 (d, 2H), 2.80-2.83 (d, 2H), 1.56-1.66 (m, 2H), 1.33-1.45 (m, 2H), 0.90-0.97 (t, 3H).

15 Example 13



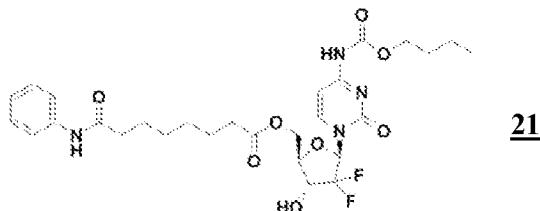
[0108] **Preparation of 1-[(2R,4R,5R)-5-((4-Anilino-4-oxo-butanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-4-(butyloxycarbonylamino)-1,2-dihydro-pyrimidin-2-one (19).** Using Method E and 4-anilino-4-oxo-butanoic acid, **16** was converted to **19** (white solid, 90% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.89 (s, 1H), 10.03 (s, 1H), 8.03-8.07 (d, 1H), 7.58-7.62 (d, 2H), 7.26-7.34 (t, 2H), 7.17-7.20 (d, 1H), 7.00-7.08 (t, 1H), 6.51 (s, 1H), 6.19-6.28 (t, 1H), 4.27-4.53 (m, 3H), 4.12-4.19 (t, 3H), 2.70 (s, 4H), 1.59-1.67 (t, 2H), 1.33-1.44 (t, 2H), 0.90-0.97 (t, 3H).

Example 14

[0109] Preparation of 1-[(2R,4R,5R)-5-((6-Anilino-6-oxo-hexanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-4-(butyloxycarbonylamino)-1,2-dihydro-pyrimidin-2-one (20). Using Method E and 6-anilino-6-oxo-hexanoic acid, **16** was converted to **20** (yellow oil, 93% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.90 (s, 1H), 9.90 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.26-7.34 (t, 2H), 7.15-7.18 (d, 1H), 7.01-7.08 (t, 1H), 6.51 (s, 1H), 6.20-6.29 (t, 1H), 4.39-4.42 (s, 2H), 4.08-4.18 (m, 4H), 2.46 (s, 2H), 2.35 (s, 2H), 1.62 (s, 8H), 0.89-0.96 (t, 3H).

5 **10 Example 15**

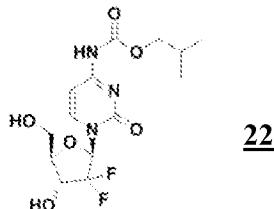
Using Method E and 6-anilino-6-oxo-hexanoic acid, **16** was converted to **20** (yellow oil, 93% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.90 (s, 1H), 9.90 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.26-7.34 (t, 2H), 7.15-7.18 (d, 1H), 7.01-7.08 (t, 1H), 6.51 (s, 1H), 6.20-6.29 (t, 1H), 4.39-4.42 (s, 2H), 4.08-4.18 (m, 4H), 2.46 (s, 2H), 2.35 (s, 2H), 1.62 (s, 8H), 0.89-0.96 (t, 3H).



[0110] Preparation of 1-[(2R,4R,5R)-5-((8-Anilino-8-oxo-octanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-4-(butyloxycarbonylamino)-1,2-dihydro-pyrimidin-2-one (21). Using Method E and 8-anilino-8-oxo-octanoic acid, **16** was converted to **21** (colorless oil, 90% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.92 (s, 1H), 9.87 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.15-7.19 (d, 1H), 7.00-7.08 (t, 1H), 6.51 (s, 1H), 6.21-6.29 (t, 1H), 4.32-4.49 (m, 2H), 4.08-4.18 (m, 4H), 2.36-2.45 (t, 2H), 2.24-2.32 (t, 2H), 1.58-1.62 (d, 4H), 1.36 (s, 4H), 0.89-0.96 (t, 3H).

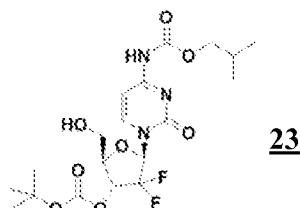
15 **10 Example 15**

Using Method E and 8-anilino-8-oxo-octanoic acid, **16** was converted to **21** (colorless oil, 90% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.92 (s, 1H), 9.87 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.15-7.19 (d, 1H), 7.00-7.08 (t, 1H), 6.51 (s, 1H), 6.21-6.29 (t, 1H), 4.32-4.49 (m, 2H), 4.08-4.18 (m, 4H), 2.36-2.45 (t, 2H), 2.24-2.32 (t, 2H), 1.58-1.62 (d, 4H), 1.36 (s, 4H), 0.89-0.96 (t, 3H).

Example 16

[0111] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(2-

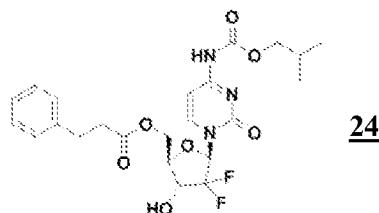
5 **methylpropoxycarbonylamino)pyrimidin-2-one (22).** Using Method A and isobutyl chloroformate, gemcitabine hydrochloride was converted to **22** (white solid, 97% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.88 (s, 1H), 8.25-8.26 (d, 1H), 7.12-7.14 (d, 1H), 6.35 (s, 1H), 6.19-6.22 (t, 1H), 5.33 (s, 1H), 4.22-4.24 (d, 1H), 3.91-3.96 (m, 3H), 3.83-3.85 (d, 1H), 3.68-3.70 (d, 1H), 1.91-1.97 (m, 1H), 0.94-0.95 (d, 6H).



10

[0112] Preparation of 1-[(2R,4R,5R)-4-tert-Butyloxycarbonyloxy-3,3-difluoro-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonylamino)pyrimidin-2-one (23). Using Method D, **22** was converted to **23**

15 (white solid, 61% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.93 (s, 1H), 8.18-8.19 (d, 1H), 7.16-7.17 (d, 1H), 6.30-6.34 (t, 1H), 5.34-5.37 (t, 1H), 5.21-5.25 (m, 1H), 4.26-4.29 (m, 1H), 3.94-3.96 (d, 2H), 3.81-3.83 (d, 1H), 3.69-3.74 (d, 1H), 1.92-1.98 (m, 1H), 1.49 (s, 9H), 0.94-0.96 (d, 6H).

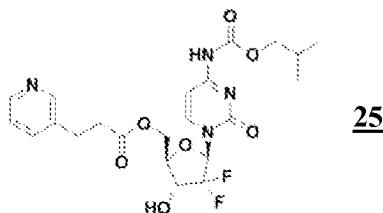


[0113] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-phenyl-

20 propanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonylamino)pyrimidin-2-one (24). Using Method E and 3-phenylpropanoic acid, **23** was

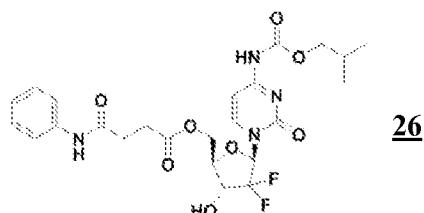
converted to **24** (colorless oil, 61% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.93 (s, 1H), 8.00-8.02 (d, 1H), 7.15-7.31 (m, 5H), 6.52 (m, 1H), 6.22-6.25 (t, 1H), 4.35-4.44 (m, 2H), 4.25-4.27 (d, 1H), 4.05-4.10 (m, 2H), 3.94-3.96 (d, 2H), 2.89-2.92 (t, 2H), 2.74-2.77 (t, 2H), 1.92-1.97 (m, 1H), 0.94-0.96 (d, 6H).

5 Example 17

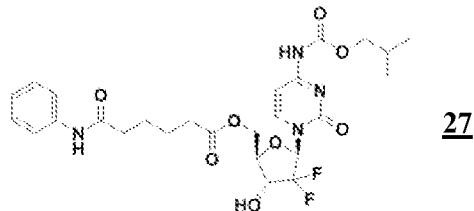


[0114] **Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-(3-pyridyl)-propanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonylamino)pyrimidin-2-one (25).** Using Method E and 3-(3-pyridyl)propanoic acid, **23** 10 was converted to **25** (white solid, 78% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.94 (s, 1H), 8.50 (s, 1H), 8.42-8.44 (d, 1H), 7.99-8.03 (d, 1H), 7.69-7.73 (m, 1H), 7.29-7.36 (m, 1H), 7.13-7.17 (d, 1H), 6.51-6.54 (d, 1H), 6.19-6.28 (t, 1H), 4.40 (s, 2H), 4.12-4.19 (t, 4H), 2.89-2.92 (d, 2H), 2.79-2.83 (d, 2H), 1.91-1.98 (t, 1H), 0.93-0.96 (d, 6H).

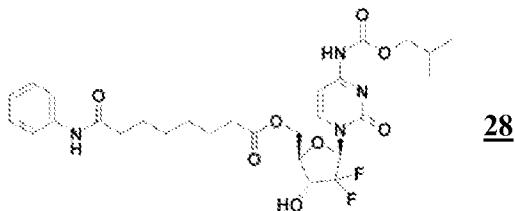
15 Example 18



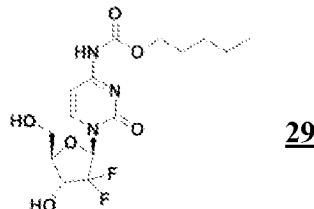
[0115] **Preparation of 1-[(2R,4R,5R)-5-((4-Anilino-4-oxo-butanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonylamino)pyrimidin-2-one (26).** Using Method E and 4-anilino-4-oxo-butanoylic acid, **23** 20 was converted to **26** (white solid, 78% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.93 (s, 1H), 10.03 (s, 1H), 8.03-8.07 (d, 1H), 7.58-7.62 (d, 2H), 7.26-7.34 (t, 2H), 7.16-7.18 (d, 1H), 7.00-7.08 (t, 1H), 6.51-6.54 (d, 1H), 6.20-6.28 (t, 1H), 4.10-4.52 (m, 4H), 3.92-3.96 (d, 2H), 2.69 (s, 4H), 1.91-1.98 (t, 1H), 0.93-0.96 (d, 6H).

Example 19**[0116] Preparation of 1-[2R,4R,5R]-5-((6-Anilino-6-oxo-hexanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonyl)-amino)pyrimidin-2-one (27).**

Using Method E and 6-anilino-6-oxo-hexanoic acid, **23** was converted to **27** (white solid, 83% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.93 (s, 1H), 9.89 (s, 1H), 8.02-8.06 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.14-7.18 (d, 1H), 7.01-7.08 (t, 1H), 6.51-6.54 (d, 1H), 6.21-6.29 (t, 1H), 4.12-4.48 (m, 4H), 3.91-3.95 (d, 2H), 2.43-2.49 (t, 2H), 2.32-2.38 (t, 2H), 1.90-1.97 (t, 1H), 1.63 (s, 4H), 0.92-0.95 (d, 6H).

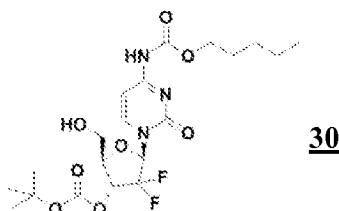
Example 20**[0117] Preparation of 1-[2R,4R,5R]-5-((8-Anilino-8-oxo-octanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonyl)-amino)pyrimidin-2-one (28).**

Using Method E and 8-anilino-8-oxo-octanoic acid, **23** was converted to **28** (white solid, 45% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.93 (s, 1H), 9.86 (s, 1H), 8.02-8.04 (d, 1H), 7.60-7.62 (d, 2H), 7.29-7.32 (t, 2H), 7.15-7.17 (d, 1H), 7.03-7.06 (t, 1H), 6.52 (m, 1H), 6.23-6.26 (t, 1H), 4.43-4.45 (d, 1H), 4.35-4.39 (m, 1H), 4.26-4.28 (m, 1H), 4.12-4.14 (t, 1H), 3.93-3.94 (d, 2H), 2.40-2.43 (t, 2H), 2.30-2.33 (t, 2H), 1.92-1.96 (m, 1H), 1.57-1.59 (m, 4H), 1.34 (m, 4H), 0.93-0.94 (d, 6H).

Example 21

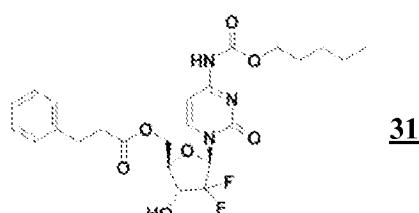
[0118] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)pyrimidin-2-one

5 **(29).** Using Method A and pentyl chloroformate, gemcitabine hydrochloride was converted to **29** (white solid, 95% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.87 (s, 1H), 8.23-8.27 (d, 1H), 7.11-7.15 (d, 1H), 6.34-6.37 (d, 1H), 6.16-6.24 (t, 1H), 5.34 (s, 1H), 4.11-4.18 (t, 3H), 3.82-3.94 (m, 2H), 3.57-3.72 (m, 1H), 1.61-1.68 (t, 2H), 1.34-1.38 (t, 4H), 0.88-0.95 (t, 3H).



10

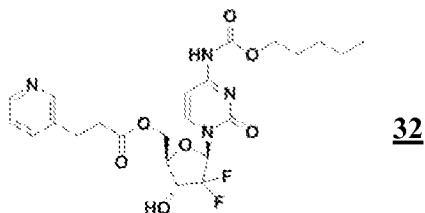
[0119] Preparation of 1-[(2R,4R,5R)-4-tert-Butyloxycarbonyloxy-3,3-difluoro-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)pyrimidin-2-one (30). Using Method D, **29** was converted to **30** (white solid, 73% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.16-8.20 (d, 1H), 7.14-7.18 (d, 1H), 6.27-6.36 (t, 1H), 5.34-5.39 (t, 1H), 5.17-5.30 (m, 1H), 4.26-4.29 (m, 1H), 4.12-4.18 (t, 2H), 3.71-3.79 (m, 2H), 1.61-1.68 (t, 2H), 1.49 (s, 9H), 1.34-1.38 (t, 4H), 0.88-0.95 (t, 3H).



20 **[0120] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-phenylpropanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)pyrimidin-2-one (31).** Using Method E and 3-phenylpropanoic acid, **30** was

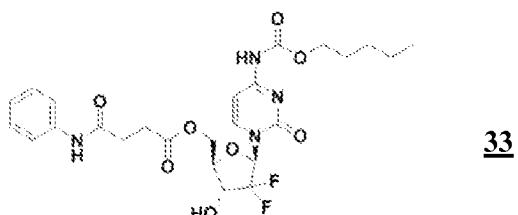
converted to **31** (yellow oil, 97% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 7.98-8.02 (d, 1H), 7.20-7.30 (m, 5H), 7.13-7.17 (d, 1H), 6.54 (m, 1H), 6.19-6.27 (t, 1H), 4.08-4.40 (m, 6H), 2.87-2.94 (t, 2H), 2.71-2.78 (t, 2H), 1.61-1.67 (t, 2H), 1.33-1.37 (t, 4H), 0.88-0.94 (t, 3H).

5 Example 22

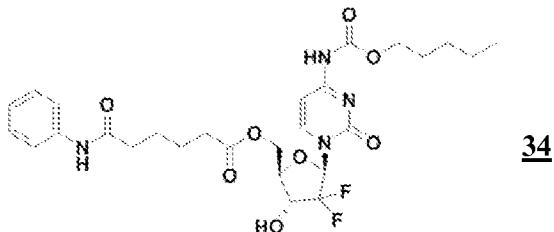


[0121] **Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-(3-pyridyl)-propanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)-pyrimidin-2-one (32).** Using Method E and 3-(3-pyridyl)propanoic acid, **30** was 10 converted to **32** (white solid, 97% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.50-8.51 (d, 1H), 8.42-8.45 (m, 1H), 7.99-8.03 (d, 1H), 7.68-7.74 (m, 1H), 7.30-7.36 (m, 1H), 7.14-7.17 (d, 1H), 6.51-6.54 (d, 1H), 6.19-6.28 (t, 1H), 4.23-4.41 (m, 3H), 4.07-4.08 (t, 3H), 2.89-2.97 (t, 2H), 2.75-2.83 (t, 2H), 1.61-1.68 (t, 2H), 1.30-1.37 (t, 4H), 0.88-0.95 (t, 3H).

15 Example 23

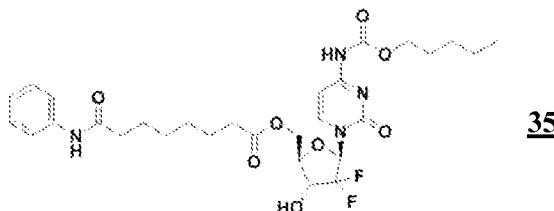


[0122] **Preparation of 1-[(2R,4R,5R)-5-((4-Anilino-4-oxo-butanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)-pyrimidin-2-one (33).** Using Method E and 4-anilino-4-oxo-butanoic acid, **30** was 20 converted to **33** (yellow solid, 87% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 10.03 (s, 1H), 8.03-8.07 (d, 1H), 7.58-7.62 (d, 2H), 7.26-7.34 (t, 2H), 7.17-7.20 (d, 1H), 7.00-7.08 (t, 1H), 6.52 (m, 1H), 6.20-6.28 (t, 1H), 4.21-4.52 (m, 3H), 4.11-4.17 (t, 3H), 2.70 (s, 4H), 1.61-1.67 (t, 2H), 1.34-1.37 (t, 4H), 0.88-0.95 (t, 3H).

Example 24

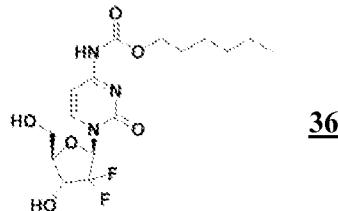
[0123] Preparation of 1-[2R,4R,5R]-5-((6-Anilino-6-oxo-hexanoxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)-pyrimidin-2-one (34).

Using Method E and 6-anilino-6-oxo-hexanoic acid, **30** was converted to **34** (white solid, 81% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 9.89 (s, 1H), 8.02-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.15-7.18 (d, 1H), 7.01-7.08 (t, 1H), 6.53 (m, 1H), 6.21-6.29 (t, 1H), 4.26-4.48 (m, 3H), 4.08-4.17 (t, 3H), 2.46-2.53 (t, 2H), 2.32-2.35 (t, 2H), 1.63 (s, 6H), 1.33-1.36 (t, 4H), 0.87-0.94 (t, 3H).

Example 25

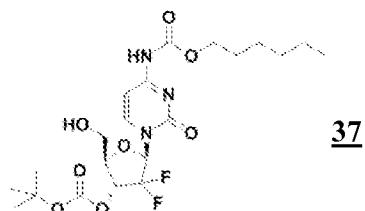
[0124] Preparation of 1-[2R,4R,5R]-5-((8-Anilino-8-oxo-octanoxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)-pyrimidin-2-one (35).

Using Method E and 8-anilino-8-oxo-octanoic acid, **30** was converted to **35** (white solid, 86% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 9.87 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.15-7.19 (d, 1H), 7.01-7.08 (t, 1H), 6.51-6.54 (d, 1H), 6.21-6.29 (t, 1H), 4.24-4.48 (m, 3H), 4.08-4.17 (t, 3H), 2.38-2.45 (t, 2H), 2.28-2.36 (t, 2H), 1.60-1.61 (d, 6H), 1.33-1.36 (t, 8H), 0.87-0.94 (t, 3H).

Example 26

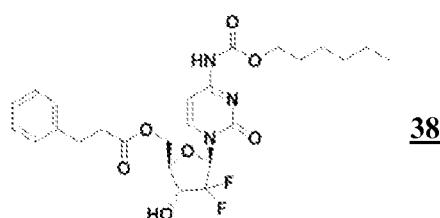
[0125] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)pyrimidin-2-one (36).

5 Using Method A and hexyl chloroformate, gemcitabine hydrochloride was converted to **36** (white solid, 99% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.88 (s, 1H), 8.23-8.28 (d, 1H), 7.11-7.15 (d, 1H), 6.34-6.37 (d, 1H), 6.16-6.24 (t, 1H), 5.34 (s, 1H), 4.21-4.26 (m, 1H), 4.10-4.18 (t, 2H), 3.65-3.94 (m, 3H), 1.60-1.67 (t, 2H), 1.31-1.33 (t, 6H), 0.87-0.94 (t, 3H).



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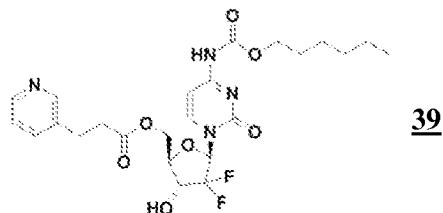
[0126] Preparation of 1-[(2R,4R,5R)-4-tert-Butyloxycarbonyloxy-3,3-difluoro-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)pyrimidin-2-one (37). Using Method D, **36** was converted to **37** (white solid, 76% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.93 (s, 1H), 8.15-8.20 (d, 1H), 7.14-7.18 (d, 1H), 6.27-6.36 (t, 1H), 5.36 (s, 1H), 5.17-5.26 (m, 1H), 4.24-4.31 (m, 1H), 4.11-4.18 (t, 2H), 3.66-3.86 (m, 2H), 1.60-1.67 (t, 2H), 1.49 (s, 9H), 1.31-1.33 (d, 6H), 0.87-0.94 (t, 3H).



[0127] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-phenylpropanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)pyrimidin-2-one (38). Using Method E and 3-phenylpropanoic acid, **37** was

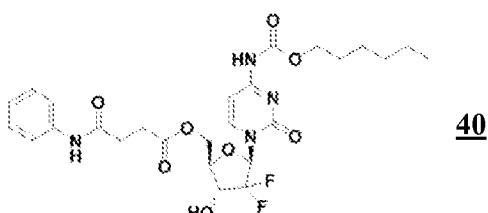
converted to **38** (yellow oil, 82% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 7.98-8.03 (d, 1H), 7.20-7.31 (m, 5H), 7.13-7.17 (d, 1H), 6.51 (s, 1H), 6.19-6.27 (t, 1H), 4.24-4.48 (m, 3H), 4.11-4.18 (t, 3H), 2.87-2.95 (t, 2H), 2.70-2.78 (t, 2H), 1.60-1.67 (t, 2H), 1.31-1.33 (d, 6H), 0.87-0.94 (t, 3H).

5 Example 27

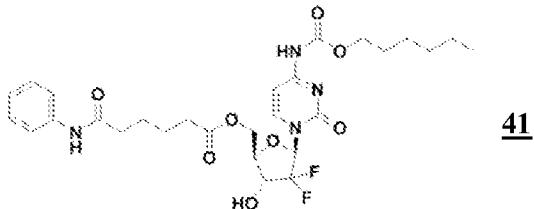


[0128] **Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-(3-pyridyl)-propanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)-pyrimidin-2-one (39).** Using Method E and 3-(3-pyridyl)propanoic acid, **37** was 10 converted to **39** (white solid, 86% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.49-8.51 (d, 1H), 8.41-8.45 (m, 1H), 7.99-8.03 (d, 1H), 7.67-7.74 (m, 1H), 7.29-7.36 (m, 1H), 7.13-7.17 (d, 1H), 6.53 (s, 1H), 6.19-6.27 (t, 1H), 4.24-4.48 (m, 3H), 4.04-4.18 (t, 3H), 2.88-2.97 (t, 2H), 2.75-2.83 (t, 2H), 1.60-1.67 (t, 2H), 1.31-1.32 (d, 6H), 0.87-0.94 (t, 3H).

15 Example 28

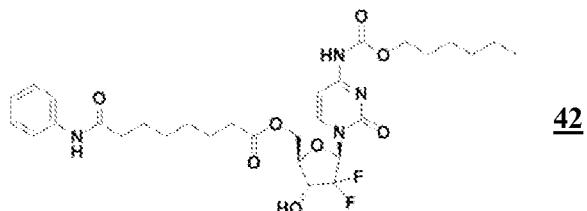


[0129] **Preparation of 1-[(2R,4R,5R)-5-((4-Anilino-4-oxo-butanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)-pyrimidin-2-one (40).** Using Method E and 4-anilino-4-oxo-butanoic acid, **37** was 20 converted to **40** (white solid, 81% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.90 (s, 1H), 10.03 (s, 1H), 8.03-8.07 (d, 1H), 7.58-7.62 (d, 2H), 7.26-7.34 (t, 2H), 7.17-7.20 (d, 1H), 7.00-7.08 (t, 1H), 6.51-6.54 (d, 1H), 6.19-6.27 (t, 1H), 4.47-4.52 (d, 1H), 4.22-4.40 (m, 2H), 4.11-4.17 (t, 3H), 2.70 (s, 4H), 1.60-1.67 (t, 2H), 1.31-1.32 (d, 6H), 0.87-0.94 (t, 3H).

Example 29

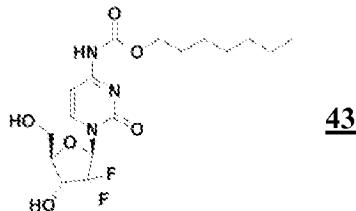
[0130] Preparation of 1-[(2R,4R,5R)-5-((6-Anilino-6-oxo-hexanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)-pyrimidin-2-one (41).

Using Method E and 6-anilino-6-oxo-hexanoic acid, **37** was converted to **41** (yellow solid, 73% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 9.90 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.14-7.18 (d, 1H), 7.01-7.08 (t, 1H), 6.53 (m, 1H), 6.20-6.29 (t, 1H), 4.38-4.48 (d, 2H), 4.26-4.32 (d, 1H), 4.10-4.17 (t, 3H), 2.42-2.49 (t, 2H), 2.31-2.39 (t, 2H), 1.63 (s, 6H), 1.31-1.32 (d, 6H), 0.87-0.93 (t, 3H).

Example 30

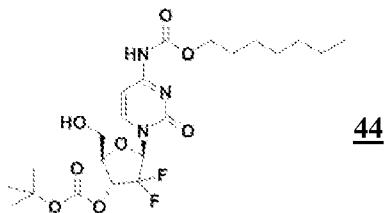
[0131] Preparation of 1-[(2R,4R,5R)-5-((8-Anilino-8-oxo-octanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)-pyrimidin-2-one (42).

Using Method E and 8-anilino-8-oxo-octanoic acid, **37** was converted to **42** (white solid, 85% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.90 (s, 1H), 9.86 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.14-7.18 (d, 1H), 7.00-7.08 (t, 1H), 6.53 (m, 1H), 6.21-6.29 (t, 1H), 4.26-4.39 (m, 3H), 4.08-4.17 (t, 3H), 2.38-2.45 (t, 2H), 2.28-2.35 (t, 2H), 1.59-1.62 (d, 6H), 1.31-1.32 (d, 10H), 0.86-0.93 (t, 3H).

Example 31

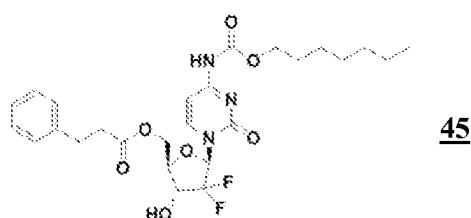
[0132] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)pyrimidin-2-one

5 **(43).** Using Method A and heptyl chloroformate, gemcitabine hydrochloride was converted to **43** (white solid, 93% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.87 (s, 1H), 8.24-8.28 (d, 1H), 7.12-7.16 (d, 1H), 6.33-6.37 (d, 1H), 6.16-6.24 (t, 1H), 5.31-5.36 (t, 1H), 4.19-4.33 (m, 1H), 4.10-4.17 (t, 2H), 3.63-3.94 (m, 3H), 1.60-1.66 (t, 2H), 1.29-1.31 (t, 8H), 0.86-0.92 (t, 3H).



10

[0133] Preparation of 1-[(2R,4R,5R)-4-tert-Butyloxycarbonyloxy-3,3-difluoro-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)pyrimidin-2-one (44). Using Method D, **43** was converted to **44** (white solid, 72% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.16-8.20 (d, 1H), 7.14-7.18 (d, 1H), 6.27-6.36 (t, 1H), 5.34-5.39 (t, 1H), 5.17-5.30 (m, 1H), 4.26-4.29 (t, 1H), 4.11-4.18 (t, 2H), 3.64-3.86 (m, 2H), 1.61-1.67 (t, 2H), 1.49 (s, 9H), 1.29-1.31 (t, 8H), 0.86-0.93 (t, 3H).

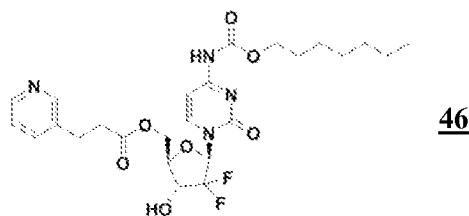


20 **[0134] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-phenylpropanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)pyrimidin-2-one (45).** Using Method E and 3-phenylpropanoic acid, **44** was

converted to **45** (yellow oil, 96% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 7.99-8.03 (d, 1H), 7.20-7.31 (m, 5H), 7.14-7.18 (d, 1H), 6.52 (s, 1H), 6.20-6.28 (t, 1H), 4.25-4.48 (m, 3H), 4.12-4.18 (t, 3H), 2.87-2.95 (t, 2H), 2.70-2.78 (t, 2H), 1.60-1.67 (t, 2H), 1.30-1.33 (d, 8H), 0.86-0.93 (t, 3H).

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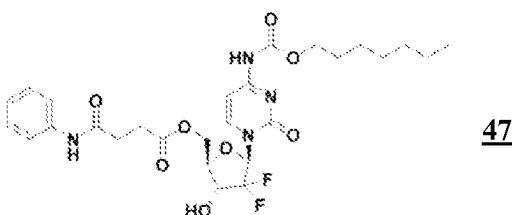
Example 32



[0135] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-(3-pyridyl)-propanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)-pyrimidin-2-one (46**).**

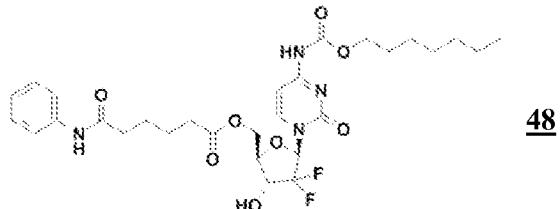
Using Method E and 3-(3-pyridyl)propanoic acid, **44** was converted to **46** (white solid, 47% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.50-8.51 (d, 1H), 8.42-8.45 (m, 1H), 7.99-8.03 (d, 1H), 7.68-7.73 (m, 1H), 7.29-7.36 (m, 1H), 7.14-7.17 (d, 1H), 6.50-6.53 (d, 1H), 6.19-6.28 (t, 1H), 4.24-4.47 (m, 3H), 4.10-4.18 (t, 3H), 2.89-2.97 (t, 2H), 2.75-2.83 (t, 2H), 1.60-1.67 (t, 2H), 1.30-1.33 (d, 8H), 0.86-0.93 (t, 3H).

Example 33

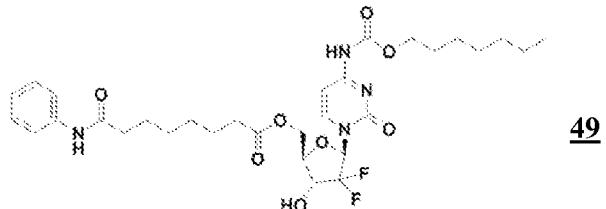


[0136] Preparation of 1-[(2R,4R,5R)-5-((4-Anilino-4-oxo-butanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)-pyrimidin-2-one (47**).**

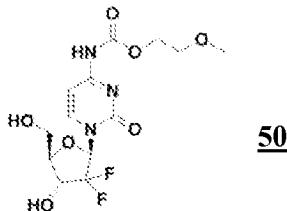
Using Method E and 4-anilino-4-oxo-butanoic acid, **44** was converted to **47** (white solid, 92% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.89 (s, 1H), 10.02 (s, 1H), 8.03-8.06 (d, 1H), 7.58-7.62 (d, 2H), 7.26-7.34 (t, 2H), 7.17-7.20 (d, 1H), 7.00-7.07 (t, 1H), 6.50-6.54 (d, 1H), 6.20-6.28 (t, 1H), 4.22-4.53 (m, 3H), 4.11-4.17 (t, 3H), 2.70 (s, 4H), 1.60-1.67 (t, 2H), 1.30-1.31 (d, 8H), 0.86-0.93 (t, 3H).

Example 34

[0137] **Preparation of 1-[(2R,4R,5R)-5-((6-Anilino-6-oxo-hexanooyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(heptyloxy carbonylamino)pyrimidin-2-one (48).** Using Method E and 6-anilino-6-oxo-hexanoic acid, **44** was converted to **48** (white solid, 90% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.89 (s, 1H), 9.89 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.14-7.18 (d, 1H), 7.01-7.08 (t, 1H), 6.51-6.54 (d, 1H), 6.21-6.29 (t, 1H), 4.25-4.48 (d, 3H), 4.10-4.17 (t, 3H), 2.42-2.49 (t, 2H), 2.32-2.39 (t, 2H), 1.64 (s, 6H), 1.31 (s, 8H), 0.86-0.93 (t, 3H).

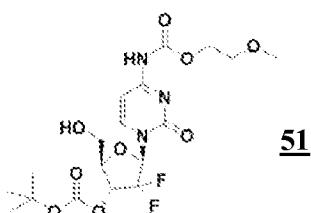
Example 35

[0138] **Preparation of 1-[(2R,4R,5R)-5-((8-Anilino-8-oxo-octanooyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(heptyloxy carbonylamino)pyrimidin-2-one (49).** Using Method E and 8-anilino-8-oxo-octanoic acid, **44** was converted to **49** (white solid, 90% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.90 (s, 1H), 9.86 (s, 1H), 8.01-8.05 (d, 1H), 7.59-7.63 (d, 2H), 7.27-7.34 (t, 2H), 7.15-7.19 (d, 1H), 7.00-7.08 (t, 1H), 6.51-6.54 (d, 1H), 6.21-6.29 (t, 1H), 4.21-4.48 (m, 3H), 4.10-4.17 (t, 3H), 2.38-2.45 (t, 2H), 2.28-2.36 (t, 2H), 1.59-1.62 (d, 6H), 1.30-1.34 (d, 12H), 0.86-0.92 (t, 3H).

Example 36

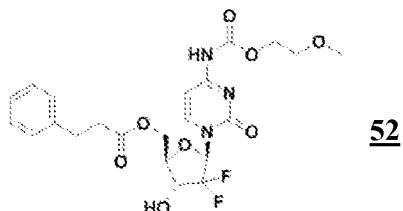
[0139] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonyl amino)pyrimidin-2-one (50).

Using Method A and 2-methoxyethyl chloroformate, gemcitabine hydrochloride was converted to **50** (white solid, 60% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.92 (s, 1H), 8.25-8.27 (d, 1H), 7.11-7.13 (d, 1H), 6.30-6.32 (t, 1H), 6.18-6.22 (t, 1H), 5.32-5.35 (t, 1H), 4.23-4.26 (m, 2H), 4.13-4.22 (m, 1H), 3.86-3.90 (m, 1H), 3.78-3.81 (m, 1H), 3.62-3.66 (m, 1H), 3.54-3.57 (m, 2H), 3.32 (s, 3H).



[0140] Preparation of 1-[(2R,4R,5R)-4-tert-Butyloxycarbonyloxy-3,3-difluoro-5-(hydroxymethyl)oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonyl amino)pyrimidin-2-one (51).

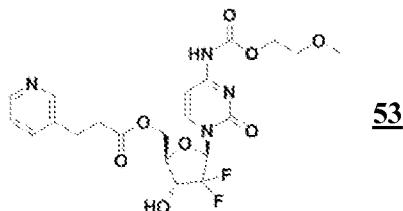
Using Method D, **50** was converted to **51** (white solid, 62% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.97 (s, 1H), 8.18-8.19 (d, 1H), 7.15-7.16 (d, 1H), 6.30-6.33 (t, 1H), 5.35-5.37 (t, 1H), 5.21-5.26 (m, 1H), 4.27-4.30 (m, 3H), 3.81-3.83 (m, 1H), 3.69-3.74 (m, 1H), 3.59-3.61 (t, 2H), 3.31 (s, 3H), 1.50 (s, 9H).



[0141] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-phenylpropanoyloxy methyl)oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonyl amino)pyrimidin-2-one (52).

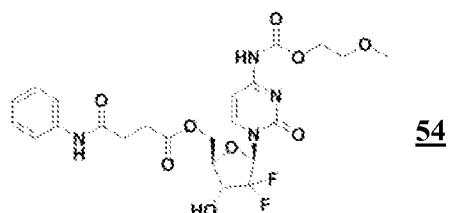
amino)pyrimidin-2-one (52). Using Method E and 3-phenylpropanoic acid, **51** was converted to **52** (white solid, 88% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.96 (s, 1H), 8.00-8.01 (d, 1H), 7.26-7.32 (m, 4H), 7.20-7.23 (t, 1H), 7.14-7.15 (d, 1H), 6.52 (s, 1H), 6.22-6.25 (t, 1H), 4.37-4.44 (m, 2H), 4.28-4.30 (m, 3H), 4.10-4.12 (m, 1H), 5 3.59-3.60 (t, 2H), 3.31 (s, 3H), 2.89-2.92 (t, 2H), 2.73-2.76 (t, 2H).

Example 37



[0142] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-(3-pyridyl)propanoyloxy)methyl]oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxyloxycarbonyl-amino)pyrimidin-2-one (53). Using Method E and 3-(3-pyridyl)propanoic acid, **51** was converted to **53** (white solid, 13% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.97 (s, 1H), 8.51 (s, 1H), 8.44 (s, 1H), 8.00-8.02 (d, 1H), 7.70-7.71 (d, 1H), 7.32-7.33 (t, 1H), 7.13-7.15 (d, 1H), 6.51-6.52 (d, 1H), 6.22-6.25 (t, 1H), 4.35-4.44 (m, 2H), 4.28-4.30 (m, 3H), 4.06-4.11 (m, 1H), 3.59-3.60 (t, 2H), 3.31 (s, 3H), 2.91-2.94 (t, 2H), 15 2.78-2.81 (t, 2H).

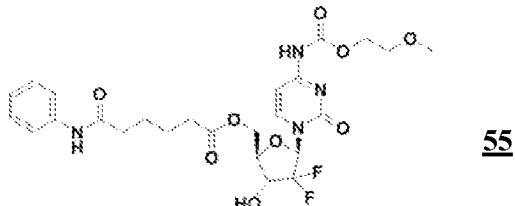
Example 38



[0143] Preparation of 1-[(2R,4R,5R)-5-((4-Anilino-4-oxo-butanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxyloxycarbonyl-amino)pyrimidin-2-one (54). Using Method E and 4-anilino-4-oxo-butanoic acid, **51** was converted to **54** (white solid, 84% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.97 (s, 1H), 10.03 (s, 1H), 8.04-8.06 (d, 1H), 7.59-7.61 (d, 2H), 7.28-7.32 (t, 2H), 7.17-7.19 (d, 1H), 7.02-7.06 (t, 1H), 6.52-6.54 (d, 1H), 6.22-6.26 (t, 1H), 4.47-4.51

(m, 1H), 4.34-4.39 (m, 1H), 4.27-4.30 (t, 3H), 4.11-4.15 (m, 1H), 3.58-3.60 (m, 2H), 3.31 (s, 3H), 2.68-2.73 (m, 4H).

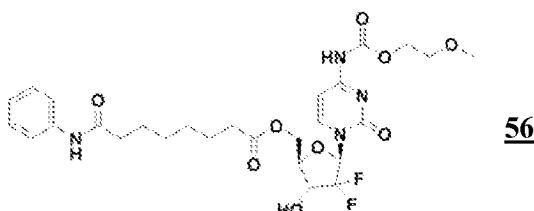
Example 39



5 [0144] **Preparation of 1-[(2R,4R,5R)-5-((6-Anilino-6-oxo-hexanoxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonyl amino)pyrimidin-2-one (55).** Using Method E and 6-anilino-6-oxo-hexanoic acid, **51** was converted to **55** (colorless oil, 86% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.91 (s, 1H), 9.84 (s, 1H), 7.98-8.00 (d, 1H), 7.56-7.58 (d, 2H), 7.25-7.29 (t, 2H), 7.10-7.12 (d, 1H), 6.99-7.03 (t, 1H), 6.48 (m, 1H), 6.18-6.22 (t, 1H), 4.32-4.43 (m, 2H), 4.23-4.25 (m, 3H), 4.07-4.11 (m, 1H), 3.54-3.56 (m, 2H), 3.27 (s, 3H), 2.40-2.44 (t, 2H), 2.29-2.33 (t, 2H), 1.59-1.61 (t, 4H).

10

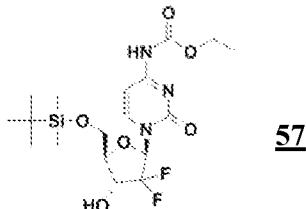
Example 40



15 [0145] **Preparation of 1-[(2R,4R,5R)-5-((8-Anilino-8-oxo-octanoxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonyl amino)pyrimidin-2-one (56).** Using Method E and 8-anilino-8-oxo-octanoic acid, **51** was converted to **56** (colorless oil, 80% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.97 (s, 1H), 9.87 (s, 1H), 8.03-8.05 (d, 1H), 7.61-7.63 (d, 2H), 7.29-7.33 (t, 2H), 7.15-7.17 (d, 1H), 7.04-7.08 (t, 1H), 6.54 (m, 1H), 6.24-6.28 (t, 1H), 4.36-4.47 (m, 2H), 4.28-4.30 (m, 3H), 4.12-4.16 (m, 1H), 3.58-3.61 (m, 2H), 3.32 (s, 3H), 2.41-2.44 (t, 2H), 2.31-2.35 (t, 2H), 1.58-1.64 (t, 4H), 1.34-1.37 (m, 4H).

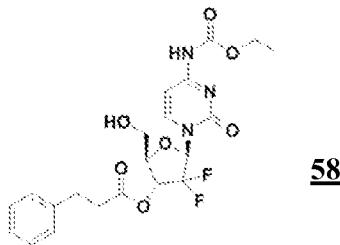
20

[0146] *N*4-3'O-derivatized gemcitabine prodrugs can be synthesized according to Figure 3.

Example 41

[0147] Method F: Preparation of 1-[(2R,4R,5R)-5-tert-Butyldimethylsilyloxy-methyl-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonyl-amino)pyrimidin-2-one (57).

tert-Butyldimethylsilyl chloride (737 mg, 4.89 mmol) was added to a solution of **8** (1.367 g, 4.08 mmol) in 8 mL of pyridine at 0 °C under N₂. The reaction mixture was stirred overnight at RT, diluted with H₂O, then extracted with EtOAc. The organic extract was washed with saturated aqueous CuSO₄ solution, and brine, dried over Na₂SO₄ and concentrated in vacuo. The residue was purified by 10 flash column chromatography (1:1 → 3:1 EtOAc/Hexane) to give 1.4 g of **57** (white solid, 76% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 10.90 (s, 1H), 8.14-8.16 (d, 1H), 7.14-7.16 (d, 1H), 6.42-6.43 (d, 1H), 6.20-6.23 (t, 1H), 4.17-4.23 (m, 3H), 3.98-4.08 (m, 2H), 3.87-3.90 (m, 1H), 1.25-1.28 (t, 3H), 0.94 (s, 9H), 0.14 (s, 6H).



[0148] Method G: Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-5-hydroxymethyl-4-(3-phenylpropanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonyl-amino)pyrimidin-2-one (58).

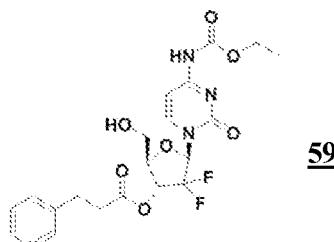
To a mixture of **57** (143 mg, 0.32 mmol), 3-phenylpropanoic acid (853 mg, 0.35 mmol), 4-dimethylaminopyridine (8 mg, 0.06 mmol) and 4 mL of dimethoxyethane, N,N'-dicyclohexylcarbodiimide (144 mg, 0.70 mmol) was added at 0 °C. The reaction mixture was stirred overnight at RT and, after filtering off the resulting precipitates, was then concentrated in vacuo.

Purification by flash column chromatography (1:2 EtOAc/Hexane) provided 112 mg of a colorless oil. To a solution of this colorless oil (112 mg, 0.19 mmol) in 2.5 mL of THF at 0 °C was added a mixture of trifluoroacetic acid (0.27 mL, 3.47 mmol) and

0.27 mL of water. The reaction mixture was stirred at 0 °C for 5 h, quenched with saturated aqueous NaHCO₃ solution and extracted with EtOAc. The extract was washed with water and brine, dried over Na₂SO₄ and concentrated in vacuo.

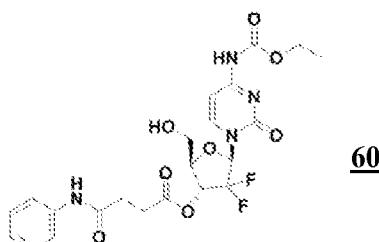
Purification by flash column chromatography (2:1 EtOAc/Hexane) afforded **58** (white solid, 48% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 10.90 (s, 1H), 8.20-8.22 (d, 1H), 7.21-7.35 (m, 5H), 7.16-7.19 (d, 1H), 6.29-6.34 (t, 1H), 5.37-5.44 (m, 1H), 5.31-5.34 (t, 1H), 4.18-4.25 (m, 3H), 3.76-3.80 (m, 1H), 3.59-3.66 (m, 1H), 2.92-2.97 (t, 2H), 2.82-2.86 (t, 2H), 1.27-1.30 (t, 3H); MS (HR-ESI) m/z 490.1402 [M+Na]⁺.

Example 42



[0149] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-5-hydroxymethyl-4-(3-(3-pyridyl)propanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (**59**). Using Method G and 3-(3-pyridyl)propanoic acid, **57** was converted to **59** (white solid, 73% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 10.90 (s, 1H), 8.52 (s, 1H), 8.44-8.46 (d, 1H), 8.19-8.22 (d, 1H), 7.71-7.74 (d, 1H), 7.33-7.37 (t, 1H), 7.15-7.18 (d, 1H), 6.29-6.32 (t, 1H), 5.34-5.42 (m, 1H), 5.31-5.33 (t, 1H), 4.17-4.26 (m, 3H), 3.77-3.81 (d, 1H), 3.62-3.66 (m, 1H), 2.93-2.96 (t, 2H), 2.90-2.91 (t, 2H), 1.25-1.29 (t, 3H).

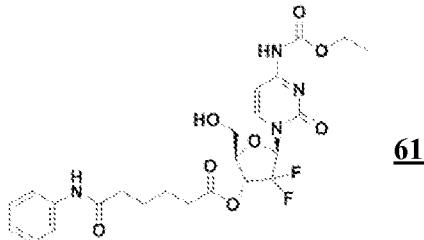
Example 43



[0150] Preparation of 1-[(2R,4R,5R)-4-(4-Anilino-4-oxo-butanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (**60**). Using Method G and 4-anilino-4-oxo-butanic acid, **57** was

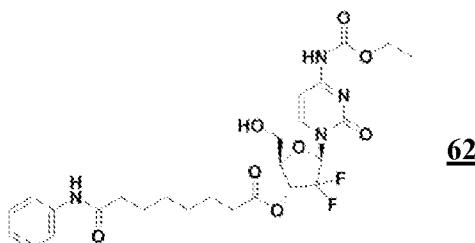
converted to **60** (white solid, 87% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.90 (s, 1H), 10.06 (s, 1H), 8.22-8.23 (d, 1H), 7.60-7.61 (d, 2H), 7.29-7.34 (t, 2H), 7.14-7.18 (t, 1H), 7.04-7.08 (t, 1H), 6.33-6.37 (t, 1H), 5.40-5.47 (m, 1H), 5.34-5.37 (t, 1H), 4.26-4.29 (m, 1H), 4.18-4.23 (m, 2H), 3.80-3.86 (m, 1H), 3.66-3.72 (m, 1H), 2.78-5 2.82 (t, 2H), 2.69-2.72 (t, 2H), 1.25-1.29 (t, 3H).

Example 44



[0151] Preparation of 1-[*(2R,4R,5R)*-4-(6-Anilino-6-oxo-hexanoxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (**61**). Using Method G and 6-anilino-6-oxo-hexanoic acid, **57** was converted to **61** (white solid, 32% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.91 (s, 1H), 9.90 (s, 1H), 8.20-8.22 (d, 1H), 7.60-7.63 (d, 2H), 7.30-7.33 (t, 2H), 7.16-7.18 (d, 1H), 7.03-7.07 (t, 1H), 6.30-6.34 (t, 1H), 5.39-5.45 (m, 1H), 5.34 (s, 1H), 4.26-4.28 (t, 1H), 4.18-4.23 (m, 2H), 3.81-3.83 (d, 1H), 3.68-3.71 (m, 1H), 2.54 (s, 2H), 2.37 (s, 1H), 2H), 1.65 (s, 4H), 1.25-1.29 (t, 3H).

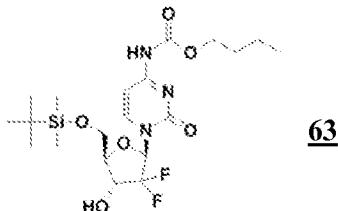
Example 45



[0152] Preparation of 1-[*(2R,4R,5R)*-4-(8-Anilino-8-oxo-octanoxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (**62**). Using Method G and 8-anilino-8-oxo-octanoic acid, **57** was converted to **62** (white solid, 47% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.89 (s, 1H), 9.87 (s, 1H), 8.20-8.23 (d, 1H), 7.60-7.63 (d, 2H), 7.29-7.34 (t, 2H), 7.16-7.19 (d, 1H), 7.03-7.07 (t, 1H), 6.29-6.35 (t, 1H), 5.38-5.44 (m, 1H), 5.34 (s, 1H), 4.25-4.29

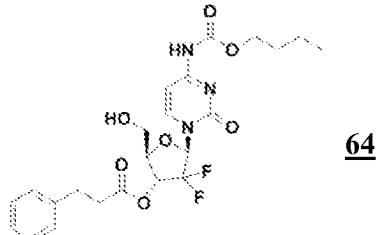
(m, 1H), 4.18-4.24 (m, 2H), 3.80-3.84 (m, 1H), 3.67-3.71 (m, 1H), 2.47-2.52 (t, 2H), 2.31-2.35 (t, 2H), 1.60-1.64 (t, 4H), 1.36 (s, 4H), 1.25-1.30 (t, 3H); MS (HR-ESI) m/z 567.2266 [M+H]⁺.

Example 46



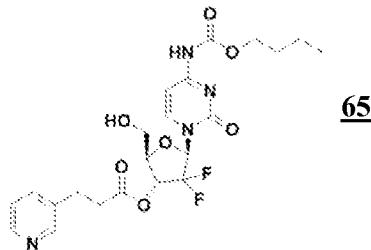
[0153] Preparation of 1-[(2R,4R,5R)-5-tert-Butyldimethylsilyloxymethyl-3,3-difluoro-4-hydroxy-oxolan-2-yl]-4-butyloxycarbonylamino-1,2-dihydro-pyrimidin-2-one (63).

Using Method F, **15** was converted to **63** (colorless oil, 88% yield): ¹H NMR (500 MHz, DMSO-d₆) δ 10.90 (s, 1H), 8.14-8.15 (d, 1H), 7.13-7.15 (d, 1H), 6.43-6.44 (d, 1H), 6.20-6.23 (t, 1H), 4.18 (m, 1H), 4.14-4.17 (t, 2H), 3.98-4.04 (m, 2H), 3.87-3.90 (m, 1H), 1.60-1.65 (m, 2H), 1.37-1.41 (m, 2H), 0.94 (s, 9H), 0.94 (t, 3H), 0.14 (s, 6H).



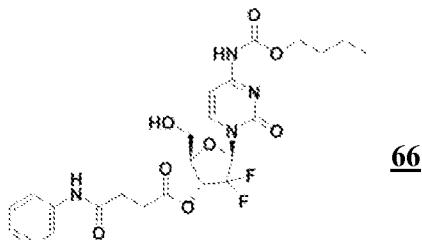
[0154] Preparation of 4-Butyloxycarbonylamino-1-[(2R,4R,5R)-3,3-difluoro-5-hydroxymethyl-4-(3-phenylpropanoyloxy)oxolan-2-yl]-1,2-dihydropyrimidin-2-one (64).

Using Method G and 3-phenylpropanoic acid, **63** was converted to **64** (white solid, 69% yield): ¹H NMR (500 MHz, DMSO-d₆) δ 10.90 (s, 1H), 8.20-8.22 (d, 1H), 7.23-7.34 (m, 5H), 7.15-7.17 (d, 1H), 6.29-6.33 (t, 1H), 5.37-5.43 (m, 1H), 5.33-5.35 (t, 1H), 4.22-4.25 (m, 1H), 4.14-4.17 (t, 2H), 3.77-3.79 (d, 1H), 3.60-3.65 (m, 1H), 2.92-2.96 (m, 2H), 2.82-2.85 (t, 2H), 1.62-1.64 (m, 2H), 1.38-1.42 (m, 2H), 0.92-0.95 (t, 3H).

Example 47

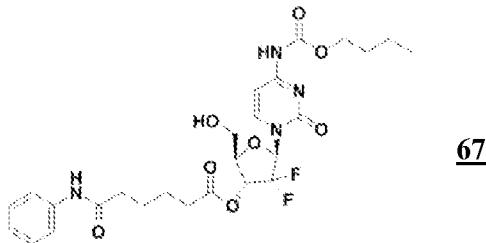
[0155] Preparation of 4-Butyloxycarbonylamino-1-[(2R,4R,5R)-3,3-difluoro-5-hydroxymethyl-4-(3-pyridyl)propanoyloxy]oxolan-2-yl]-1,2-dihydro-pyrimidin-2-one (65).

Using Method G and 3-(3-pyridyl)propanoic acid, **63** was converted to **65** (white solid, 44% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.92 (s, 1H), 8.52 (s, 1H), 8.46 (s, 1H), 8.20-8.21 (d, 1H), 7.72-7.73 (d, 1H), 7.34-7.36 (m, 1H), 7.15-7.17 (d, 1H), 6.29-6.33 (t, 1H), 5.40-5.42 (m, 1H), 5.33-5.35 (t, 1H), 4.24-4.25 (t, 1H), 4.15-4.17 (t, 2H), 3.78-3.80 (m, 1H), 3.62-3.66 (m, 1H), 2.94-2.97 (t, 2H), 2.88-2.91 (t, 2H), 1.61-1.64 (t, 2H), 1.39-1.42 (t, 2H), 0.92-0.95 (t, 3H).

Example 48

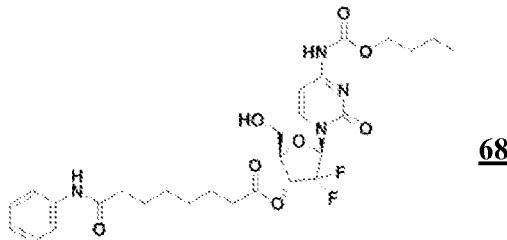
[0156] Preparation of 1-[(2R,4R,5R)-4-(4-Anilino-4-oxo-butanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-4-butyloxycarbonylamino-1,2-dihydro-pyrimidin-2-one (66).

Using Method G and 4-anilino-4-oxo-butanoylic acid, **63** was converted to **66** (white solid, 87% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 10.06 (s, 1H), 8.20-8.24 (d, 1H), 7.59-7.62 (d, 2H), 7.28-7.36 (t, 2H), 7.14-7.18 (d, 1H), 7.02-7.09 (t, 1H), 6.29-6.37 (t, 1H), 5.32-5.59 (m, 2H), 4.25-4.29 (m, 1H), 4.12-4.19 (t, 2H), 3.79-3.88 (m, 1H), 3.66-3.74 (m, 1H), 2.77-2.79 (d, 2H), 2.71-2.73 (d, 2H), 1.59-1.66 (t, 2H), 1.33-1.44 (m, 2H), 0.90-0.97 (t, 3H).

Example 49

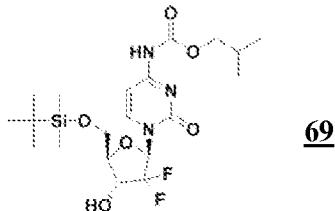
[0157] Preparation of 1-[(2R,4R,5R)-4-(6-Anilino-6-oxo-hexanoxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-4-butyloxycarbonylamino-1,2-dihydro-pyrimidin-2-one (67).

Using Method G and 6-anilino-6-oxo-hexanoic acid, **63** was converted to **67** (white solid, 63% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.91 (s, 1H), 9.91 (s, 1H), 8.21-8.22 (d, 1H), 7.61-7.63 (d, 2H), 7.30-7.33 (t, 2H), 7.16-7.18 (d, 1H), 7.04-7.07 (t, 1H), 6.31-6.34 (t, 1H), 5.39-5.45 (m, 1H), 5.34-5.36 (t, 1H), 4.27-4.28 (t, 1H), 4.15-4.17 (t, 2H), 3.80-3.83 (m, 1H), 3.68-3.72 (m, 1H), 2.35-2.38 (t, 2H), 1.64-1.66 (m, 8H), 1.40-1.42 (m, 2H), 0.92-0.95 (t, 3H).

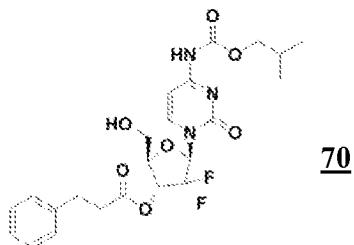
Example 50

[0158] Preparation of 1-[(2R,4R,5R)-4-(8-Anilino-8-oxo-octanoxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-4-butyloxycarbonylamino-1,2-dihydro-pyrimidin-2-one (68).

Using Method G and 8-anilino-8-oxo-octanoic acid, **63** was converted to **68** (white solid, 53% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.91 (s, 1H), 9.88 (s, 1H), 8.21-8.22 (d, 1H), 7.61-7.63 (d, 2H), 7.29-7.33 (t, 2H), 7.16-7.18 (d, 1H), 7.03-7.06 (t, 1H), 6.30-6.34 (t, 1H), 5.39-5.45 (m, 1H), 5.34-5.35 (t, 1H), 4.26-4.28 (t, 1H), 4.15-4.17 (t, 2H), 3.80-3.83 (m, 1H), 3.66-3.71 (m, 1H), 2.48-2.51 (t, 2H), 2.31-2.34 (t, 2H), 1.60-1.64 (m, 6H), 1.40-1.42 (m, 6H), 0.92-0.95 (t, 3H).

Example 51**[0159] Preparation of 1-[2R,4R,5R]-5-tert-Butyldimethylsilyloxymethyl-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonyl-amino)pyrimidin-2-one (69).**

Using Method F, **22** was converted to **69** (white solid, 77% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.93 (s, 1H), 8.14-8.16 (d, 1H), 7.12-7.14 (d, 1H), 6.43-6.45 (d, 1H), 6.20-6.23 (t, 1H), 4.19-4.21 (m, 1H), 3.98-4.02 (m, 2H), 3.94-3.95 (d, 2H), 3.87-3.90 (m, 1H), 1.90-1.98 (m, 1H), 0.95 (d, 6H), 0.94 (s, 9H), 0.14 (s, 6H).

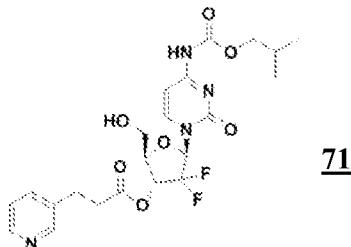


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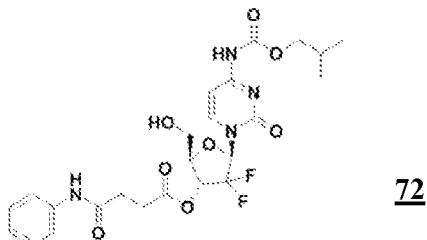
[0160] Preparation of 1-[2R,4R,5R]-3,3-Difluoro-5-hydroxymethyl-4-(3-phenylpropanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonyl-amino)pyrimidin-2-one (70). Using Method G and 3-phenylpropanoic acid, **69** was converted to **70** (white solid, 71% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.94 (s, 1H), 8.20-8.22 (d, 1H), 7.22-7.34 (m, 5H), 7.15-7.16 (d, 1H), 6.30-6.33 (t, 1H), 5.38-5.41 (m, 1H), 5.27-5.33 (m, 1H), 4.22-4.24 (m, 1H), 3.94-3.95 (d, 2H), 3.77-3.79 (d, 1H), 3.61-3.64 (d, 1H), 2.92-2.94 (d, 2H), 2.82-2.85 (t, 2H), 1.92-1.97 (m, 1H), 0.94-0.96 (d, 6H).

15

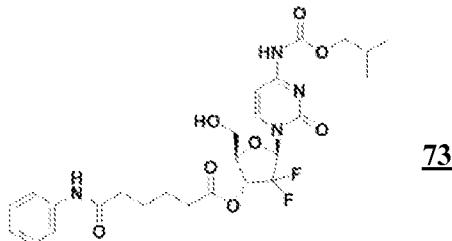
58

Example 52

[0161] **Preparation of 1-[2R,4R,5R]-3,3-Difluoro-5-hydroxymethyl-4-(3-(3-pyridyl)propanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonylamino)pyrimidin-2-one (71).** Using Method G and 3-(3-pyridyl)propanoic acid, **69** was converted to **71** (white solid, 74% yield): ¹H NMR (500 MHz, DMSO-d₆) δ 10.94 (s, 1H), 8.52 (s, 1H), 8.45-8.46 (d, 1H), 8.20-8.21 (d, 1H), 7.72-7.73 (d, 1H), 7.34-7.36 (m, 1H), 7.15-7.16 (d, 1H), 6.29-6.33 (t, 1H), 5.38-5.41 (m, 1H), 5.34 (s, 1H), 4.24-4.25 (m, 1H), 3.94-3.95 (d, 2H), 3.78-3.80 (d, 1H), 3.63-3.65 (d, 1H), 2.94-2.95 (d, 2H), 2.89-2.91 (d, 1H), 1.92-1.97 (m, 2H), 0.94-0.96 (d, 6H).

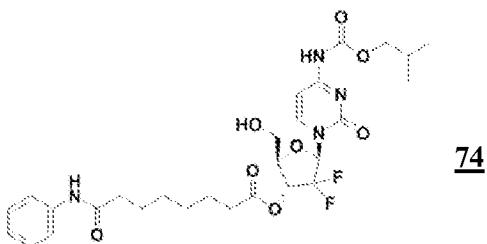
Example 53

[0162] **Preparation of 1-[2R,4R,5R]-4-(4-Anilino-4-oxo-butanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonylamino)pyrimidin-2-one (72).** Using Method G and 4-anilino-4-oxo-butanicoic acid, **69** was converted to **72** (white solid, 88% yield): ¹H NMR (200 MHz, DMSO-d₆) δ 10.94 (s, 1H), 10.06 (s, 1H), 8.21-8.25 (d, 1H), 7.58-7.62 (d, 2H), 7.28-7.36 (t, 2H), 7.14-7.18 (d, 1H), 7.02-7.09 (t, 1H), 6.29-6.37 (t, 1H), 5.32-5.51 (m, 2H), 4.25-4.29 (m, 1H), 3.93-3.96 (d, 2H), 3.79-3.88 (m, 1H), 3.64-3.74 (m, 1H), 2.77-2.79 (d, 2H), 2.71-2.73 (d, 2H), 1.88-2.01 (m, 1H), 0.93-0.96 (d, 6H).

Example 54

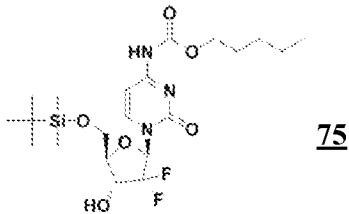
[0163] Preparation of 1-[(2R,4R,5R)-4-(6-Anilino-6-oxo-hexanoxyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonylamino)pyrimidin-2-one (73).

Using Method G and 6-anilino-6-oxo-hexanoic acid, **69** was converted to **73** (white solid, 39% yield): ¹H NMR (400 MHz, DMSO-d₆) δ 10.94 (s, 1H), 9.92 (s, 1H), 8.21-8.23 (d, 1H), 7.61-7.63 (d, 2H), 7.30-7.34 (t, 2H), 7.16-7.18 (d, 1H), 7.03-7.07 (t, 1H), 6.30-6.35 (t, 1H), 5.60-5.62 (d, 1H), 5.39-5.46 (m, 1H), 5.34-5.37 (t, 1H), 4.26-4.29 (m, 1H), 3.94-3.95 (d, 1H), 3.81-3.84 (d, 1H), 3.67-3.72 (m, 1H), 2.37 (s, 2H), 1.91-1.98 (m, 1H), 1.65 (s, 6H), 0.94-0.96 (d, 6H).

Example 55

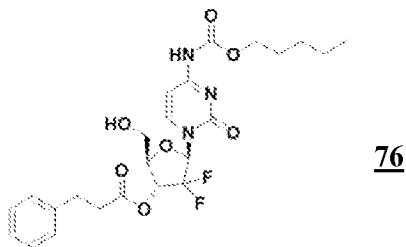
[0164] Preparation of 1-[(2R,4R,5R)-4-(8-Anilino-8-oxo-octanoxyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(2-methylpropoxycarbonylamino)pyrimidin-2-one (74).

Using Method G and 8-anilino-8-oxo-octanoic acid, **69** was converted to **74** (white solid, 53% yield): ¹H NMR (500 MHz, DMSO-d₆) δ 10.95 (s, 1H), 9.88 (s, 1H), 8.21-8.22 (d, 1H), 7.61-7.62 (d, 2H), 7.30-7.33 (t, 2H), 7.15-7.17 (d, 1H), 7.03-7.06 (t, 1H), 6.30-6.34 (t, 1H), 5.39-5.43 (m, 1H), 5.35 (m, 1H), 4.26-4.28 (m, 1H), 3.94-3.95 (d, 2H), 3.80-3.83 (d, 1H), 3.68-3.69 (d, 1H), 2.48-2.51 (t, 2H), 2.31-2.34 (t, 2H), 1.92-1.96 (m, 1H), 1.60-1.62 (d, 4H), 1.35 (s, 4H), 0.94-0.96 (d, 6H).

Example 56

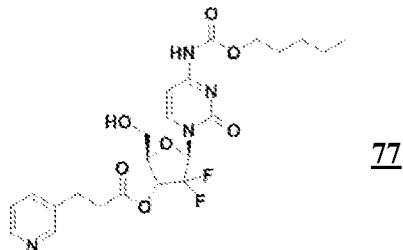
[0165] Preparation of 1-[(2R,4R,5R)-5-tert-Butyldimethylsilyloxymethyl-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)-pyrimidin-2-one (75). Using Method F, **29** was converted to the **75** (colorless oil, 68% yield): ^1H NMR (200 MHz, DMSO- d_6) δ 10.90 (s, 1H), 8.13-8.17 (d, 1H), 7.12-7.16 (d, 1H), 6.42-6.44 (d, 1H), 6.18-6.25 (t, 1H), 4.11-4.18 (m, 3H), 3.96-4.08 (m, 2H), 3.84-3.92 (m, 1H), 1.61-1.67 (t, 2H), 1.30-1.39 (t, 4H), 0.94 (s, 9H), 0.94 (t, 3H), 0.14 (s, 6H).

5 Using Method F, **29** was converted to the **75** (colorless oil, 68% yield): ^1H NMR (200 MHz, DMSO- d_6) δ 10.90 (s, 1H), 8.13-8.17 (d, 1H), 7.12-7.16 (d, 1H), 6.42-6.44 (d, 1H), 6.18-6.25 (t, 1H), 4.11-4.18 (m, 3H), 3.96-4.08 (m, 2H), 3.84-3.92 (m, 1H), 1.61-1.67 (t, 2H), 1.30-1.39 (t, 4H), 0.94 (s, 9H), 0.94 (t, 3H), 0.14 (s, 6H).

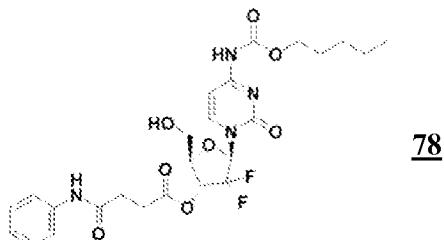


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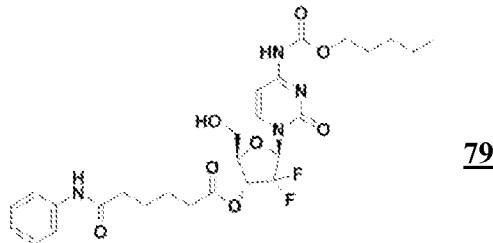
[0166] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-5-hydroxymethyl-4-(3-phenylpropanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)-pyrimidin-2-one (76). Using Method G and 3-phenylpropanoic acid, **75** was converted to **76** (colorless oil, 90% yield): ^1H NMR (200 MHz, DMSO- d_6) δ 10.91 (s, 1H), 8.19-8.23 (d, 1H), 7.21-7.37 (m, 5H), 7.14-7.18 (d, 1H), 6.27-6.36 (t, 1H), 5.31-5.48 (m, 2H), 4.22-4.25 (m, 1H), 4.12-4.18 (t, 2H), 3.76-3.82 (d, 1H), 3.57-3.68 (m, 1H), 2.91-2.99 (t, 2H), 2.79-2.87 (t, 2H), 1.61-1.68 (t, 2H), 1.30-1.38 (t, 4H), 0.89-0.95 (t, 3H).

Example 57

[0167] **Preparation of 1-[*(2R,4R,5R)-3,3-Difluoro-5-hydroxymethyl-4-(3-(3-pyridyl)propanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)-pyrimidin-2-one (77).*** Using Method G and 3-(3-pyridyl)propanoic acid, 75 was converted to 77 (white solid, 51% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.52 (s, 1H), 8.44-8.46 (d, 1H), 8.18-8.22 (d, 1H), 7.70-7.74 (d, 1H), 7.31-7.38 (m, 1H), 7.14-7.18 (d, 1H), 6.27-6.35 (t, 1H), 5.31-5.43 (m, 2H), 4.21-4.26 (m, 1H), 4.11-4.18 (t, 2H), 3.76-3.82 (d, 1H), 3.58-3.69 (m, 1H), 2.89-2.95 (t, 4H), 1.61-1.68 (t, 2H), 1.30-1.39 (t, 4H), 0.88-0.95 (t, 3H).

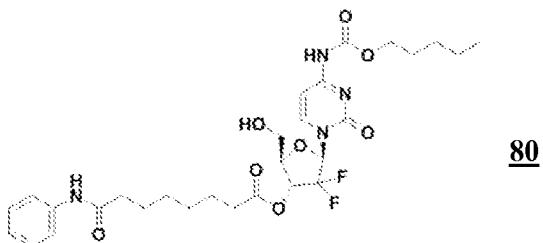
Example 58

[0168] **Preparation of 1-[*(2R,4R,5R)-4-(4-Anilino-4-oxo-butanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(pentyloxycarbonylamino)-pyrimidin-2-one (78).*** Using Method G and 4-anilino-4-oxo-butanoylic acid, 75 was converted to 78 (white solid, 59% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.90 (s, 1H), 10.06 (s, 1H), 8.20-8.24 (d, 1H), 7.59-7.62 (d, 2H), 7.28-7.36 (t, 2H), 7.14-7.18 (d, 1H), 7.02-7.10 (t, 1H), 6.29-6.37 (t, 1H), 5.32-5.51 (m, 2H), 4.25-4.29 (m, 1H), 4.11-4.18 (t, 2H), 3.80-3.95 (m, 1H), 3.69-3.72 (m, 1H), 2.77-2.79 (d, 2H), 2.71-2.73 (d, 2H), 1.61-1.68 (t, 2H), 1.31-1.37 (t, 4H), 0.88-0.95 (t, 3H).

Example 59

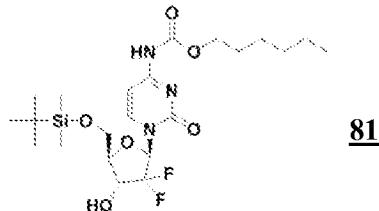
[0169] Preparation of 1-[(2R,4R,5R)-4-(6-Anilino-6-oxo-hexanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-pentyloxycarbonylamino-pyrimidin-2-one (79).

Using Method G and 6-anilino-6-oxo-hexanoic acid, **75** was converted to **79** (white solid, 88% yield): ^1H NMR (200 MHz, DMSO- d_6) δ 10.91 (s, 1H), 9.91 (s, 1H), 8.20-8.23 (d, 1H), 7.60-7.64 (d, 2H), 7.28-7.36 (t, 2H), 7.15-7.19 (d, 1H), 7.01-7.09 (t, 1H), 6.28-6.37 (t, 1H), 5.32-5.49 (m, 2H), 4.26-4.29 (m, 1H), 4.12-4.18 (t, 2H), 3.79-3.87 (m, 1H), 3.70-3.75 (m, 1H), 2.54 (s, 2H), 2.37 (s, 2H), 1.66 (s, 6H), 1.32-1.37 (t, 4H), 0.88-0.95 (t, 3H).

Example 60

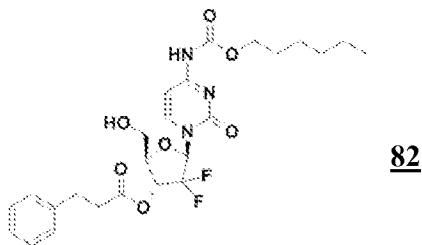
[0170] Preparation of 1-[(2R,4R,5R)-4-(8-Anilino-8-oxo-octanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-pentyloxycarbonylamino-pyrimidin-2-one (80).

Using Method G and 8-anilino-8-oxo-octanoic acid, **75** was converted to **80** (white solid, 79% yield): ^1H NMR (200 MHz, DMSO- d_6) δ 10.92 (s, 1H), 9.88 (s, 1H), 8.19-8.23 (d, 1H), 7.60-7.64 (d, 2H), 7.27-7.35 (t, 2H), 7.14-7.18 (d, 1H), 7.01-7.08 (t, 1H), 6.28-6.36 (t, 1H), 5.35-5.49 (m, 2H), 4.25-4.29 (m, 1H), 4.11-4.18 (t, 2H), 3.65-3.85 (m, 2H), 2.46-2.53 (t, 2H), 2.29-2.36 (t, 2H), 1.66 (s, 6H), 1.31-1.35 (t, 8H), 0.88-0.95 (t, 3H).

Example 61

[0171] Preparation of 1-[(2R,4R,5R)-5-tert-Butyldimethylsilyloxymethyl-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)pyrimidin-2-one (81).

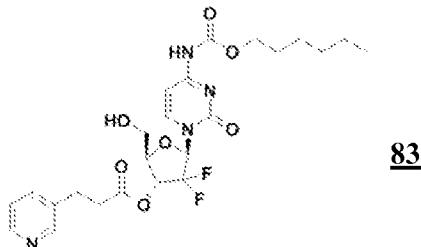
Using Method F, **36** was converted to **81** (colorless oil, 70% yield): ^1H NMR (400 MHz, DMSO- d_6) δ 10.90 (s, 1H), 8.14-8.16 (d, 1H), 7.13-7.15 (d, 1H), 6.44-6.46 (d, 1H), 6.19-6.23 (t, 1H), 4.18-4.25 (m, 1H), 4.12-4.16 (t, 2H), 3.98-4.04 (m, 2H), 3.86-3.90 (m, 1H), 1.61-1.65 (t, 2H), 1.31-1.34 (d, 6H), 0.94 (s, 9H), 0.94 (t, 3H), 0.14 (s, 6H).



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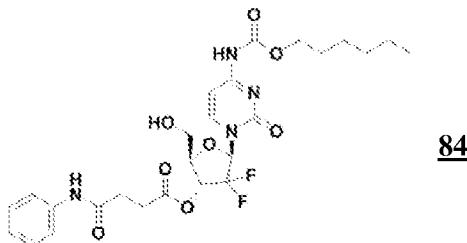
[0172] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-5-hydroxymethyl-4-(3-phenylpropanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)pyrimidin-2-one (82).

Using Method G and 3-phenylpropanoic acid, **81** was converted to **82** (white solid, 92% yield): ^1H NMR (400 MHz, DMSO- d_6) δ 10.92 (s, 1H), 8.20-8.22 (d, 1H), 7.27-7.32 (m, 5H), 7.15-7.17 (d, 1H), 6.29-6.31 (t, 1H), 5.37-5.44 (m, 1H), 5.34 (s, 1H), 4.23-4.24 (t, 1H), 4.13-4.16 (t, 2H), 3.77-3.80 (d, 1H), 3.61-3.64 (d, 1H), 2.92-2.94 (d, 2H), 2.84-2.86 (d, 2H), 1.62-1.65 (t, 2H), 1.27-1.37 (d, 6H), 0.89-0.91 (t, 3H).

Example 62

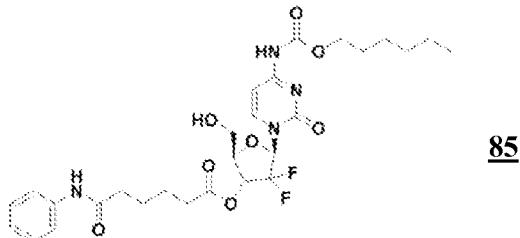
[0173] Preparation of 1-[2R,4R,5R]-3,3-Difluoro-5-hydroxymethyl-4-(3-(3-pyridyl)propanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)-pyrimidin-2-one (83).

Using Method G and 3-(3-pyridyl)propanoic acid, **81** was converted to **83** (white solid, 46% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.92 (s, 1H), 8.52 (s, 1H), 8.45-8.46 (d, 1H), 8.20-8.21 (d, 1H), 7.71-7.73 (d, 1H), 7.33-7.36 (t, 1H), 7.15-7.17 (d, 1H), 6.29-6.33 (t, 1H), 5.38-5.44 (m, 1H), 5.33-5.36 (t, 1H), 4.24-4.25 (t, 1H), 4.13-4.16 (t, 2H), 3.77-3.80 (d, 1H), 3.61-3.66 (d, 1H), 2.94-2.95 (d, 2H), 2.89-2.91 (d, 2H), 1.62-1.65 (t, 2H), 1.32-1.37 (t, 6H), 0.89-0.90 (t, 3H).

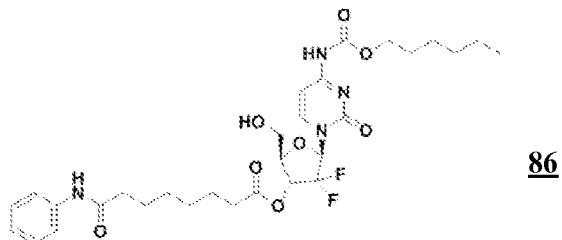
Example 63

[0174] Preparation of 1-[2R,4R,5R]-4-(4-Anilino-4-oxo-butanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)-pyrimidin-2-one (84).

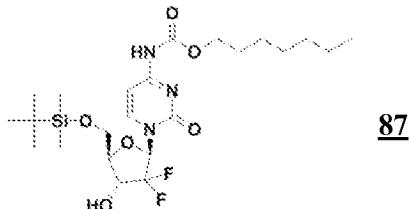
Using Method G and 4-anilino-4-oxo-butanic acid, **81** was converted to **84** (white solid, 61% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.91 (s, 1H), 10.06 (s, 1H), 8.21-8.23 (d, 1H), 7.60-7.61 (d, 2H), 7.30-7.34 (t, 2H), 7.15-7.17 (d, 1H), 7.04-7.08 (t, 1H), 6.31-6.35 (t, 1H), 5.40-5.47 (m, 1H), 5.34-5.37 (t, 1H), 4.26-4.29 (m, 1H), 4.13-4.16 (t, 2H), 3.80-3.83 (d, 1H), 3.66-3.72 (m, 1H), 2.78-2.82 (t, 2H), 2.69-2.72 (t, 2H), 1.60-1.67 (m, 2H), 1.31-1.39 (m, 6H), 0.89-0.92 (t, 3H).

Example 64

[0175] **Preparation of 1-[(2R,4R,5R)-4-(6-Anilino-6-oxo-hexanoxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)-5-pyrimidin-2-one (85).** Using Method G and 6-anilino-6-oxo-hexanoic acid, **81** was converted to **85** (white solid, 80% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.91 (s, 1H), 9.92 (s, 1H), 8.21-8.23 (d, 1H), 7.61-7.63 (d, 2H), 7.30-7.34 (t, 2H), 7.16-7.18 (d, 1H), 7.03-7.07 (t, 1H), 6.30-6.35 (t, 1H), 5.39-5.46 (m, 1H), 5.34-5.37 (t, 1H), 4.28-4.29 (t, 1H), 4.13-4.16 (t, 2H), 3.81-3.84 (d, 1H), 3.67-3.72 (m, 1H), 2.54 (s, 2H), 2.37 (s, 2H), 1.65 (s, 6H), 1.32 (s, 6H), 0.89-0.91 (t, 3H).

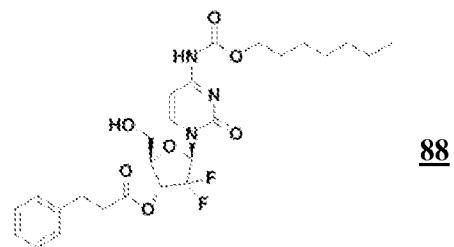
Example 65

[0176] **Preparation of 1-[(2R,4R,5R)-4-(8-Anilino-8-oxo-octanoxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(hexyloxycarbonylamino)-5-pyrimidin-2-one (86).** Using Method G and 8-anilino-8-oxo-octanoic acid, **81** was converted to **86** (white solid, 57% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.92 (s, 1H), 9.98 (s, 1H), 8.21-8.22 (d, 1H), 7.61-7.63 (d, 2H), 7.29-7.33 (t, 2H), 7.16-7.18 (d, 1H), 7.03-7.06 (t, 1H), 6.30-6.34 (t, 1H), 5.39-5.46 (m, 1H), 5.34-5.37 (t, 1H), 4.26-4.28 (t, 1H), 4.13-4.16 (t, 2H), 3.80-3.84 (d, 1H), 3.66-3.71 (m, 1H), 2.48-2.51 (t, 2H), 2.31-2.35 (t, 2H), 1.60-1.65 (m, 6H), 1.31-1.36 (m, 10H), 0.89-0.92 (t, 3H).

Example 66

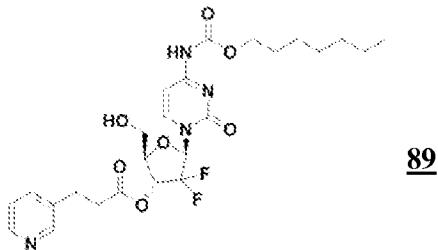
[0177] Preparation of 1-[(2R,4R,5R)-5-tert-Butyldimethylsilyloxymethyl-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)-

5 pyrimidin-2-one (**87**). Using Method F, **43** was converted to **87** (white solid, 70% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.13-8.16 (d, 1H), 7.12-7.16 (d, 1H), 6.42-6.44 (d, 1H), 6.18-6.25 (t, 1H), 4.11-4.23 (m, 3H), 3.86-4.08 (m, 3H), 1.60-1.67 (t, 2H), 1.31 (s, 8H), 0.94 (s, 9H), 0.94 (t, 3H), 0.14 (s, 6H).



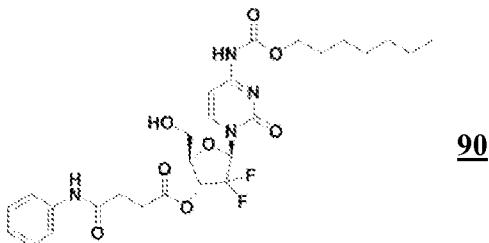
10 [0178] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-5-hydroxymethyl-4-(3-phenyl-propanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)-

pyrimidin-2-one (**88**). Using Method G and 3-phenylpropanoic acid, **87** was converted to **88** (white solid, 57% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.92 (s, 1H), 8.19-8.23 (d, 1H), 7.27-7.32 (m, 5H), 7.14-7.18 (d, 1H), 6.27-6.36 (t, 1H), 5.25-5.48 (m, 2H), 4.22-4.27 (m, 1H), 4.11-4.18 (t, 2H), 3.76-3.82 (d, 1H), 3.57-3.68 (m, 1H), 2.91-2.97 (t, 2H), 2.80-2.87 (t, 2H), 1.61-1.67 (t, 2H), 1.27-1.37 (t, 8H), 0.87-0.93 (t, 3H).

Example 67

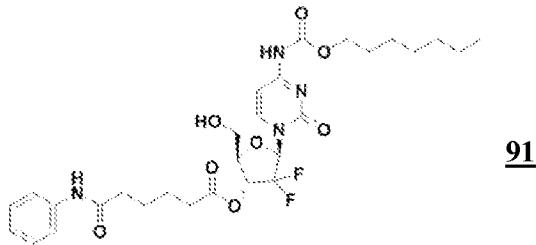
[0179] Preparation of 1-[*(2R,4R,5R)-3,3-Difluoro-5-hydroxymethyl-4-(3-(3-pyridyl)propanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)-pyrimidin-2-one (**89**).*

Using Method G and 3-(3-pyridyl)propanoic acid, **87** was converted to **89** (white solid, 76% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.92 (s, 1H), 8.51-8.52 (d, 1H), 8.43-8.47 (m, 1H), 8.18-8.21 (d, 1H), 7.70-7.75 (m, 1H), 7.31-7.38 (m, 1H), 7.14-7.18 (d, 1H), 6.27-6.35 (t, 1H), 5.31-5.48 (m, 2H), 4.23-4.26 (m, 1H), 4.11-4.18 (t, 2H), 3.76-3.82 (d, 1H), 3.58-3.69 (m, 1H), 2.89-2.95 (t, 4H), 1.61-1.67 (t, 2H), 1.30-1.31 (t, 8H), 0.87-0.93 (t, 3H).

Example 68

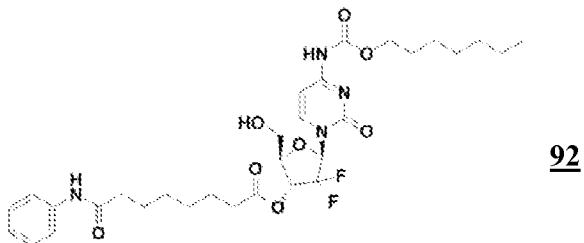
[0180] Preparation of 1-[*(2R,4R,5R)-4-(4-Anilino-4-oxo-butanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)-pyrimidin-2-one (**90**).*

Using Method G and 4-anilino-4-oxo-butanoylic acid **87** was converted to **90** (white solid, 47% yield): ^1H NMR (200 MHz, DMSO-d₆) δ 10.91 (s, 1H), 10.05 (s, 1H), 8.20-8.24 (d, 1H), 7.59-7.62 (d, 2H), 7.28-7.36 (t, 2H), 7.14-7.18 (d, 1H), 7.02-7.09 (t, 1H), 6.29-6.37 (t, 1H), 5.36-5.51 (m, 2H), 4.25-4.29 (m, 1H), 4.11-4.18 (t, 2H), 3.79-3.86 (d, 1H), 3.64-3.72 (d, 1H), 2.77-2.82 (t, 2H), 2.69-2.73 (t, 2H), 1.60-1.67 (t, 2H), 1.30-1.31 (d, 8H), 0.86-0.93 (t, 3H).

Example 69

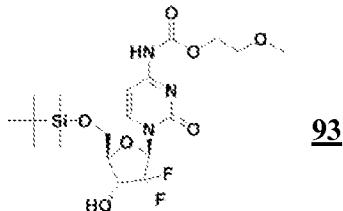
[0181] Preparation of 1-[(2R,4R,5R)-4-(6-Anilino-6-oxo-hexanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)-pyrimidin-2-one (91).

Using Method G and 6-anilino-6-oxo-hexanoic acid, **87** was converted to **91** (white solid, 77% yield): ^1H NMR (200 MHz, DMSO- d_6) δ 10.91 (s, 1H), 9.91 (s, 1H), 8.20-8.23 (d, 1H), 7.60-7.64 (d, 2H), 7.28-7.36 (t, 2H), 7.15-7.19 (d, 1H), 7.01-7.09 (t, 1H), 6.28-6.37 (t, 1H), 5.35-5.49 (m, 2H), 4.26-4.29 (m, 1H), 4.11-4.18 (t, 2H), 3.66-3.94 (m, 2H), 2.54 (s, 2H), 2.37 (s, 2H), 1.66 (s, 6H), 1.32 (s, 8H), 0.87-0.93 (t, 3H).

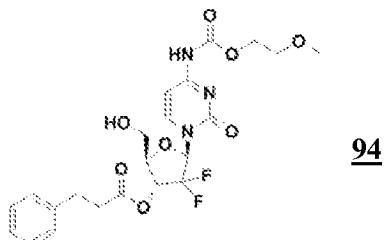
Example 70

[0182] Preparation of 1-[(2R,4R,5R)-4-(8-Anilino-8-oxo-octanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(heptyloxycarbonylamino)-pyrimidin-2-one (92).

Using Method G and 8-anilino-8-oxo-octanoic acid, **87** was converted to **92** (white solid, 36% yield): ^1H NMR (200 MHz, DMSO- d_6) δ 10.91 (s, 1H), 9.88 (s, 1H), 8.19-8.23 (d, 1H), 7.60-7.64 (d, 2H), 7.27-7.35 (t, 2H), 7.15-7.18 (d, 1H), 7.01-7.09 (t, 1H), 6.28-6.36 (t, 1H), 5.35-5.49 (m, 2H), 4.25-4.29 (m, 1H), 4.11-4.18 (t, 2H), 3.64-3.85 (m, 2H), 2.46-2.52 (t, 2H), 2.29-2.36 (t, 2H), 1.58-1.64 (t, 6H), 1.30-1.35 (t, 12H), 0.86-0.93 (t, 3H).

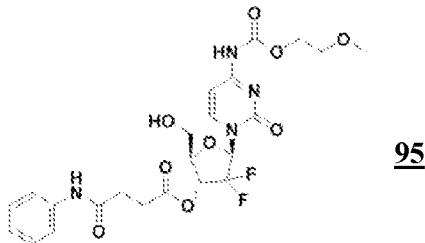
Example 71

[0183] Preparation of 1-[(2R,4R,5R)-5-tert-Butyldimethylsilyloxymethyl-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonyl-amino)pyrimidin-2-one (**93**). Using Method F, **50** was converted to **93** (colorless solid, 82% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.97 (s, 1H), 8.14-8.16 (d, 1H), 7.12-7.14 (d, 1H), 6.42-6.44 (d, 1H), 6.20-6.23 (t, 1H), 4.28-4.30 (t, 2H), 4.19-4.21 (m, 1H), 3.98-4.02 (m, 2H), 3.87-3.90 (m, 1H), 3.58-3.60 (t, 2H), 3.31 (s, 3H), 0.94 (s, 9H), 0.14 (s, 6H).



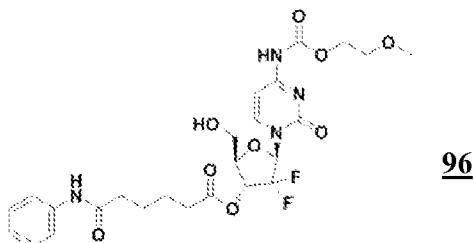
10

[0184] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-5-hydroxymethyl-4-(3-phenylpropanoyloxy)oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonyl-amino)pyrimidin-2-one (**94**). Using Method G and 3-phenylpropanoic acid, **93** was converted to **94** (white solid, 66% yield): ^1H NMR (500 MHz, DMSO- d_6) δ 10.97 (s, 1H), 8.20-8.22 (d, 1H), 7.22-7.34 (m, 5H), 7.14-7.16 (d, 1H), 6.30-6.33 (t, 1H), 5.38-5.41 (m, 1H), 5.33 (s, 1H), 4.28-4.30 (t, 2H), 4.23-4.24 (m, 1H), 3.77-3.79 (d, 1H), 3.64 (s, 1H), 3.59-3.61 (t, 2H), 3.31 (s, 3H), 2.93-2.95 (t, 2H), 2.82-2.85 (t, 2H).

Example 72

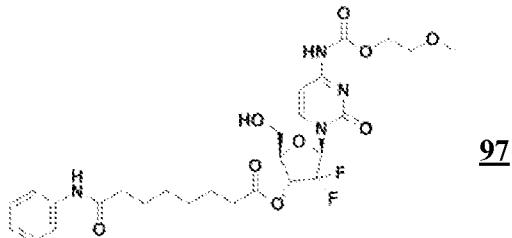
[0185] Preparation of 1-[(2R,4R,5R)-4-(4-Anilino-4-oxo-butanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonylamino)pyrimidin-2-one (95).

Using Method G and 4-anilino-4-oxo-butanic acid, **93** was converted to **95** (white solid, 88% yield): ^1H NMR (400 MHz, DMSO- d_6) δ 10.95 (s, 1H), 10.01 (s, 1H), 8.31-8.33 (d, 1H), 7.60-7.62 (d, 2H), 7.28-7.36 (t, 2H), 7.11-7.13 (d, 1H), 7.03-7.07 (t, 1H), 6.38-6.39 (d, 1H), 5.36-5.38 (t, 2H), 4.27-4.30 (m, 2H), 4.8-4.25 (m, 1H), 3.82-3.86 (d, 1H), 3.67-3.71 (d, 1H), 3.58-3.60 (m, 2H), 3.31 (s, 3H), 2.61-2.67 (m, 4H).

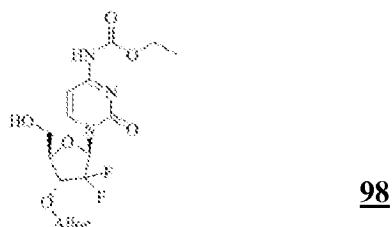
Example 73

[0186] Preparation of 1-[(2R,4R,5R)-4-(6-Anilino-6-oxo-hexanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy carbonylamino)pyrimidin-2-one (96).

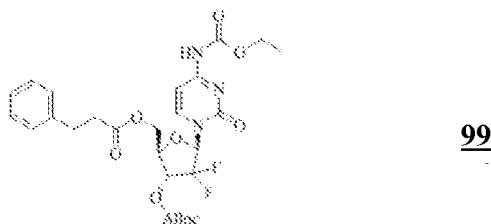
Using Method G and 6-anilino-6-oxo-hexanoic acid, **93** was converted to **96** (white solid, 91% yield): ^1H NMR (400 MHz, DMSO- d_6) δ 10.97 (s, 1H), 9.93 (s, 1H), 8.21-8.23 (d, 1H), 7.61-7.62 (d, 2H), 7.30-7.34 (t, 2H), 7.15-7.17 (d, 1H), 7.03-7.07 (t, 1H), 6.30-6.34 (t, 1H), 5.36-5.45 (m, 2H), 4.27-4.30 (m, 3H), 3.80-3.84 (m, 1H), 3.66-3.71 (m, 1H), 3.58-3.61 (m, 2H), 3.31 (s, 3H), 2.53-2.55 (t, 2H), 2.35-2.38 (t, 2H), 1.64-1.66 (t, 4H).

Example 74**[0187] Preparation of 1-[(2R,4R,5R)-4-(8-Anilino-8-oxo-octanoyloxy)-3,3-difluoro-5-hydroxymethyl-oxolan-2-yl]-1,2-dihydro-4-(2-methoxyethoxy-carbonylamino)pyrimidin-2-one (97).**

Using Method G and 8-anilino-8-oxo-octanoic acid, **93** was converted to **97** (white solid, 97% yield): ^1H NMR (500 MHz, DMSO-d₆) δ 10.96 (s, 1H), 9.88 (s, 1H), 8.21-8.22 (d, 1H), 7.61-7.62 (d, 2H), 7.30-7.33 (t, 2H), 7.15-7.16 (d, 1H), 7.03-7.06 (t, 1H), 6.30-6.33 (t, 1H), 5.39-5.43 (m, 2H), 4.27-4.30 (t, 3H), 3.80-3.83 (d, 1H), 3.68-3.69 (d, 1H), 3.59-3.61 (t, 2H), 3.31 (s, 3H), 2.48-2.51 (t, 2H), 2.31-2.34 (t, 2H), 1.60-1.63 (t, 4H), 1.35 (s, 4H).

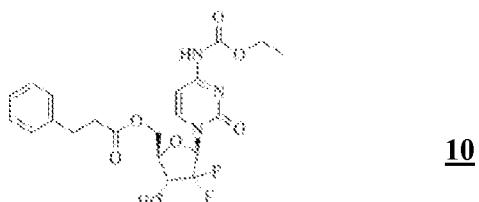
Example 75**[0188] Preparation of Ethyl 1-((2R,4R,5R)-4-(allyloxycarbonyloxy)-3,3-difluoro-5-(hydroxymethyl)tetra-hydrofuran-2-yl)-2-oxo-1,2-dihydropyrimidin-4-ylcarbamate (98).**

Using Method B and allyl chloroformate, **8** was converted to **98** (white solid, 54% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.91 (s, 1H), 8.18-8.20 (d, 1H), 7.16-7.19 (d, 1H), 6.31-6.36 (t, 1H), 5.96-6.03 (m, 1H), 5.31-5.39 (m, 3H), 5.43 (s, 1H), 4.73-4.76 (t, 2H), 4.30-4.33 (dd, 1H), 4.17-4.23 (dd, 2H), 3.81-3.87 (m, 1H), 3.70-3.76 (m, 1H), 1.26-1.29 (t, 3H); MS (HR-ESI): m/z 442.1035 [M+Na]⁺.



[0189] Preparation of ((2R,3R,5R)-3-(Allyloxycarbonyloxy)-5-(4-(ethoxycarbonylamino)-2-oxopyrimidin-1(2H)-yl)-4,4-difluorotetrahydrofuran-2-yl)methyl 3-phenylpropanoate (99). Using Method C and 3-phenylpropanoic acid,

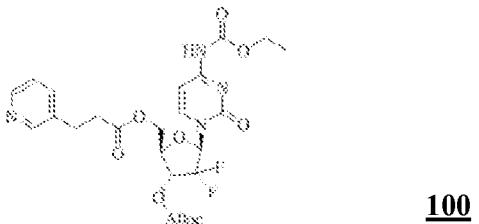
5 **98** was converted to **99** (colorless oil, 54% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.94 (s, 1H), 8.05-8.07 (d, 1H), 7.17-7.33 (m, 6H), 6.34 (t, 1H), 5.95-6.00 (m, 1H), 5.38-5.43 (d, 2H), 5.30-5.34 (d, 1H), 4.72-4.75 (t, 2H), 4.47-4.51 (d, 2H), 4.41-4.44 (m, 1H), 4.18-4.23 (dd, 2H), 2.87-2.92 (t, 2H), 2.70-2.75 (t, 2H), 1.25-1.29 (t, 3H); m/z 550.1629 [M-H]⁺.



10

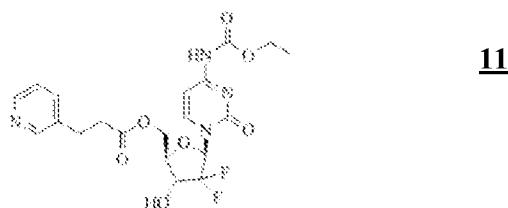
[0190] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-phenylpropanoyloxymethyl)oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (10). Using method C, **99** was converted to **10** (colorless solid, 98% yield): ^1H NMR (400 MHz, DMSO-d₆) δ 10.89 (s, 1H), 7.99-8.02 (d, 1H), 7.15-7.33 (m, 6H), 6.49-6.52 (d, 1H), 6.21-6.26 (t, 1H), 4.34-4.46 (m, 2H), 4.17-4.28 (m, 3H), 4.04-4.13 (m, 1H), 2.88-2.93 (t, 2H), 2.74-2.77 (t, 2H), 1.26-1.29 (t, 3H); MS (HR-ESI): m/z 490.1405 [M+H]⁺.

Example 76



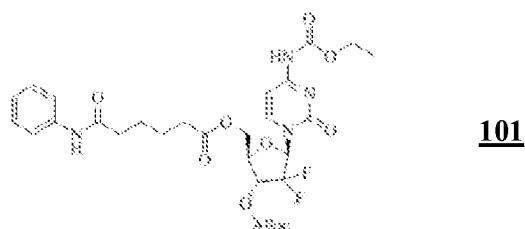
20 **[0191] Preparation of ((2R,3R,5R)-3-(Allyloxycarbonyloxy)-5-(4-(ethoxycarbonylamino)-2-oxopyrimidin-1(2H)-yl)-4,4-difluorotetrahydrofuran-**

2-yl)methyl 3-(pyridin-3-yl)-Propanoate (100). Using Method C and 3-(3-pyridyl)propionic acid, **98** was converted to **100** (colorless oil, 63% yield): ¹H NMR (400 MHz, DMSO-d₆) δ10.94 (s, 1H), 8.49-8.50 (d, 1H), 8.42-8.44 (d, 1H), 8.05-8.07 (d, 1H), 7.69-7.71 (d, 1H), 7.31-7.34 (m, 1H), 7.17-7.19 (d, 1H), 6.34 (t, 1H), 5.95-6.02 (m, 1H), 5.38-5.43 (dd, 2H), 5.30-5.34 (d, 1H), 4.73-4.74 (d, 2H), 4.49-4.53 (m, 2H), 4.40-4.48 (m, 1H), 4.20-4.22 (m, 2H), 2.89-2.93 (t, 2H), 2.75-2.79 (t, 2H), 1.25-1.29 (t, 3H).



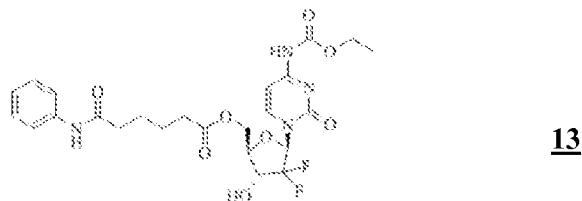
[0192] Preparation of 1-[(2R,4R,5R)-3,3-Difluoro-4-hydroxy-5-(3-(3-pyridyl)-propanoyloxy)methyl]oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (11). Using Method C, **100** was converted to **11** (yellow solid, 73% yield): ¹H NMR (400 MHz, DMSO-d₆) δ10.89 (s, 1H), 8.50 (s, 1H), 8.42-8.45 (dd, 1H), 7.99-8.02 (d, 1H), 7.69-7.72 (d, 1H), 7.31-7.35 (m, 1H), 7.15-7.18 (d, 1H), 6.50-6.52 (d, 1H), 6.21-6.26 (t, 1H), 4.34-4.46 (m, 2H), 4.17-4.24 (m, 3H), 4.04-4.12 (m, 1H), 2.90-2.95 (t, 2H), 2.78-2.82 (t, 2H), 1.25-1.29 (t, 3H); MS (FAB): m/z 469.1528 [M+H]⁺

Example 77



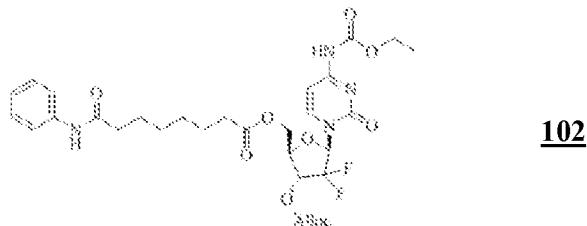
[0193] Preparation of ((2R,3R,5R)-3-(Allyloxycarbonyloxy)-5-(4-(ethoxycarbonylamino)-2-oxopyrimidin-1(2H)-yl)-4,4-difluorotetrahydrofuran-2-yl)methyl 6-oxo-6-(phenyl amino)hexanoate (101). Using Method C and adipanilic acid, **98** was converted to **101** (colorless oil, 84% yield): ¹H NMR (400 MHz, DMSO-d₆) δ10.94 (s, 1H), 9.89 (s, 1H), 8.07-8.10 (d, 1H), 7.59-7.62 (d, 2H), 7.28-7.33 (t, 2H), 7.18-7.20 (d, 1H), 7.02-7.07 (t, 1H), 6.33-6.38 (t, 1H), 5.94-6.04 (m,

1H), 5.31-5.43 (m, 3H), 4.72-4.75 (m, 2H), 4.49-4.53 (d, 2H), 4.40-4.45 (m, 1H), 4.19-4.21 (dd, 2H), 2.42-2.45 (t, 2H), 2.32-2.36 (t, 2H), 1.62 (s, 4H), 1.27-1.29 (t, 3H).

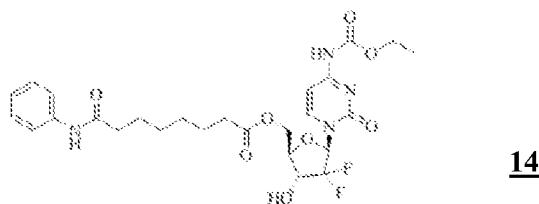


[0194] Preparation of 1-[2R,4R,5R]-5-((6-Anilino-6-oxo-hexanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (13). Using Method C, **101** was converted to **13** (white solid, 56% yield): ^1H NMR (400 MHz, DMSO- d_6) δ 10.88 (s, 1H), 9.88 (s, 1H), 8.02-8.05 (d, 1H), 7.59-7.65 (d, 2H), 7.29-7.35 (t, 2H), 7.16-7.19 (d, 1H), 7.03-7.07 (t, 1H), 6.50-6.53 (d, 1H), 6.23-6.26 (t, 1H), 4.35-4.47 (m, 2H), 4.18-4.35 (m, 3H), 4.05-4.08 (d, 1H), 2.44-2.46 (t, 2H), 2.34-2.36 (t, 2H), 1.63 (s, 4H), 1.24-1.28 (t, 3H); MS (HR-ESI): m/z 561.1762 [M+Na] $^+$.

Example 78



[0195] Preparation of ((2R,3R,5R)-3-(Allyloxycarbonyloxy)-5-(4-(ethoxycarbonylamino)-2-oxopyrimidin-1(2H)-yl)-4,4-difluorotetrahydrofuran-2-yl)methyl 8-oxo-8-(phenylamino)octanoate (102). Using Method C and suberanilic acid, **98** was converted to **102** (colorless oil, 34% yield): ^1H NMR (400 MHz, DMSO- d_6) δ 10.84 (s, 1H), 9.86 (s, 1H), 8.07-8.10 (d, 1H), 7.60-7.63 (d, 2H), 7.28-7.32 (t, 2H), 7.18-7.20 (d, 1H), 7.02-7.06 (t, 1H), 6.34-6.36 (m, 1H), 5.95-6.03 (m, 1H), 5.31-5.43 (m, 3H), 4.73 (s, 2H), 4.49-4.52 (d, 2H), 4.41-4.45 (m, 1H), 4.17-4.22 (dd, 2H), 2.37-2.41 (t, 2H), 2.30-2.34 (t, 2H), 1.55-1.63 (dd, 4H), 1.34 (s, 4H), 1.24-1.28 (t, 3H).



[0196] **Preparation of 1-[(2R,4R,5R)-5-((8-Anilino-8-oxo-octanoyloxy)methyl)-3,3-difluoro-4-hydroxy-oxolan-2-yl]-1,2-dihydro-4-(ethoxycarbonylamino)-pyrimidin-2-one (14).** Using Method C, **102** was converted to **14** (white solid, 66% yield): ^1H NMR (400 MHz, DMSO- d_6) δ 10.88 (s, 1H), 9.85 (s, 1H), 8.02-8.04 (d, 1H), 7.60-7.63 (d, 2H), 7.28-7.33 (t, 2H), 7.16-7.19 (d, 1H), 7.02-7.07 (t, 1H), 6.50-6.53 (d, 1H), 6.22-6.27 (t, 1H), 4.34-4.47 (m, 2H), 4.11-4.30 (m, 4H), 2.39-2.44 (t, 2H), 2.30-2.34 (t, 2H), 1.57-1.64 (m, 4H), 1.33-1.36 (t, 4H), 1.24-1.28 (t, 3H); MS (HR-ESI): m/z 565.2112 [M-H]⁻.

10 Example 79

[0197] **Method H: In Vitro Metabolic Conversion Assay Using Human Liver S9 Fractions.** A representative sampling of prodrug compounds was incubated with human liver S9 fractions (Life Technologies Corporation) at 10 μM in duplicates. Incubations were carried out at 37 °C in a shaker water bath. Samples were taken at 0 and 60 minutes. Negative controls (without S9 fractions) and positive controls (7-ethoxycoumarin and 7-hydroxycoumarin) were run concurrently with the test articles in duplicates. All samples were analyzed using LC/MS/MS; depletion of the parent compounds and the formation of gemcitabine were monitored, though the latter was not quantitatively monitored. The test results are tabulated in Table 1.

20 Table 1

Test Sample	Compound	% of Parent Remaining	Formation of Gemcitabine
1	3	1%	✓
2	6	8%	✓
3	10	0%	✓
4	11	0%	✓
5	13	13%	✓
6	14	0%	✓
7	58	0%	✓
8	59	1%	✓
9	62	2%	✓

[0198] After incubation with human liver S9 fractions for 60 minutes, depletion of each test compound was observed along with formation of gemcitabine as a metabolite.

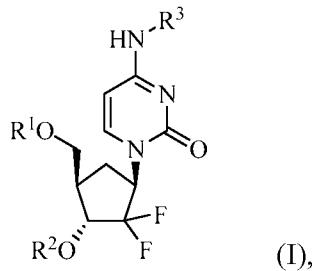
Example 80

5 **[0199] Method I: Efficacy Evaluation in HCT116 Tumor Cell Xenograft Model in Nude Mice.** Compounds **17, 18, 19** and **32** were evaluated for oral activity against human HCT116 colorectal adenocarcinoma in female nude mice. For the treatment groups, the above compounds were given perorally in 15% Tween 80 at a dose of 20 mg/kg once daily for 14 days. As a reference group, gemcitabine was administered 10 intraperitoneally at 160 mg/kg once every three days for 4 doses. A control group received only the vehicle on the same peroral schedule as that of the treatment groups. Treatment began on Day 1 in all groups of female nude mice (n=8) bearing subcutaneous tumors of ~180 mm³ in size; the study duration was 14 days. Treatment results were presented as Tumor Growth Inhibition (TGI) as a percentage of average 15 tumor size of untreated mice in the control group at Day 14. Compounds **17, 18, 19** and **32** showed TGI's of 77.3%, 81.1%, 75.8% and 86.7% respectively, as compared to a TGI of 85.6% for gemcitabine as a reference.

20 **[0200]** Although the foregoing has been described in some detail by way of illustration and example for purposes of clarity and understanding, one of skill in the art will appreciate that certain changes and modifications can be practiced within the scope of the appended claims. In addition, each reference provided herein is incorporated by reference in its entirety to the same extent as if each reference was 25 individually incorporated by reference.

WHAT IS CLAIMED IS:

1 1. A compound according to formula I:



3 or a pharmaceutically acceptable salt thereof; wherein
 4 R¹ and R² are independently selected from the group consisting of
 5 H, -C(=O)-(CH₂)₂-Ar and -C(=O)-(CH₂)_n-C(=O)-NH-Ar, and at least one of R¹ and
 6 R² is other than H, and Ar is aryl or heteroaryl;

7 R³ is selected from the group consisting of H and -C(=O)-O-R⁴;
 8 R⁴ is selected from the group consisting of alkyl, substituted alkyl,
 9 alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, arylalkyl, substituted
 10 arylalkyl, cycloheteroalkyl, substituted cycloheteroalkyl, heteroalkyl and substituted
 11 heteroalkyl; and

12 the subscript n is an integer of from 2 to 6.

1 2. A compound according to claim 1, wherein
 2 R¹ and R² are independently selected from the group consisting of
 3 H, -C(=O)-(CH₂)₂-Ar and -C(=O)-(CH₂)_n-C(=O)-NH-phenyl, and at least one of R¹
 4 and R² is other than H, and Ar is phenyl or 3-pyridyl; and
 5 the subscript n is 2, 4 or 6.

1 3. A compound according to claim 2, wherein R² and R³ are H.

1 4. A compound according to claim 2, wherein R² is H and R¹ and
 2 R³ are other than H.

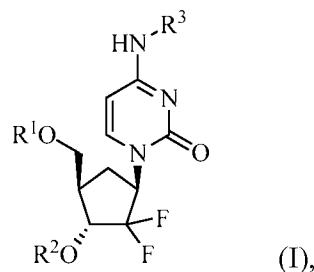
1 5. A compound according to claim 2, wherein R¹ is H and R² and
 2 R³ are other than H.

1 **6.** A compound according to claim **4** or claim **5**, wherein R⁴ is
 2 selected from the group consisting of alkyl and substituted alkyl.

1 **7.** A compound according to claim **6**, wherein R⁴ is C₁-C₈ alkyl.

1 **8.** A compound according to claim **4** or claim **5**, wherein R⁴ is
 2 C₃-C₈ heteroalkyl.

1 **9.** A pharmaceutical composition comprising a compound of
 2 formula I:



4 or a pharmaceutically acceptable salt of thereof; wherein
 5 R¹ and R² are independently selected from the group consisting of
 6 H, -C(=O)-(CH₂)₂-Ar and -C(=O)-(CH₂)_n-C(=O)-NH-Ar, and at least one of R¹ and
 7 R² is other than H, and Ar is aryl or heteroaryl;

8 R³ is selected from the group consisting of H and -C(=O)-O-R⁴;

9 R⁴ is selected from the group consisting of alkyl, substituted alkyl,
 10 alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, arylalkyl, substituted
 11 arylalkyl, cycloheteroalkyl, substituted cycloheteroalkyl, heteroalkyl and substituted
 12 heteroalkyl; and

13 the subscript n is 2-6; and

14 a pharmaceutically acceptable carrier.

1 **10.** A pharmaceutical composition according to claim **9**, wherein
 2 R¹ and R² are independently selected from the group consisting of
 3 H, -C(=O)-(CH₂)₂-Ar or -C(=O)-(CH₂)_n-C(=O)-NH-phenyl, and at least one of R¹ and
 4 R² is other than H, and Ar is phenyl or 3-pyridyl; and
 5 the subscript n is 2, 4 or 6.

1 **11.** A pharmaceutical composition according to claim **10**, wherein
2 R² and R³ are H.

1 **12.** A pharmaceutical composition according to claim **10**, wherein
2 R² is H and R¹ and R³ are other than H.

1 **13.** A pharmaceutical composition according to claim **10**, wherein
2 R¹ is H and R² and R³ are other than H.

1 **14.** A pharmaceutical composition according to claim **12** or claim
2 **13**, wherein R⁴ is selected from the group consisting of alkyl and substituted alkyl.

1 **15.** A pharmaceutical composition according to claim **14**, wherein
2 R⁴ is C₁-C₈ alkyl.

1 **16.** A pharmaceutical composition according to claim **12** or claim
2 **13**, wherein R⁴ is C₃-C₈ heteroalkyl.

1 **17.** A method for inhibiting the growth of cancer cells, the method
2 comprising contacting the cells with an effective amount of a compound according to
3 any of claims **1-8**.

1 **18.** A method according to claim **17**, further comprising contacting
2 the cells with an anti-cancer agent.

1 **19.** A method according to claim **18**, wherein the anti-cancer agent
2 is selected from the group consisting of a conventional chemotherapeutic agent, a
3 targeted therapeutic agent, a radiotherapeutic agent, and a mixture thereof.

1 **20.** A method according to claim **18**, wherein the anti-cancer agent
2 is selected from the group consisting of cisplatin, oxaliplatin, carboplatin, erlotinib,
3 gefitinib, lapatinib, cetuximab, zalutumumab, minotuzumab, and matuzumab.

1 **21.** A method according to claim **17**, wherein the cancer cells are
2 selected from the group consisting of pancreatic cancer cells, non-small cell lung
3 cancer cells, breast cancer cells, ovarian cancer cells, and bladder cancer cells.

1 **22.** A method for treating cancer, the method comprising
2 administering to the subject an effective amount of a pharmaceutical composition
3 according to any of claims **9-16**.

1 **23.** A method according to claim **22**, further comprising
2 administering to the subject an anti-cancer agent.

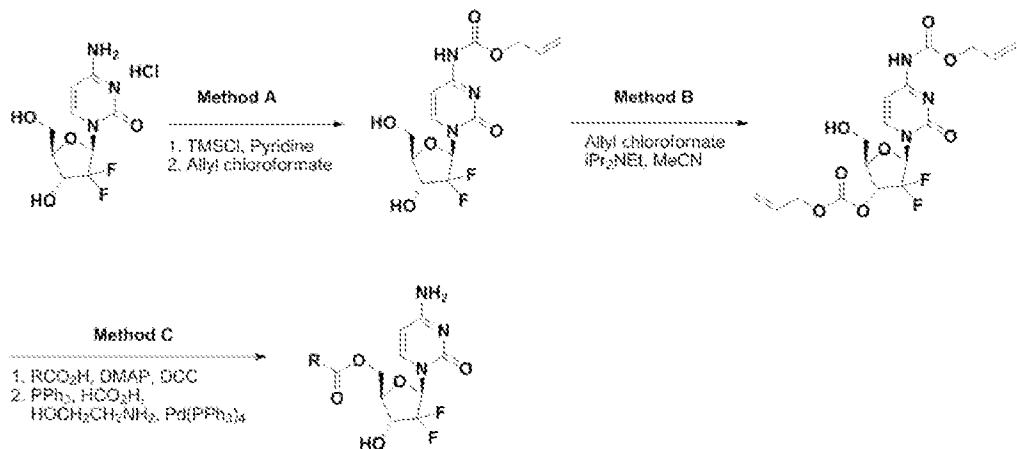
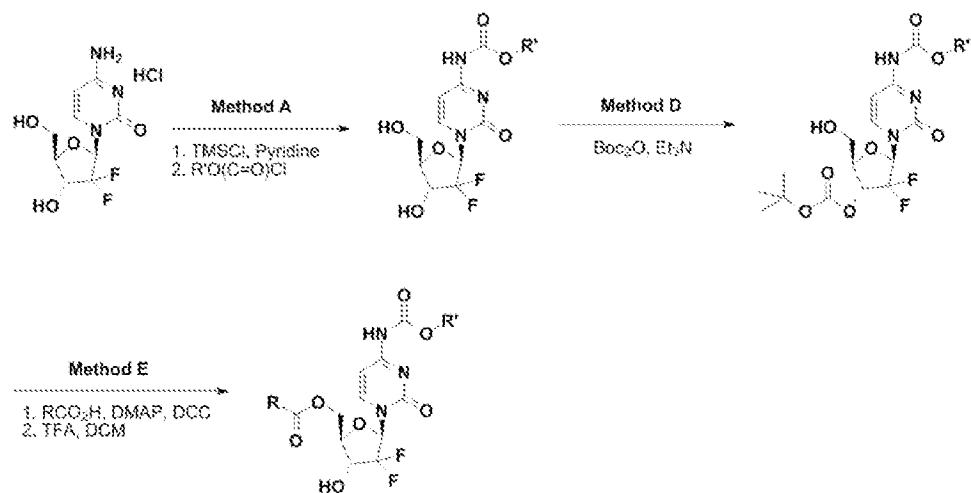
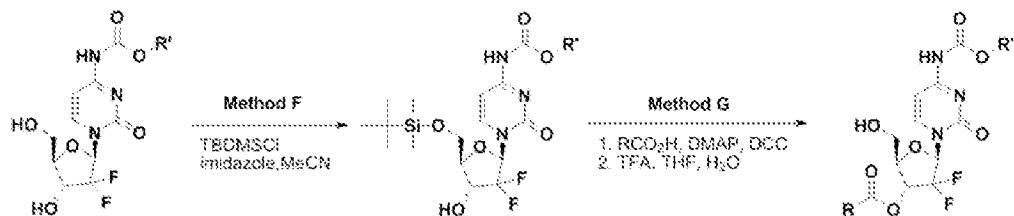
1 **24.** A method according to claim **23**, wherein the anti-cancer agent
2 is selected from the group consisting of a conventional chemotherapeutic agent, a
3 targeted therapeutic agent, a radiotherapeutic agent and a mixture thereof.

1 **25.** A method according to claim **23**, wherein the anti-cancer agent
2 is selected from the group consisting of cisplatin, oxaliplatin, carboplatin, erlotinib,
3 gefitinib, lapatinib, cetuximab, zalutumumab, minotuzumab, and matuzumab.

1 **26.** A method according to claim **22**, wherein administering the
2 composition is conducted orally.

1 **27.** A method according to claim **22**, wherein administering the
2 composition is conducted parenterally.

1 **28.** A method according to claim **22**, wherein the cancer is selected
2 from the group consisting of pancreatic cancer, non-small cell lung cancer, breast
3 cancer, ovarian cancer, and bladder cancer.

Figure 1**Figure 2****Figure 3**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 13/69640

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61K 31/70; C07H 19/02 (2014.01)
USPC - 514/49; 536/28.51; 536/28.2; 536/28.5

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

USPC: 514/49; 536/28.51

IPC: A61K 31/70; C07H 19/02 (2014.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 536/28.2; 536/28.5 (See Search Words below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PATBASE: FT=AU BE BR CA CH CN DE DK EP ES FI FR GB IN JP KR SE TH TW US WO

Google: Scholar/Patents: hydroxyl prodrugs benzylpropanyl carbamate nucleoside propyl phenyl ester gemcitabine phenylpropanoyl oxy phenylpropanoic acid phenylsuccinamic

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010/0016254 A1 (GALLOP et al) 21 January 2010 (21.01.2010) para [0034]; [0323]; [0324]; [0335]; [0340]; [0401]; [0443]	1-16
Y	US 2011/0002991 A1 (MICKLE et al) 06 January 2011 (06.01.2011) para [0012]; [0013]; [0052]; [0073]; Figure 1, 2	1-16

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“E” earlier application or patent but published on or after the international filing date

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“O” document referring to an oral disclosure, use, exhibition or other means

“&” document member of the same patent family

“P” document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search

14 February 2014 (14.02.2014)

Date of mailing of the international search report

18 MAR 2014

Name and mailing address of the ISA/US

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 13/69640

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.: 17-28 because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.