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(54) **PEPTIDE NUCLEIC ACID DERIVATIVES WITH GOOD CELL PENETRATION AND STRONG AFFINITY FOR NUCLEIC ACID**

PEPTIDNUKLEINSÄUREDERIVATE MIT GUTER ZELLDURCHDRINGUNG UND STARKER AFFINITÄT FÜR NUKLEINSÄURE

DÉRIVÉS D'ACIDES NUCLÉIQUES PEPTIDIQUES PRÉSENTANT UNE BONNE PÉNÉTRATION CELLULAIRE ET UNE GRANDE AFFINITÉ POUR LES ACIDES NUCLÉIQUES

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Description

FIELD OF INVENTION

[0001] The present invention relates to peptide nucleic acid derivatives chemically modified to show good cell penetration and strong affinity for nucleic acid.

BRIEF DESCRIPTIONS OF DRAWINGS

[0002]

Figure 1 provides HPLC chromatograms before and after purification of Oligo 17 by reverse phase HPLC.
Figure 2 provides a MALDI-TOF mass spectrum for a purified batch of Oligo 17.
Figure 3 provides graphs of absorbance changes with temperature for Oligo 17 against complementary or mismatch DNA.
Figure 4(a) and 4(b) provide confocal microscopy images (at 63x objective) 1, 2, 3 and 24h after HeLa cells were treated with Oligo 1 and Oligo 2 at 5μM, respectively.
Figure 5(a) and 5(b) provide confocal microscopy images (at 63x objective) 0.5 and 1h after MCF-7 cells were treated with Oligo 6 and Oligo 7 at 2.5μM, respectively.
Figure 6(a) and 6(b) provide confocal microscopy pictures (at 40x objective) 6 or 24h after HeLa cells were treated with Oligo 1 and Oligo 6 at 1μM, respectively.
Figure 7(a) and 7(b) provide confocal microscopy pictures (40x objective) 24h after JAR cells were treated with Oligo 21 and Oligo 28 at 2μM, respectively.
Figure 7(c) and 7(d) provide confocal microscopy pictures (at 40x objective) 24h after A549 cells were treated with Oligo 21 and Oligo 28 at 2μM, respectively.
Figure 7(e) and 7(f) provide confocal microscopy pictures (at 40x objective) 12h after HeLa cells were treated with Oligo 21 and Oligo 28 at 2μM, respectively.
Figure 7(g) provides confocal microscopy pictures (at 40x objective) 24h after HeLa cells were treated with Oligo 21 at 2μM.
Figure 8(a), 8(b) and 8(c) provide confocal microscopy images (40x objective) 24h after HeLa, A549, and JAR cells were treated with 2μM Oligo 22, respectively.
Figure 9 provides western blotting results for JAR cells treated with 5μM or 10μM Oligo 9, 5μM or 10μM Oligo 10, cotreatment with the oligomers at 5μM or 10μM each, and blank (no oligomer treatment).
Figure 10 is the representative structure for the PNA oligomers of this invention.

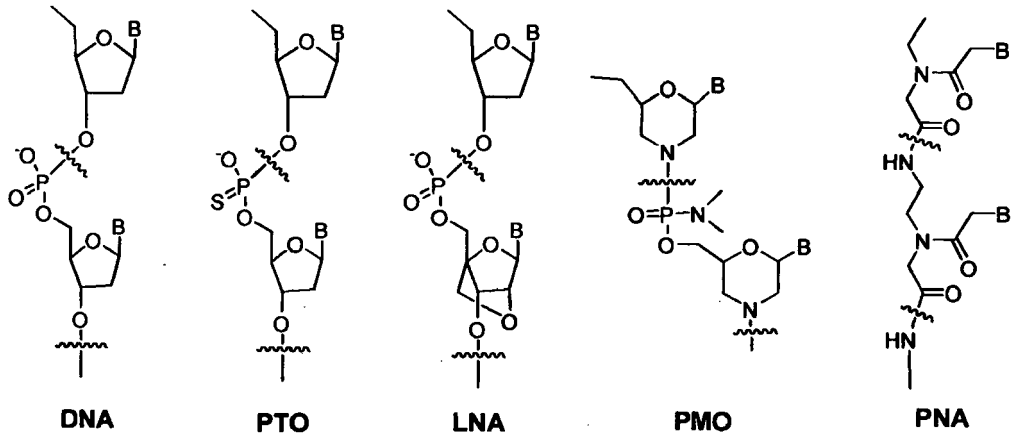
BACKGROUND OF THE INVENTION

[0003] Oligonucleotides have been used for diverse biological purposes including antisense inhibition of gene expression, PCR (polymerase chain reaction), diagnostic analysis by gene chips, and so on. Since oligonucleotides interact in a sequence specific manner with nucleic acids such as DNA and RNA, they are quite useful to predictably modulate biological processes involving DNA or RNA within cell. Unlike small molecule drugs, however, oligonucleotides do not readily penetrate mammalian cell membrane, and therefore hardly affect biological processes within cell unless properly modified or formulated to readily penetrate plasma membrane.

[0004] **Proteins as Drug Targets:** Proteins mediate diverse cellular functions. It would not be surprising to find that most of currently marketed drugs show therapeutic activity through modulating functions of protein(s). For example, non-steroidal anti-inflammatory drug aspirin inhibits enzymes called cyclooxygenases for its anti-inflammatory activity. Losartan binds to and antagonize the function of a trans-membrane receptor called angiotensin II receptor for its anti-hypertensive activity. Rosiglitazone selectively activates an intracellular receptor called peroxisome proliferator-activated receptor γ (PPARγ) to elicit its antidiabetic activity. Etanercept is a fusion protein which binds to a cytokine called tumor necrosis factor-α (TNF-α), and neutralizes the biological activity of TNF-α for its anti-rheumatic activity. Herceptin is a monoclonal antibody to treat breast cancer by selectively binding to erbB2 over-expressed in certain types of breast cancer cells.

[0005] **Antisense Inhibition of Protein Synthesis:** Proteins are encoded by DNA (2-deoxyribose nucleic acid). In response to cellular stimulation, DNA is transcribed to produce pre-mRNA (pre-messenger ribonucleic acid) in the nucleus. The intron portion(s) of pre-mRNA is enzymatically spliced out yielding mRNA (messenger ribonucleic acid), which is then translocated to the cytosolic compartment. In the cytosol, a complex of translational machinery called ribosome binds to mRNA and carries out the protein synthesis as it scans the genetic information encoded along the mRNA. (Biochemistry vol 41, 4503-4510, 2002; Cancer Res. vol 48, 2659-2668, 1988)

[0006] An oligonucleotide binding to mRNA or pre-mRNA in a sequence specific manner is called antisense oligonucleotide (AO). AO may tightly bind to an mRNA and inhibit the protein synthesis by ribosome along the mRNA in the cytosol. AO needs to be present within cell in order to inhibit the synthesis of its target protein. AO may tightly bind to a pre-mRNA in the nucleus and affect the splicing of the pre-mRNA, producing an mRNA of altered sequence and consequently an altered protein.



[0007] **Unnatural Oligonucleotides:** Oligonucleotides of DNA or RNA are susceptible to degradation by endogenous nucleases, limiting their therapeutic utility. To date, many types of unnatural oligonucleotides have been developed and studied intensively. (Clin. Exp. Pharmacol. Physiol. vol 33, 533-540, 2006) Some of them show extended metabolic stability compared to DNA and RNA. Provided above are chemical structures for some of representative unnatural oligonucleotides. Such oligonucleotides predictably bind to a complementary nucleic acid as DNA or RNA does.

[0008] Phosphorothioate oligonucleotide (PTO) is a DNA analog with one of the backbone phosphate oxygen atoms replaced with sulfur atom per monomer. Such a small structural change made PTO comparatively resistant to degradation by nucleases. (Ann. Rev. Biochem. vol 54, 367-402, 1985)

[0009] Reflecting the structural similarity of PTO and DNA, they both poorly penetrate cell membrane in most mammalian cell types. For some types of cells abundantly expressing transporter(s) for DNA, however, DNA and PTO show good cell penetration. Systemically administered PTOs are known to readily distribute to the liver and kidney. (Nucleic Acids Res. vol 25, 3290-3296, 1997)

[0010] In order to facilitate PTO's cell penetration in vitro, lipofection has been popularly practiced. However, lipofection physically alters cell membrane, causes cytotoxicity, and therefore would not be ideal for long term therapeutic use.

[0011] Over the past 20 years, antisense PTOs and variants of PTOs have been clinically evaluated to treat cancers, immunological disorders, metabolic diseases, and so on. (Biochemistry vol 41, 4503-4510, 2002; Clin. Exp. Pharmacol. Physiol. vol 33, 533-540, 2006) Many of such antisense drug candidates have not been successful partly due to PTO's poor cell penetration. In order to overcome the poor cell penetration, PTO needs to be administered at high dose for therapeutic activity. However, PTOs are known to be associated with dose dependent toxicities such as increased coagulation time, complement activation, tubular nephropathy, Kupffer cell activation, and immune stimulation including splenomegaly, lymphoid hyperplasia, mononuclear cell infiltration. (Clin. Exp. Pharmacol. Physiol. vol 33, 533-540, 2006)

[0012] Many antisense PTOs have been found to show due clinical activity for diseases with a significant contribution from the liver or kidney. ISIS-301012 (mipomersen) is a PTO analog which inhibits the synthesis of apoB-100, a protein involved in LDL cholesterol transport. Mipomersen manifested due clinical activity in a certain population of atherosclerosis patients most likely due to its preferential distribution to the liver. (www.medscape.com/viewarticle/556073: Accessed on Feb 19, 2009) ISIS-113715 is an antisense PTO analog inhibiting the synthesis protein tyrosine phosphatase 1B (PTP1B), and was found to show therapeutic activity in type II diabetes patients. (Curr. Opin. Mol. Ther. vol 6, 331-336, 2004)

[0013] In phosphoroamidite morpholino oligonucleotide (PMO), the backbone phosphate and 2-deoxyribose of DNA are replaced with phosphoamidite and morpholine, respectively. (Appl. Microbiol. Biotechnol. vol 71, 575-586, 2006) While the DNA backbone is negatively charged, the PMO backbone is not charged. Thus the binding between PMO and mRNA is free of electrostatic repulsion between the backbones, and tends to be stronger than that between DNA and mRNA. Since PMO is structurally very different from DNA, PMO wouldn't be recognized by the hepatic transporter(s) recognizing DNA. However, PMO doesn't readily penetrate cell membrane.

[0014] Peptide nucleic acid (PNA) is a polypeptide with N-(2-aminoethyl)glycine as the unit backbone, and was dis-

covered by Nielsen and colleagues. (Science vol 254, 1497-1500, 1991) Like DNA and RNA, PNA also selectively binds to complementary nucleic acid [Nature (London) vol 365, 566-568, 1992] Like PMO, the backbone of PNA is not charged. Thus the binding between PNA and RNA tends to be stronger than that between DNA and RNA. Since PNA is structurally markedly different from DNA, PNA wouldn't be recognized by the hepatic transporter(s) recognizing DNA, and would show a tissue distribution profile very different from that of DNA or PTO. However, PNA also poorly penetrates mammalian cell membrane. (Adv. Drug Delivery Rev. vol 55, 267-280, 2003)

[0015] In locked nucleic acid (LNA), the backbone ribose ring of RNA is structurally constrained to increase the binding affinity for RNA or DNA. Thus, LNAs may be regarded as high affinity DNA or RNA derivatives. (Biochemistry vol 45, 7347-7355, 2006)

[0016] **Antisense Mechanisms:** Antisense mechanism differs depending on types of AOs. RNAse H recognizes a duplex of mRNA with DNA, RNA, or PTO, and degrades the duplex portion of mRNA. Thus, the antisense activity of PTO is significantly amplified by RNAse H. In the meantime, RNAse H does not recognize a duplex of mRNA with PMO, PNA, or LNA. In other words, PMO, PNA and LNA must rely purely on the steric blocking of mRNA for their antisense activity. (Biochemistry vol 41, 4501-4510, 2002)

[0017] For oligonucleotides with the same binding affinity for mRNA, PTO should therefore show stronger antisense activity than PMO, PNA, and LNA. For steric block AOs such as PMO, PNA, and LNA, strong affinity for mRNA is desired for antisense activity.

[0018] **Antisense Activity of PNA:** The binding affinity of PNA for mRNA would increase as the length of PNA increases to a certain point. However, the antisense activity of PNA doesn't seem to always increase to the length of PNA. There were cases that the antisense activity of PNA reached the maximum activity at 12 to 13-mer and decreases thereafter. (Nucleic acids Res. vol 32, 4893-4902, 2004) On the other hand, optimum antisense activity was reached with 15 to 18-mer PNAs against a certain mRNA, reflecting that the structural accessibility of the target binding site of the mRNA would be important. (Biochemistry vol 40, 53-64, 2001)

[0019] In many cases, PNAs have been reported to inhibit protein synthesis by ribosome at micromolar level under good cell penetrating conditions. (Science vol 258, 1481-85, 1992; Biochemistry vol 40, 7853-7859, 2001; Nucleic acids Res. vol 32, 4893-4902, 2004) However, PNAs targeting a highly accessible position of mRNA were found to show antisense activity at sub-micromolar level (Neuropeptides vol 38, 316-324, 2004; Biochemistry vol 40, 53-64, 2001) or even at sub-nanomolar level (Nucleic Acids Res. vol 36, 4424-4432, 2008) under good transfection conditions.

[0020] In addition to targeting a highly accessible site in mRNA, strong binding affinity of PNA for mRNA would be very required for good antisense activity. Unlike DNA, PTO, and LNA, the backbone of PNA is not charged. PNA tends to aggregate and become less suitable for binding to mRNA as its size increases. It is desired to improve PNA's binding affinity for mRNA without increasing the length of PNA. Incorporation of PNA monomers with a point charge would be beneficial in preventing PNA from aggregating.

[0021] **Cell Penetration Strategies for PNA:** PNAs do not readily penetrate cell membrane and tend to show poor antisense activity unless properly transfected. In early years, the antisense activity of PNA was assessed by microinjection (Science vol 258, 1481-85, 1992) or electroporation (Biochemistry vol 40, 7853-7859, 2001). Microinjection and electroporation are invasive and inappropriate to be applied for therapeutic purposes. In order to improve the cell penetration, various strategies have been developed. (Adv. Drug Delivery Rev. vol 55, 267-280, 2003; Curr. Top. Med. Chem. vol 7, 727-737, 2007)

[0022] PNAs have been effectively delivered into cell by covalent incorporation of cell penetrating peptides (Neuropeptides vol 38, 316-324, 2004), lipofection following duplex formation with a complementary DNA (Biochemistry vol 40, 53-64, 2001), lipofection of PNAs with a covalently attached 9-aminoacridine (Nucleic Acids Res. vol 32, 2695-2706, 2004), lipofection of PNAs with covalently attached phosphonate anions (Nucleic Acids Res. vol 36, 4424-4432, 2008), and so on. Also cell penetration was improved by attaching to PNA a lipophilc moiety such as adamantane (Bioconjugate Chem. vol 10, 965-972, 1999) or amphiphilic group such as tetraphenyl phosphonium. (Nucleic Acids Res. vol 29, 1852-1863, 2001) Nevertheless, such a covalent modification is unlikely to increase the binding affinity for mRNA despite marked improvement in the cell penetration.

[0023] **PNAs with a Covalently Attached CPP:** Cell penetrating peptides (CPPs) are polypeptides showing good cell penetration, and have multiple positive charges from arginine or lysine residues. To date many CPPs such as transportan, penetratin, NLS (nuclear localization signal), and Tat have been discovered. CPPs are known to efficiently carry a covalently attached cargo into cell. PNAs with a covalently attached CPP also showed good cell penetration.

[0024] Although some PNAs with a covalently attached CPP showed antisense IC_{50}s around 100nM (Neuropeptides vol 38, 316-324, 2004), micromolar antisense IC_{50}s are rather prevalent for such PNAs.

[0025] PNAs with a covalently linked CPP are composed of two portions, the hydrophobic PNA domain and the positively charged CPP domain. Such a PNA tends to aggregate and be trapped in endosomes within cell, and would not be available for the antisense inhibition of protein synthesis. (Curr. Top. Med. Chem. vol 7, 727-737, 2007; Nucleic Acids Res. vol 33, 6837-6849, 2005) Furthermore, such a covalently attached CPP hardly increases the binding affinity of PNA for mRNA.

[0026] **PNAs with a Chiral Backbone**: There have been attempts to introduce a chiral substituent on the PNA backbone of 2-aminoethyl-glycine (Aeg). For example, the aqueous solubility of PNA was significantly improved by incorporating PNA monomer(s) with a backbone of 2-aminoethyl-lysine in place of Aeg. (Angew. Chem. Int. Ed. Engl. vol 35, 1939-1941, 1996)

[0027] By introducing the backbone of L-(2-amino-2-methyl)ethyl-glycine in place of Aeg, the binding affinity of PNA for DNA and RNA was significantly improved. A 10-mer PNA with all of the backbone of L-(2-amino-2-methyl)ethyl-glycine in place of 2-aminoethyl-glycine showed an increase of 19°C and 10°C in T_m against complementary DNA and RNA, respectively. Such an increase doesn't seem to be proportional to the number of substitution with L-(2-amino-2-methyl)ethyl-glycine, though. (J. Am. Chem. Soc. vol 128, 10258-10267, 2006)

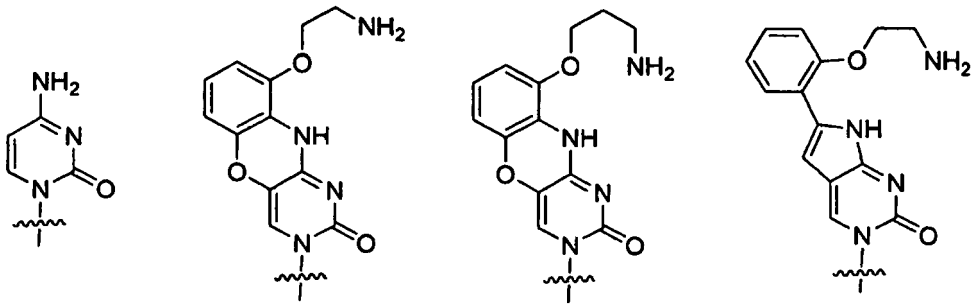
[0028] **GPNA:** The cell penetration of PNA was reported to be markedly improved by incorporating PNA monomers with a backbone of 2-aminoethyl-arginine in place of Aeg. (J. Am. Chem. Soc. vol 125, 6878-6879, 2003) Such PNAs have been termed 'GPNA' since they have guanidinium moiety on the backbone.

[0029] GPNAs with the backbone of 2-aminoethyl-D-arginine were reported to have stronger affinity for DNA and RNA than the corresponding GPNAs with that of 2-aminoethyl-L-arginine. (Chem. Commun. 244-246, 2005) For a 10-mer GPNA with 5 GPNA monomers with the backbone of 2-aminoethyl-D-arginine there was an increase of 7°C in T_m (melting temperature) against complementary DNA compared to the corresponding unmodified PNA. (Bioorg. Med. Chem. Lett. vol 16, 4931-4935, 2006)

[0030] A 16-mer antisense GPNA against human EGFR-TK was reported to show antitumor activity upon ip (intra peritoneal) administration in athymic nude mice, although the in vitro antisense activity was not documented for the antisense GPNA in the prior art. (WO 2008/061091)

[0031] **PNAs with Modified Nucleobase:** Like cases with DNA, nucleobase modifications have been pursued to improve PNA's affinity for nucleic acids.

[0032] PNAs with adenine replaced with 2,6-diaminopurine were evaluated for their affinity for complementary DNA or RNA. Substitution with 2,6-diaminopurine was found to elicit an increase of 2.5 ~ 6°C in T_m per replacement. (Nucleic Acids Res. vol 25, 4639-4643,1997)



Cytosine and Modified Cytosines

[0033] PNAs with cytosine replaced with 9-(2-aminoethoxy)phenoxazine were evaluated for their affinity for complementary DNA or RNA. A single substitution with 9-(2-aminoethoxy)phenoxazine elicited an increase of 10.7 ~ 23.7°C in T_m, although such an increase was markedly dependent on the nucleotide sequence. Nucleobase 9-(2-aminopropoxy)phenoxazine also induced a large increase in T_m. Due to a huge increase in T_m, PNA monomer with either 9-(2-aminoethoxy)-phenoxazine or 9-(2-aminopropoxy)phenoxazine as a cytosine replacement has been termed 'G-clamp'. (Org. Lett. vol 4, 4395-4398, 2002) However, cell penetration data was not reported for PNAs with G-clamp(s).

[0034] PNAs with cytosine replaced with either 6-{2-(2-aminoethoxy)phenyl}-pyrrolocytosine or 6-{2,6-di(2-aminoethoxy)phenyl}pyrrolocytosine were evaluated for their affinity for complementary DNA or RNA. A single substitution with either 6-{2-(2-aminoethoxy)phenyl}pyrrolocytosine or 6-{2,6-di(2-aminoethoxy)-phenyl}pyrrolocytosine increased T_m by 3 ~ 11.5°C. (J. Am. Chem. Soc. vol 130, 12574-12575, 2008) However, such PNAs were not evaluated for cell penetration.

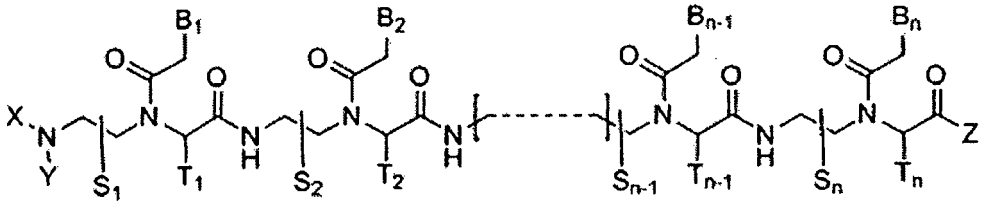
[0035] **Other Use of PNAs**: By tightly binding to a microRNA, PNA can inhibit the regulatory function of the microRNA, leading to an increase in the expression level of the protein(s) directly regulated by the microRNA. (RNA vol 14, 336-346, 2008) By tightly binding to a ribonucleoprotein such as telomerase, PNA can modulate the cellular function of the ribonucleoprotein. (Bioorg. Med. Chem. Lett, vol 9, 1273-78, 1999) By tightly binding to a certain portion of a gene in the nucleus, PNA can modulate the transcription level of the gene. (Biochemistry vol 46, 7581-89, 2007.)

[0036] Since PNA tightly binds to DNA and RNA, and sensitively discriminates a single base pair mismatch, PNA would be suitable for high fidelity detection of single nucleotide polymorphism (SNP). Since PNA binds tightly to DNA and RNA with high sequence specificity, PNA may find various other therapeutic and diagnostic applications involving

DNA or RNA. (FASEB vol 14, 1041-1060, 2000)

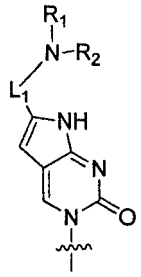
SUMMARY OF INVENTION

[0037] The present invention provides a peptide nucleic acid derivative of **Formula I** or a pharmaceutically acceptable salt thereof:

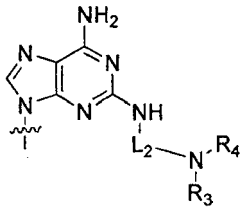


Formula I

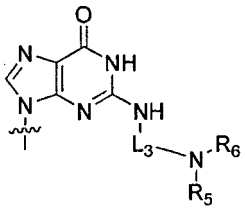
wherein,
n is an integer equal to or larger than 5;
S_1, S_2, ..., 5_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n independently represent hydrogen, deuterium, substituted or non-substituted alkyl, or substituted or non-substituted aryl radical;
X and Y independently represent hydrogen, deuterium, substituted or non-substituted alkyl, substituted or non-substituted acyl, substituted or non-substituted sulfonyl, or substituted or non-substituted aryl radical;
Z represents hydroxy, substituted or non-substituted alkyloxy, substituted or non-substituted aryloxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases; and,
at least one of B_1, B_2, ..., B_{n-1}, and B_n is independently selected from unnatural nucleobases represented by **Formula II, Formula III,** or **Formula IV:**



Formula II

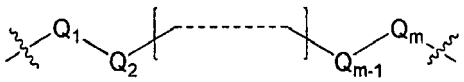


Formula III



Formula IV

wherein,
R_1, R_2, R_3, R_4, R_5 and R_6 are independently selected from substituted or non-substituted alkyl, and hydrogen radical; and,
L_1, L_2 and L_3 are a covalent linker represented by Formula V connecting a basic amino group to the moiety responsible for nucleobase pairing properties:
wherein



Formula V

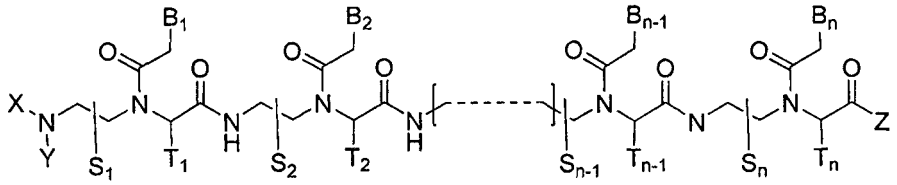
Q_1 and Q_m are substituted or non-substituted methylene (-CH2-) radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen (-O-), sulfur (-S-), and substituted or non-substituted amino radical [-N(H)-, or -N(substituent)-]; and,
m is an integer from 2 to 15.

[0038] A PNA oligomer of Formula I shows improved binding affinity for nucleic acid and cell penetration compared to its corresponding 'unmodified' PNA oligomer. PNA oligomers of this invention are useful to sequence specifically

inhibit or modulate cellular and physiological functions mediated by nucleic acids or physiologically active molecules having a nucleic acid domain such as ribonucleoproteins. Also PNA oligomers of this invention are useful for diagnostic purposes due to their sequence specific binding capability for nucleic acids.

DESCRIPTION OF INVENTION

[0039] The present invention provides a novel class of PNA oligomers represented by **Formula I**, or a pharmaceutically acceptable salt thereof:



Formula I

wherein,
n is an integer equal to or larger than 5;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n independently represent hydrogen, deuterium, substituted or non-substituted alkyl, or substituted or non-substituted aryl radical;
X and Y independently represent hydrogen, deuterium, hydroxy, substituted or non-substituted alkyloxy, substituted or non-substituted aryloxy, substituted or non-substituted amino, substituted or non-substituted alkyl, substituted or non-substituted acyl, substituted or non-substituted sulfonyl, or substituted or non-substituted aryl radical;
Z represents hydrogen, deuterium, hydroxy, substituted or non-substituted alkyloxy, substituted or non-substituted aryloxy, substituted or non-substituted amino, substituted or non-substituted alkyl, or substituted or non-substituted aryl radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases; and,
at least one of B_1, B_2, ..., B_{n-1}, and B_n independently represents an unnatural nucleobase with a substituted or non-substituted amino radical covalently linked to the moiety responsible for its due nucleobase pairing properties.

[0040] A PNA oligomer of this invention shows improved cell penetration and binding to nucleic acid compared to its corresponding 'unmodified' PNA oligomer. In this invention, 'unmodified' PNA oligomer refers to a PNA oligomer of **Formula I**, wherein S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical; and B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases comprising adenine, thymine, guanine, and cytosine.

[0041] A PNA oligomer of this invention readily penetrates mammalian cell membrane, and can affect or alter cellular functions by sequence specifically binding to a nucleic acid or a nucleoprotein within cell.

[0042] A PNA oligomer of **Formula I** can potently inhibit ribosomal protein synthesis by tightly binding to mRNA. A PNA oligomer of the present invention can tightly bind to a pre-mRNA and alter the splicing of the pre-mRNA to mRNA. Further, a PNA oligomer of the present invention can bind tightly to a microRNA, and inhibit mRNA degradation induced by the microRNA.

[0043] A PNA oligomer of **Formula I** can predictably bind to the nucleic acid domain of a ribonucleoprotein, for example telomerase, and modulate its physiological function(s). A PNA oligomer of the present invention can bind to a gene and modulate the transcription of the gene. A PNA oligomer of Formula I can bind to a viral gene or its transcript, and inhibit the proliferation of the virus. A PNA oligomer of this invention can affect cellular functions other than those described above by sequence specifically binding to a nucleic acid or a nucleoprotein within mammalian cell. In addition, a PNA oligomer of the present invention can tightly bind to a bacterial mRNA, nucleic acid, or gene, and inhibit bacterial proliferation or alter bacterial biosynthesis profiles.

[0044] A PNA oligomer of this invention is highly sensitive to a base mismatch in binding to its complementary DNA counterpart, and would be appropriate for detecting single nucleotide polymorphism (SNP) with high fidelity. PNA oligomers of the present invention bind tightly to their complementary DNAs with high sequence specificity, and may be useful for gene profiling. A PNA oligomer of **Formula I** may be useful to probe or locate a nucleic acid bearing molecule such as telomere within cell if properly tagged with a chromophore, for example, fluorophore. PNA oligomers of this invention may be useful for a variety of diagnostic or analytical purposes other than those detailed above.

[0045] A PNA oligomer of the present invention possesses good aqueous solubility compared to the corresponding 'unmodified' PNA oligomer, and can be used as dissolved in water, saline, or a buffer solution. A PNA oligomer of Formula I can be formulated with a cationic lipid such as lipofectamine. A PNA oligomer of this invention may be duplexed with a complementary DNA and the resulting duplex can be formulated with a cationic lipid.

[0046] A PNA oligomer of this invention may be formulated in a variety of dosage forms including but not limited to

injectable formulation, nasal spray, tablet, granules, hard capsule, soft capsule, liposomal formulation, oral suspension, transdemal formulation, and so on.

[0047] A PNA oligomer of the present invention can be administered to a subject at therapeutically effective doses, which would vary depending on indication, administration route, dosing schedule, situations of subject, and so on.

[0048] A PNA oligomer of the present invention can be administered to a subject by a variety of routes including but not limited to intravenous injection, subcutaneous injection, intraperitoneal injection, nasal inhalation, oral administration, transdermal application, and so on.

[0049] A PNA oligomer of **Formula I** can be administered to a subject in combination with a pharmaceutically acceptable adjuvant including but not limited to citric acid, hydrochloric acid, tartaric acid, stearic acid, polyethyleneglycol, polypropyleneglycol, ethanol, sodium bicarbonate, distilled water, hyaluronic acid, cationic lipid such as lipofectamine, starch, gelatin, talc, ascorbic acid, olive oil, palm oil, methylcelluose, titanium oxide, sodium carboxymethylcellulose, sweetener, preservative, and so on.

[0050] A PNA oligomer of the present invention, depending on the presence of basic or acidic functional group(s) therein, may be used as neutralized with an equivalent amount of a pharmaceutically acceptable acid or base including but not limited to sodium hydroxide, potassium hydroxide, hydrochloric acid, methanesulfonic acid, citric acid, and so on.

[0051] Preferred PNA oligomers encompass PNA oligomers of Formula I, or a pharmaceutically acceptable salt thereof:

wherein,

n is an integer equal to or larger than 5 but smaller than or equal to 30;

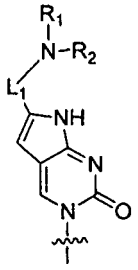
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;

X and Y are independently selected from hydrogen, substituted or non-substituted alkyl, substituted or non-substituted acyl, substituted or non-substituted sulfonyl, and substituted or non-substituted aryl radical;

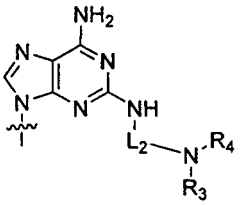
Z represents hydrogen, hydroxy, substituted or nonsubstituted alkyloxy, substituted or non-substituted amino, substituted or non-substituted alkyl, or substituted or non-substituted aryl radical;

B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases; and,

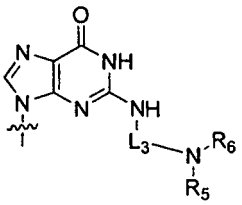
at least one of B_1, B_2, ..., B_{n-1}, and B_n is independently selected from unnatural nucleobases represented by **Formula II, Formula III**, or **Formula IV:**



Formula II



Formula III

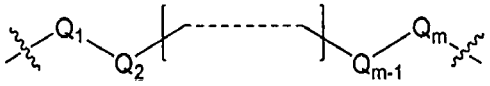


Formula IV

wherein,

R_1, R_2, R_3, R_4, R_5 and R_6 are independently selected from substituted or non-substituted alkyl, hydrogen, hydroxy, and substituted or non-substituted alkyloxy radical; and,

L_1, L_2 and L_3 are a covalent linker represented by **Formula V** connecting a basic amino group to the moiety responsible for nucleobase pairing properties:



Formula V

wherein,

Q_1 and Q_m are substituted or non-substituted methylene ($-CH_2-$) radical, and Q_m is directly linked to the basic amino group;

Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen (-O-), sulfur (-S-), and substituted or non-substituted amino radical [-N(H)-, or -N(substituent)-]; and,

m is an integer equal to or larger than 2 but smaller than or equal to 15.

[0052] PNA oligomers of particular interest comprise PNA oligomers of **Formula I**, or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer equal to or larger than 8 but smaller than or equal to 25;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, substituted or non-substituted alkyl, and substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases;
at least two of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III,** or **Formula IV**;
R_1, R_2, R_3, R_4, R_5 and R_6 are independently selected from substituted or non-substituted alkyl, and hydrogen radical;
Q_1 and Q_m are substituted or non-substituted methylene radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen, and amino radical; and,
m is an integer equal to or larger than 2 but smaller than or equal to 12.

[0053] PNA oligomers of high interest comprise PNA oligomers of **Formula I**, or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer equal to or larger than 10 but smaller than or equal to 25;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, and substituted or non-substituted acyl radical;
Z represents hydroxy, alkyloxy, or substituted or non-substituted amino radical; and,
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases;
at least three of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III,** or **Formula IV**;
R_1, R_2, R_3, R_4, R_5 and R_6 are independently selected from substituted or non-substituted alkyl, and hydrogen radical;
Q_1 and Q_m are methylene radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from methylene, oxygen, and amino radical; and,
m is an integer equal to or larger than 2 but smaller than or equal to 10.

[0054] PNA oligomers of higher interest encompass PNA oligomers of **Formula I**, or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer equal to or larger than 10 but smaller than or equal to 20;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, and substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n is independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases;
at least three of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III,** or **Formula IV**;
R_1, R_3, and R_5 are hydrogen radical, and R_2, R_4, and R_6 independently represent hydrogen, or substituted or non-substituted amidinyl radical;
Q_1 and Q_m are methylene radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from methylene, oxygen, and amino radical; and,
m is an integer equal to or larger than 2 but smaller than or equal to 10.

[0055] PNA oligomers of highest interest comprise PNA oligomers of Formula I, or a pharmaceutically acceptable salt thereof:

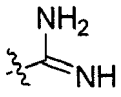
wherein,

n is an integer equal to or larger than 10 but smaller than or equal to 20;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, and substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from adenine, thymine, guanine, cytosine, and unnatural nucleobases;
at least three of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III,** or **Formula IV**;
R_1, R_3, and R_5 are hydrogen radical, and R_2, R_4, and R_6 independently represents hydrogen or amidinyl radical;
Q_1 and Q_m are methylene radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from methylene, and oxygen radical; and,
m is an integer equal to or larger than 2 but smaller than or equal to 8.

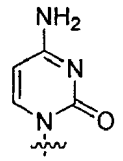
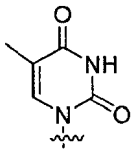
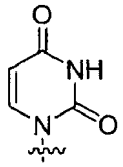
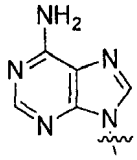
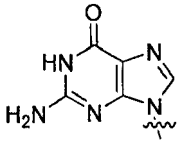
[0056] Specific PNA oligomers of strong interest comprise PNA oligomers of **Formula I**, or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer equal to or larger than 8 but smaller than or equal to 20;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X is hydrogen radical;
Y represents hydrogen, or substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from adenine, thymine, guanine, cytosine, and unnatural nucleobases;
at least three of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III**, or **Formula IV**;
R_1, R_3, and R_5 are hydrogen radical, and R_2, R_4, and R_6 independently represent hydrogen or amidinyl radical;
L_1 represents $-(CH_2)_2-O-(CH_2)_2-$, $-CH_2-O-(CH_2)_2-$, or $-CH_2-O-(CH_2)_3-$with the right end is directly linked to the basic amino group; and,
L_2 and L_3 are independently selected from $-(CH_2)_2-O-(CH_2)_2-$, $-(CH_2)_3-O-(CH_2)_2-$, $-(CH_2)_2-O-(CH_2)_3-$, $-(CH_2)_2-$, $-(CH_2)_3-$, $-(CH_2)_4-$, $-(CH_2)_5-$, $-(CH_2)_6-$, $-(CH_2)_7-$, and $-(CH_2)_8-$ with the right end is directly linked to the basic amino group.

[0057] The above used terms and abbreviations for the PNA oligomers of this invention are illustrated in the table below.

Term/Abbreviation	Illustration or definition
oligomer	oligonucleotide
hydrogen	single hydrogen atom (-H)
deuterium	single deuterium atom (-D)
alkyl	linear or branched alkyl radical
aryl	aromatic group such as phenyl, pyridyl, furyl, naphthyl, etc
methylene	$-(CH_2)-$
acyl	'-C(O)-' substituted with hydrogen, alkyl, or aryl radical
sulfonyl	'$-S(O)_2-$' substituted with alkyl, or aryl radical
alkyloxy	'R-O-' where R is substituted or non-substituted alkyl radical
oxygen	'-O-'
sulfur	'-S-'
amidinyl	

(continued)

Term/Abbreviation	Illustration or definition
cytosine (C)	
thymine (T)	
uracil (U)	
adenine (A)	
guanine (G)	

GENERAL SYNTHETIC PROCEDURES

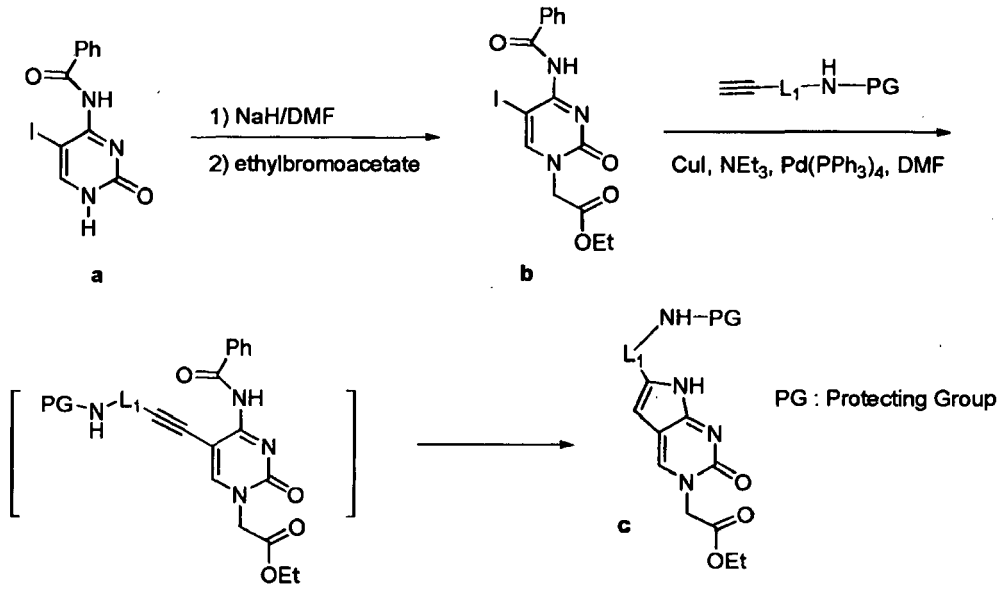
[0058] For characterization of molecules of this invention NMR spectra were recorded on a Varian Mercury 300MHz, Bruker Avance 400MHz, or Varian Inova 500MHz NMR spectrometer. Either a Bruker Daltonics Ultraflex MALDI-TOF or an Agilent LC/MS Ion Trap System was employed for determination of molecular weight. PNA oligomers were analyzed and purified by C_{18}-reverse phase HPLC either on a Hewlett Packard 1050 HPLC or a Shimazu LC-6AD HPLC. Unless noted otherwise, silica gel was used for chromatographic separation of small molecules prepared in this invention. Melting point is reported as uncorrected.

[0059] Unnatural nucleobase derivatives used for the synthesis of PNA monomers of this invention were prepared according to one of the methods (Methods A, B, and C) provided below or with minor modification(s) thereof, unless detailed otherwise in actual synthetic examples.

[0060] Method A: 6-alkyl-pyrollocytosine derivatives were synthesized as properly protected according to Scheme 1 or with minor variation(s) thereof. Such 6-alkyl-pyrollocytosine derivatives were used to synthesize PNA monomers containing a nucleobase represented by **Formula II** as a cytosine equivalent.

[0061] First compound **a** was deprotonated with NaH and then alkylated with ethylbromoacetate to obtain compound **b**. Compound **b** was subjected to a palladium catalyzed coupling with **a** terminal acetylene derivative, which was in situ annulated to product **c** according to the literature. (Nucleosides Nucleotides & Nucleic Acids vol 22, 1029-1033, 2003)

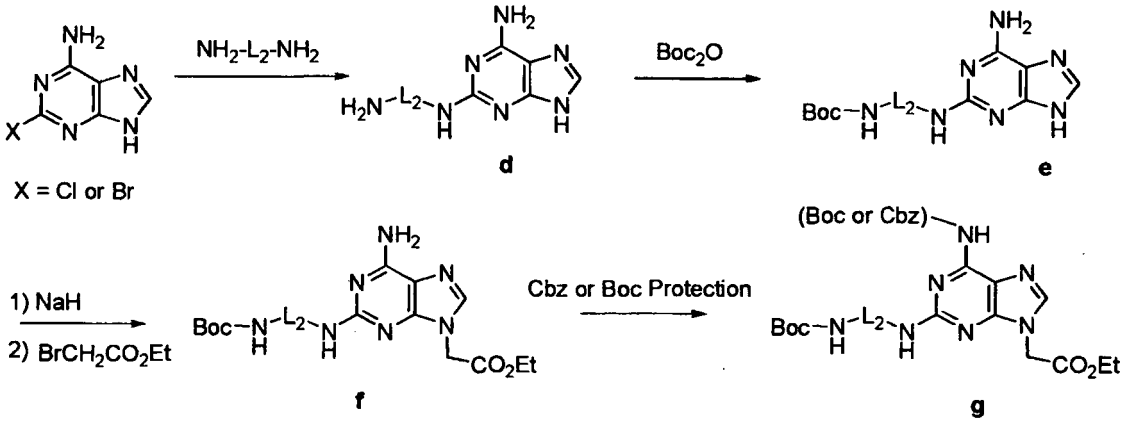
Scheme 1



[0062] Method B: 2,6-diaminopurine derivatives were synthesized as properly protected according to Scheme 2 or with minor variation(s) thereof. Such 2,6-diamino-purine derivatives were used to synthesize PNA monomers containing a nucleobase represented by **Formula III** as an adenine equivalent.

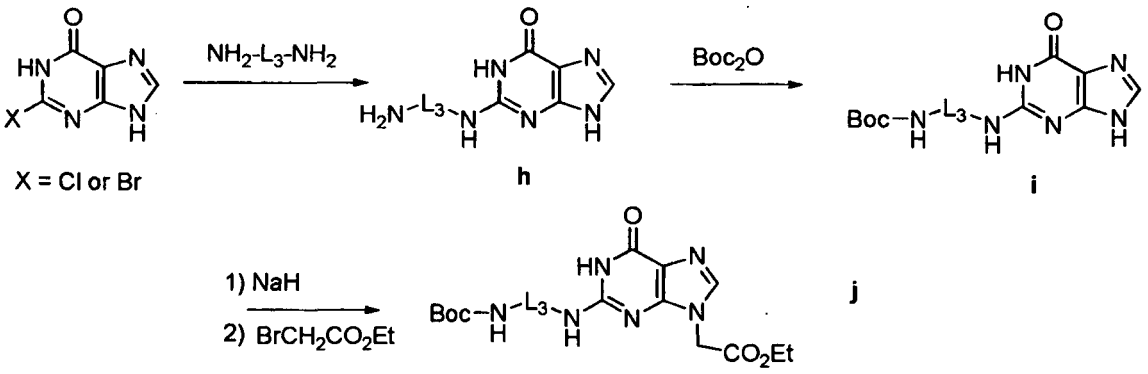
[0063] First 2-haloadenine was reacted with a diamine at high temperature to obtain compound **d**, which was then reacted with Boc_2O to give compound **e**. Compound e was deprotonated with NaH, and alkylated with ethylbromoacetate to obtain compound **f**. The aromatic amino group of compound **f** was protected with either Cbz or Boc group to yield compound **g**.

Scheme 2



[0064] Method C: N-alkylated guanine derivatives were synthesized as properly protected according to Scheme 3 or with minor variations thereof. Such guanine derivatives were used to synthesize PNA monomers containing a nucleobase represented by **Formula IV** as a guanine equivalent.

Scheme 3

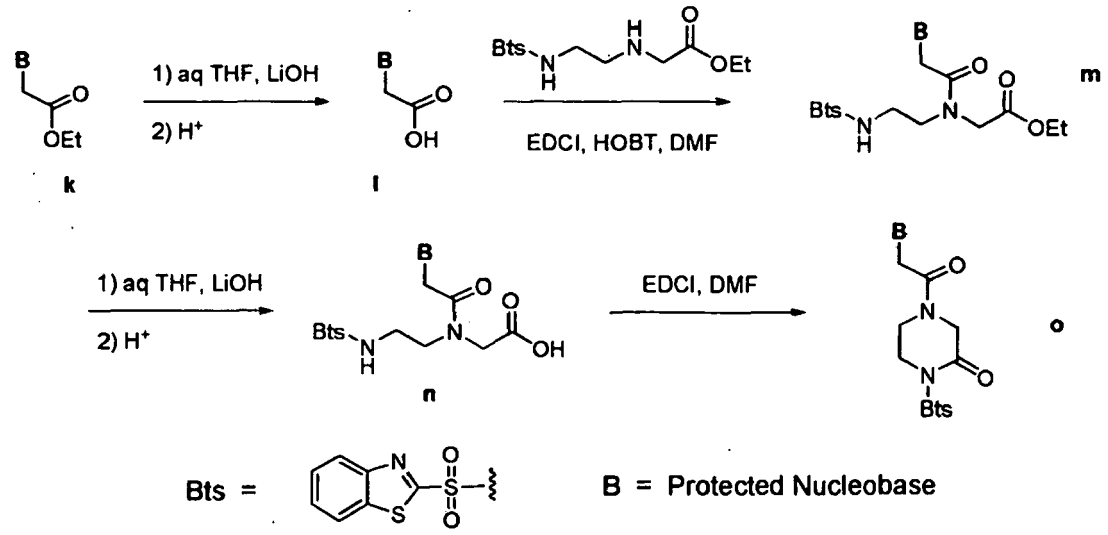


[0065] First 2-halohypoxanthine was reacted with a diamine at high temperature to obtain compound **h**, which was then reacted with Boc_2O to give compound **i**. Compound **i** was deprotonated with NaH, and alkylated with ethylbromoacetate to obtain compound **j**.

[0066] Two types of PNA monomers were synthesized according to either Method D or Method E to prepare PNA oligomers of **Formula I**. PNA oligomers were prepared by Panagene, Inc. (www.panagene.com, Daejon, South Korea) using PNA monomers of type o of Scheme 4 upon request of CTI Bio. Alternatively, PNA monomers of type q of Scheme 5 were used in-house for the synthesis of PNA oligomers according to the method described in the prior art or with minor modification(s) thereof. (USP 6,133,444)

[0067] Method D: PNA monomers with a modified nucleobase were prepared according to Scheme 4 or with minor variation(s) thereof as properly protected for the PNA oligomer synthesis method described in the literature. (Org. Lett. vol 9, 3291-3293, 2006) In Scheme 4, compound **k** may correspond to compound c of Scheme 1, compound **g** of Scheme 2, or compound **j** of Scheme 3, however, may not be necessarily limited to one of those ester compounds.

Scheme 4

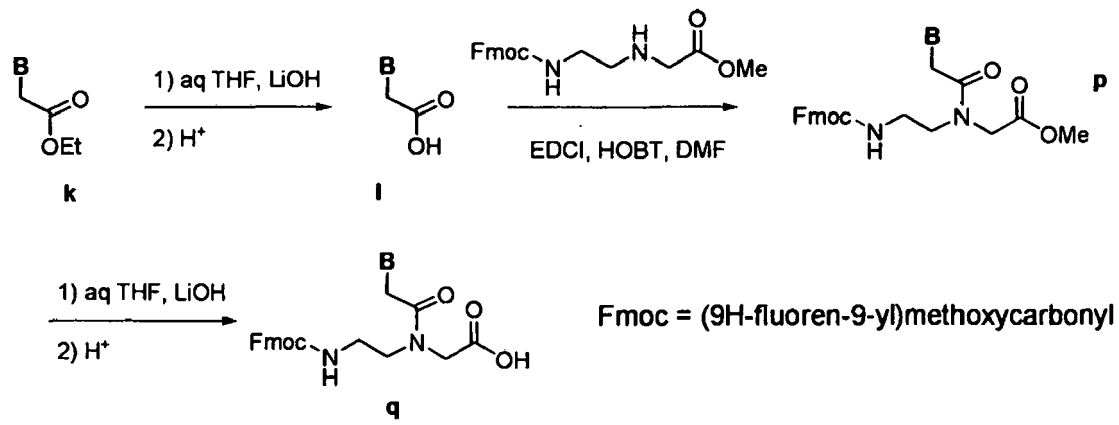


[0068] First ester **k** was subjected to alkaline hydrolysis to afford acid **l**, which was then coupled with ethyl N-[2-{N-(2-benzothiazolinyl)sulfonylamino}ethyl]-glycinate to obtain compound **m.** Compound **m** was mildly hydrolyzed with LiOH to give acid **n,** which was cyclized by an EDCI coupling reaction to obtain modified PNA monomer **o**. The chemical structure for PNA monomer **o** was assumed as in Scheme 4 throughout this invention, given that such assigned PNA

monomers have successfully yielded PNA oligomers in the literature. (Org. Lett. vol 9, 3291-3293, 2006)

[0069] Method E: Alternatively, PNA monomers with a modified nucleobase were prepared according to Scheme 5 or with minor variation(s) thereof as properly protected for the PNA oligomer synthesis method provided in the prior art. (USP 6,133,444) In Scheme 5, compound **k** may correspond to compound **c** of Scheme 1, compound **g** of Scheme 2, or compound **j** of Scheme 3, however, may not be necessarily limited to one of those ester compounds.

Scheme 5



[0070] First acid **l** was coupled with ethyl N-[2-{N-(9H-fluoren-9-yl)amino}ethyl]-glycinate to obtain compound **p** by an EDCI coupling reaction. Then compound **p** was mildly hydrolyzed with LiOH to obtain PNA monomer **q** with a modified nucleobase.

[0071] The following examples contain detailed descriptions of the preparation methods for compounds of this invention. The detailed descriptions of these examples are presented for illustrative purposes only and should not be interpreted as a restriction to the present invention. Most of these detailed descriptions fall within the scope, and serve to exemplify the above described GENERAL SYNTHETIC PROCEDURES which form a part of the invention. The abbreviations used in the following examples are defined in the following table.

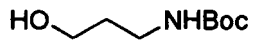
Category	Denotation
^{1}H NMR	Proton nuclear magnetic resonance. In presenting NMR data, widely accepted abbreviations were used as follows: s for singlet, d for doublet, t for triplet, q for quartet, m for multiplet, br for broad, J for coupling constant, $CDCl_3$ for deuterated chloroform, $DMSO_{d6}$ for hexa-deuterated DMSO, and so on.
MS	Mass spectroscopy. In presenting MS data, popularly accepted abbreviations were used as follows: MALDI-TOF for matrix assisted laser desorption ionization time of flight, ESI for electrospray ionization, MW for molecular weight, (m+1) for MH^+ ion peak, (m+23) for MNa^+ ion peak, etc.
Solvents	Widely accepted abbreviations were used for solvents as follows: THF for tetrahydrofuran, MC for methylene chloride, DMF for dimethylformamide, EtOH for ethanol, MeOH for methanol, DMSO for dimethylsulfoxide, EA for ethyl acetate, and so on.
Reagents	Popularly accepted abbreviations were used for reagents as follows: NaH for sodium hydride, HCl for hydrochloric acid, EDCI for 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride, HOBT for 1-hydroxy-benzotriazole, Boc for t-butyloxycarbonyl, Boc_2O for Boc anhydride or di-t-butyl-dicarbonate, Cbz for benzyloxycarbonyl, Fmoc for (9H-fluoren-9-yl)-methoxycarbonyl, Bts for (benzo[d]thiazole-2-sulfonyl), Bts-Cl for (benzo-[d]thiazole-2-sulfonyl)chloride, TFA for trifluoroacetic acid, TEA for triethyl-amine, DIEA for N,N-diisopropylethylamine, LiOH for lithium hydroxide, Aeg for N-(2-aminoethyl)glycine, Fmoc-Aeg-OH for N-[2-{(9H-fluoren-9-yl)-methoxycarbonyl}amino-ethyl]glycine, Fmoc-Aeg-OMe for methyl N-[2-(Fmoc-amino)ethyl]-glycinate, Fmoc-Aeg-OtBu for t-butyl N-[2-(Fmoc-amino)ethyl]-glycinate, Fmoc-Aeg-OSu for N-succinyl N-[2-(Fmoc-amino)-ethyl]-glycinate, HBTU for O-(benzotriazol-1-yl)-1,1,3,3-tetramethyluranium hexafluorophosphate, DCC for 1,3-dicyclohexylcarbodiimide, and so on.

(continued)

Category	Denotation
Others	Widely accepted abbreviations were used for terminologies as follows: mp for melting point, °C for degree in Celcius, h for hour, min for minute, g for gram, mg for milligram, kg for kilogram, l for liter, ml for milliliter, M for mole/l, compd for compound, aq for aqueous, RT for room temperature, and so on.

Example 1: Preparation of 3-{(t-butoxycarbonyl)amino}-1-propanol (**1**).

[0072]



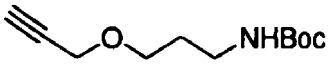
[0073] To 14g of 3-amino-1-propanol dissolved in 150ml THF and 150ml water, was added drop-wise over 30min 40.7g of Boc_2O dissolved in 100ml THF. After the reaction mixture was stirred for 24h, the THF was removed under reduced pressure. The resulting aq layer was extracted with 200ml EA, and the organic layer was washed with 0.5M aq citric acid and with distilled water, and then dried over anhydrous magnesium sulfate. Magnesium sulfate was filtered off, and the resulting filtrate was concentrated in vacuo to give 25g of compd **1** as a colourless liquid. ^{1}H NMR (400MHz; $CDCl_3$): δ 4.84 (br s, 1H), 3.66 (t, *J* = 5.6 Hz, 2H), 3.28 (q, *J* = 6.0 Hz, 2H), 3.05 (br s, 1H), 1.66 (m, 2H), 1.45 (s, 9H).

Example 2: Preparation of ethyl {(N-benzoyl)-5-iodocytosine-1-yl}acetate (**2**).

[0074] To a stirred solution of 8.3g of N-benzoyl-5-iodocytosine dissolved in 60ml DMF, was added at 0°C 1.06g of 55% NaH in mineral oil, and the solution was stirred at RT for 2h. After 2.7ml ethyl bromoacetate was added to the reaction mixture, the reaction solution was stirred for another 24h at RT, which was followed by removal of the solvent under reduced pressure. The resulting residue was dissolved and the insoluble material was filtered off. The filtrate was washed two times with saturated aq ammonium chloride, dried over anhydrous magnesium sulfate, and concentrated in vacuo. The resulting residue was purified by column chromatography (1:1 hexane/EA) to yield 6.5g of compd **2** (compd **b** in Scheme 1) as a yellow solid. mp 154-5°C. ^{1}H NMR (400MHz; $CDCl_3$) δ 13.31 (br s, 1H), 8.37 (d, *J* = 7.2 Hz, 2H), 7.69 (s, 1H), 7.55 (t, *J* = 7.4 Hz, 1H), 7.46 (t, *J* = 7.6 Hz, 2H), 4.49 (s, 2H), 4.27 *(q, J* = 7.2 Hz, 2H), 1.32 (t, *J* = 7.2 Hz, 3H).

Example 3: Preparation of 3-{3-(t-butoxycarbonylamino)propyloxy}-1-propyne (**3**).

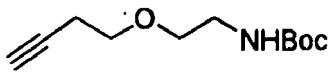
[0075]



[0076] To 6.5g of 55% NaH in mineral oil dispersed in 150ml THF at 0°C, was added dropwise over 15 min 25g of compd **1**, and the mixture was stirred for 1h. After 17.5ml propargyl bromide (80% toluene solution) was added drop-wise over 30min, the reaction mixture was stirred at RT for 20h. The reaction was quenched by slowly adding 250ml water and THF was removed under reduced pressure. Then the resulting aq mixture was extracted with 250ml EA, which was washed 3 times with 250ml water. The organic layer was dried over anhydrous magnesium sulfate, and magnesium sulfate was filtered off. The resulting filtrate was concentrated in vacuo and subjected to column chromatography (5:1 Hexane/EA) to afford 22.7g of compd **3** as a yellow liquid. ^{1}H NMR (400 MHz; $DMSO_{d6}$) δ 6.78 (t, *J* = 5.2 Hz, 1H), 4.09 (d, *J* = 2.4 Hz, 2H), 3.43-3.39 (m, 3H), 2.95 (q, *J* = 6.4 Hz, 2H), 1.60 (m, 2H), 1.37 (s, 9H).

Example 4: Preparation of 4-{2-(t-butoxycarbonylamino)ethoxy}-1-butyne (**4**)

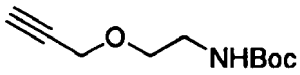
[0077]



[0078] To 3.8g of 4-(2-azidoethoxy)-1-butyne dissolved in 17ml THF, were added 7.2g of triphenylphosphine and 0.7ml water, and the reaction mixture was stirred for 8h, which was followed by removal of the solvent under reduced pressure. Then the resulting residue was dissolved in 20ml EA and extracted twice with 10ml 1M aq HCl. Aq sodium carbonate was added to the aq layer to adjust pH to 9 ~ 10. 5.96g of Boc_2O dissolved in 15ml THF was added to the solution, and the reaction mixture was stirred for 12h. After THF was removed in vacuo, the resulting solution was extracted with EA. The organic layer was washed with 0.5M aq citric acid, and dried over anhydrous magnesium sulfate. The organic layer was concentrated and purified by column chromatography (9:1 Hexane/EA) to afford 3.4g of compd **4** as a yellow oil. ^1H NMR (400MHz; $CDCl_3$) δ 4.95 (s, 1H), 3.58 (t, J = 6.8 Hz, 2H), 3.53 (t, J = 5.0 Hz, 2H), 3.32 (m, 2H), 2.46 (m, 2H), 2.00 (t, J = 2.8 Hz, 1H), 1.45 (s, 9H).

Example 5: Preparation of 3-{2-(t-butoxycarbonylamino)ethoxy}-1-propyne (**5**).

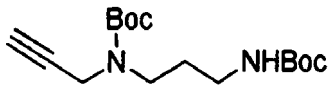
[0079]



[0080] 20g of 2-{(t-butoxycarbonyl)amino}-1-ethanol was reacted and purified by similarly following the procedure described in Example 3 to afford 23.7g of compd **5** as a pale yellow oil. ^1H NMR (400MHz; $DMSO_{d6}$) δ 6.81 (t, 1H), 4.11 (d, J = 2.4 Hz, 2H), 3.41 (m, 3H), 3.07 (q, J = 6.0 Hz, 2H), 1.38 (s, 9H).

Example 6: Preparation of 3-[N-{3-(t-butoxycarbonylamino)propyl}-N-(t-butoxy-carbonyl)amino]-1-propyne (**6**)

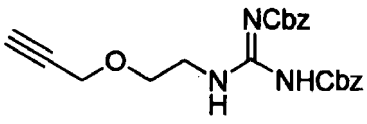
[0081]



[0082] To a stirred solution of N-[3-(t-butoxycarbonylamino)propyl]-N-(2-propynyl)amine dissolved in 83ml THF and 95ml water, was added drop-wise 42g of Boc_2O at RT. The reaction solution was stirred for 1.5h, and concentrated in vacuo. The resulting aq layer was extracted with EA. The EA layer was washed in series with 0.5M aq citric acid and brine, dried over anhydrous magnesium sulfate, concentrated under reduced pressure, and purified by column chromatography (1:1 Hexane/EA) to give 19g of compd **6** as a yellow oil. ^1H NMR (400MHz; $CDCl_3$) δ 5.26 (br s, 0.6H), 4.74 (br s, 0.4H), 4.07 (br s, 1H), 3.98 (br s, 1H), 3.40 (t, J = 6.4 Hz, 2H), 3.13 (m, 2H), 2.21 (t, 1H), 1.73 (m, 2H), 1.49 (s, 9H), 1.45 (s, 9H).

Example 7: Preparation of 3-[2-{2,3-bis(benzyloxycarbonyl)guanidino}-ethoxy]-1-propyne (**7**)

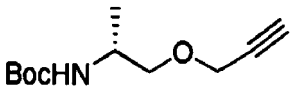
[0083]



[0084] To a stirred solution of 10.9g of compd **5** dissolved in 110ml MC, was added 110ml TFA at 0°C drop-wise over 2h, and the reaction mixture was stirred for another 3h. The reaction solution was concentrated under reduced pressure and the resulting residue was dissolved in 40ml MC at 0°C, to which was added 12.3ml TEA and then 8.8g of 1,3-bis(benzyloxycarbonyl)-2-(methylthio)pseudourea at RT. The reaction solution was stirred for 4h and washed twice with water. The organic layer was dried over anhydrous magnesium sulfate, concentrated in vacuo, and subjected to column chromatography (5:1 hexane/EA) to afford 9.8g of compd 7 as a white solid. ^1H NMR (400MHz; $DMSO_{d6}$) δ 11.72 (s, 1H), 8.58 (s, 1H), 7.40-7.35 (m, 10H), 5.18 (s, 2H), 5.12 (s, 2H), 4.18 (d, 2H), 3.67-3.66 (m, 4H), 2.43 (t, 1H).

Example 8: Preparation of 2-{(t-butoxycarbonyl)amino}-1-(2-propynyl-1-oxy)}-(R)-propane (**8**).

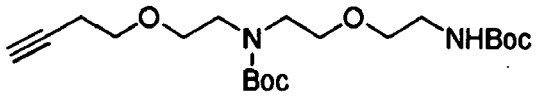
[0085]



[0086] 10.8g of t-butyl (R)-1-hydroxypropan-2-ylcarbamate was reacted and purified by similarly following the procedure described in Example 3 to afford 10.1g of compd **8** as a yellow oil. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 6.63 (d, 1H), 4.11 (d, 2H), 3.60 (m, 1H), 3.37-3.33 (m, 2H), 3.26-3.23 (m, 1H), 1.38 (s, 9H), 1.05 (d, 3H).

Example 9: Preparation of N-[2-{2-(t-butoxycarbonyl)aminoethoxy}ethyl]-N-[2-{(3-butynyl)-1-oxy}ethyl]-N-(t-butoxycarbonyl)amine (**9**).

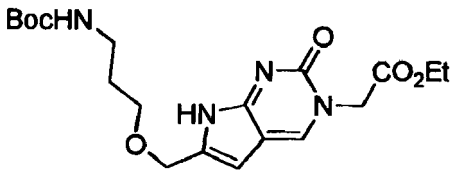
[0087]



[0088] To a stirred solution of 5g of 2-{(3-butynyl)-1-oxy}ethyl methanesulfonate and 5.32g of 2-[2-{2-(t-butoxycarbonyl)amino}ethyl-1-oxy]ethylamine in 60ml acetonitrile, was added drop-wise 3.6g of potassium carbonate dissolved in water at 0°C. The reaction solution was allowed to slowly warm to RT and stirred for another 24h, and then concentrated under reduced pressure. The resulting residue was dissolved in MC and washed with water. The organic layer was concentrated and dissolved in 80ml THF and 80ml water, to which was added 8.4g of Boc_2O dissolved in 50ml THF. The reaction mixture was stirred at RT for 16h, which was followed by removal of THF in vacuo and extraction with EA. The organic layer was washed in series with 0.5M aq citric acid, water, and brine. The organic layer was dried over anhydrous sodium sulfate, concentrated, and purified by column chromatography (hexane → 1:4 EA/hexane) to obtain 2.45g of compd **9** as a pale yellow oil. ^{1}H NMR (400MHz; $CDCl_3$) δ 5.08 (br s, 0.5H), 4.93 (br s, 0.5H), 3.61-3.46 (m, 12H), 3.31 (m, 2H), 2.48 (m, 2H), 1.99 (t, 1H), 1.48 (s, 9H), 1.46 (s, 9H).

Example 10: Preparation of ethyl 2-[6-{3-(t-butoxycarbonylamino)propyl-1-oxy}-methyl-2-oxo-2H-pyrrolo[2,3-d]pyrimidin-3(7H)-yl]acetate (**10**).

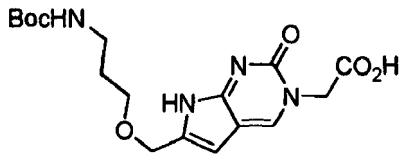
[0089]



[0090] To a stirred solution of 6.5g of compd **2** dissolved in 120ml DMF, were added in series 580mg of CuI, 4.2ml TEA, 9.74g of compd **3**, and 1.76g of $Pd(PPh_3)_4$. Then the reaction mixture was stirred for 24h at 50°C with light shielded, and concentrated under reduced pressure. The resulting residue was dissolved in 250ml EtOH and stirred at reflux for 18h. Then the solution was concentrated in vacuo and subjected to chromatographic separation (95:5 EA/EtOH) to obtain 2.3g of compd **10** as a dark red foam/solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 11.30 (br s, 1H), 8.37 (s, 1H), 6.78 (m, 1H), 6.19 (s, 1H), 4.70 (s, 2H), 4.37 (s, 2H), 4.14 (q, *J* = 7.2 Hz, 2H), 3.42 (t, *J* = 6.4 Hz, 2H), 2.98 (m, 2H), 1.63 (m, 2H), 1.36 (s, 9H), 1.20 (t, *J* = 7.2 Hz, 3H).

Example 11: Preparation of 2-[6-{3-(t-butoxycarbonylamino)propyl-1-oxy}methyl-2-oxo-2H-pyrrolo-[2,3-d]pyrimidin-3(7H)-yl]acetic acid (**11**).

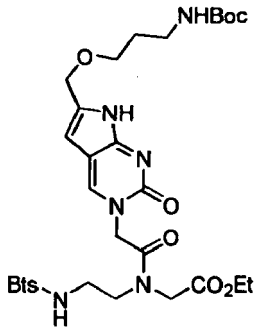
[0091]



[0092] To 3.3g of compd **10**, were added 15ml THF, 30ml water, and then 760mg LiOH, and the mixture was stirred at RT for 20 min. After THF was removed under reduced pressure, the resulting aq solution was washed with diethyl ether. The aq layer was acidified to pH 3 with 1M aq HCl and extracted with EA. The organic layer was dried over anhydrous sodium sulfate and concentrated in vacuo to yield 2.46g of compd **11** as a white solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 11.05 (s, 1H), 8.16 (s, 1H), 6.79 (t, 1H), 6.12 (s, 1H), 4.35 (s, 2H), 4.23 (s, 2H), 3.41 (t, 2H), 2.97 (q, *J* = 6.4 Hz, 2H), 1.64 (m, 2H), 1.36 (s, 9H).

Example 12: Preparation of ethyl N-[2-{(benzo[d]thiazole-2-sulfonyl)amino}-ethyl]-N-[2-[6-{3-(t-butoxycarbonylamino)propyl-1-oxy}methyl-2-oxo-2H-pyrrolo-[2,3-d]pyrimidin-3(7H)-yl]acetyl]glycinate (**12**).

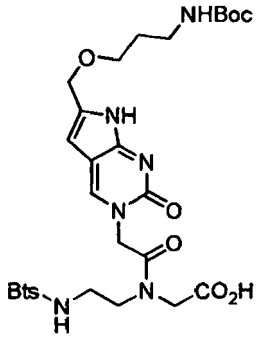
[0093]



[0094] To 4.0g of compd **11** and 3.6g of ethyl N-[2-{(benzo[d]thiazole-2-sulfonyl)amino}ethyl]glycinate dissolved in 30ml DMF, were added at RT 2.42g of EDCI and 1.70g of HOBt. The reaction mixture was stirred for 8h. After the solvent was removed in vacuo, the resulting residue was dissolved in MC, and washed with 1M aq HCl and then with water. The MC layer was concentrated under reduced pressure and purified by column chromatography (95:5 MC/MeOH) to obtain 4.6g of compd **12** as a yellow foam/solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 11.09 (br s, 1H), 8.74 (s, 0.6H), 8.58 (s, 0.4H), 8.27 (m, 1H), 8.20-8.14 (m, 2H), 7.66 (m, 2H), 6.56 (br s, 1H), 6.16 (m, 1H), 4.91 (s, 1.2H), 4.73 (s, 0.8H), 4.38 (s, 2.6H), 4.17 (m, 0.9H), 4.07 (m, 2.5H), 3.67 (m, 1.1H), 3.49-3.44 (m, 4H), 3.26 (m, 0.9H), 3.01 (m, 2H), 1.66 (m, 2H), 1.38 (s, 9H), 1.24 (t, *J* = 7.0 Hz, 1.2H), 1.17 (t, *J* = 7.0 Hz, 1.8H).

Example 13: Preparation of N-[2-{(benzo[d]thiazole-2-sulfonyl)amino}ethyl]-N-[2-[6-{3-(t-butoxycarbonylamino)propyl-1-oxy}methyl-2-oxo-2H-pyrrolo-[2,3-d]-pyrimidin-3(7H)-yl]acetyl]glycine (**13**).

[0095]

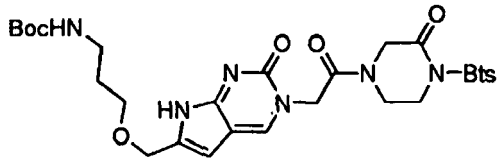


[0096] 4.5g of compd **12** and 670mg of LiOH were dispersed in 20ml THF and 20ml water, and stirred at RT for 20min. THF was removed in vacuo, and the resulting aq solution was washed with diethyl ether. The aq layer was acidified to

pH 3 with 1M aq HCl, and extracted with EA. The EA layer was dried over anhydrous sodium sulfate and concentrated under reduced pressure to afford 4.4g of compd **13** as a dark yellow solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 11.32 (br s, 1H), 8.36 (m, 1H), 8.28 (m, 1.6H), 8.22 (s, 0.4H), 7.73 (m, 2H), 6.78 (m, 1H), 6.20 (s, 1H), 4.94 (s, 1.2H), 4.84 (s, 0.8H), 4.52 (s, 0.8H), 4.37 (s, 2H), 4.30 (s, 1.2H), 4.26 (m, 1.2H), 4.07 (m, 2H), 3.87 (m, 0.8H), 3.43 (m, 2H), 2.99 (m, 2H), 1.63 (m, 2H), 1.37 (s, 9H).

Example 14: Preparation of 1-{(benzo[d]thiazole-2-sulfonyl)}-2-oxo-4-[6-{3-(t-butoxycarbonylamino)propyl-1-oxy}methyl-2-oxo-2H-pyrrolo[2,3-d]pyrimidin-3(7H)-yl]acetyl]piperazine (**14**).

[0097]

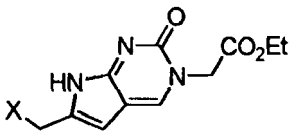


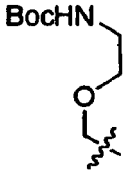
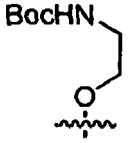
[0098] 4.4g of compd **13** and 1.49g of EDCI in 50ml DMF were stirred at RT for 16h. After the reaction mixture was concentrated in vacuo, the resulting residue was dissolved in 50ml MC. The MC solution was washed in series with 1M aq HCl and water, concentrated in vacuo, and then purified by column chromatography (acetone) to obtain 1.5g of compd **14** as a brown foam/solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 11.25 (br s, 1H), 8.36 (m, 1H), 8.29 (m, 1H), 8.25 (s, 0.6H), 8.19 (0.4H), 7.72 (m, 2H), 6.78 (t, *J* = 5.2 Hz, 1H), 6.18 (s, 1H), 4.92 (s, 1.2H), 4.82 (s, 0.8H), 4.51 (s, 0.8H), 4.37 (s, 2H), 4.29 (s, 1.2H), 4.23 (m, 1.2H), 4.06 (m, 2H), 3.87 (m, 0.8H), 3.41 (t, *J* = 6.4 Hz, 2H), 2.98 (q, *J* = 6.8 Hz, 2H), 1.62 (m, 2H), 1.36 (s, 9H). MS/ESI (m+23/MNa^+) = 682.2 (observed), MW = 659.8 ($C_{28}H_{33}N_7O_8S_2$).

[0099] Starting from acetylene derivatives **4 ~ 9**, pyrollocytosine derivatives **15 ~ 20** were prepared by similarly following the procedure described in Example 10. Spectral and physical data for compds **15 ~ 20** are provided in the table below.

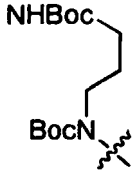
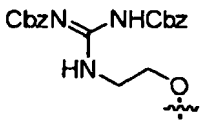
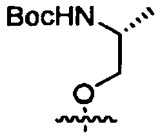
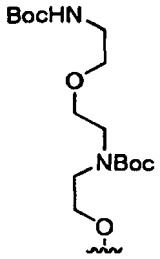
Examples 15 ~ 20: Analytical data for pyrollocytosine derivatives **15 ~ 20**.

[0100]



Compd	Starting Material	X	Spectral & Physical Data
15	**4**		^{1}H NMR (400MHz; $DMSO_{d6}$) δ 11.12 (s, 1H), 8.27 (s, 1H), 6.79 (t, *J* = 5.4 Hz, 1H), 6.00 (s, 1H), 4.68 (s, 2H), 4.14 (*q, J* = 7.2 Hz, 2H), 3.65 (t, *J* = 6.6, 2H), 3.39 (t, *J* = 6.2 Hz, 2H), 3.08 (m, 2H), 2.78 (t, *J* = 6.6 Hz, 2H), 1.37 (s, 9H), 1.20 (t, *J* = 7.2 Hz, 3H). Pale green foam/solid.
16	**5**		^{1}H NMR (400MHz; $DMSO_{d6}$) δ 11.35 (s, 1H), 8.39 (s, 1H), 6.87 (t, *J* = 5.2 Hz, 1H), 6.21 (s, 1H), 4.70 (s, 2H), 4.41 (s, 2H), 4.15 (q, *J* = 7.2 Hz, 2H), 3.43 (m, 2H), 3.12 (m, 2H), 1.38 (s, 9H), 1.21 (t, *J* = 7.2 Hz, 3H). Pale yellow foam/solid.

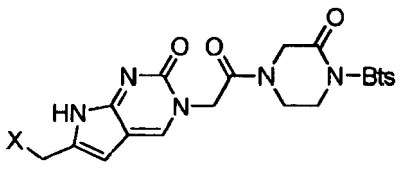
(continued)

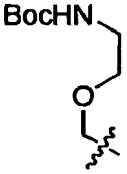
Compd	Starting Material	X	Spectral & Physical Data
17	**6**		^{1}H NMR (400MHz; DMSO$_{d6}$) δ 11.20 (br s, 0.6H), 8.86 (br s, 0.4H), 8.57 (s, 0.2H), 8.35 (s, 0.8H), 6.83-6.76 (m, 1H), 6.00 (s, 0.8H), 5.76 (s, 0.2H), 4.75 (s, 0.3H), 4.70 (s, 1.7H), 4.55 (s, 0.3H), 4.30 (s, 1.7H), 4.14 (q, *J* = 7.2 Hz, 2H), 3.18 (m, 2H), 2.90-2.88 (m, 2H), 1.58 (m, 2H), 1.40-1.36 (m, 18H), 1.20 (t, 3H). Brown foam/solid.
18	**7**		^{1}H NMR (400MHz; DMSO$_{d6}$) δ 11.57 (s, 1H), 11.33 (s, 1H), 8.50 (m, 1H), 8.37 (s, 1H), 7.44-7.31 (m, 10H), 6.22 (s, 1H), 5.22 (s, 2H), 5.03 (s, 2H), 4.70 (s, 2H), 4.44 (s, 2H), 4.14 (q, 2H), 3.57-3.53 (m, 4H), 1.21 (t, 3H). Pale brown solid.
19	**8**		^{1}H NMR (500MHz; DMSO$_{d6}$) δ 11.32 (s, 1H), 8.38 (s, 1H), 6.71 (d, 1H), 6.20 (s, 1H), 4.70 (s, 2H), 4.41 (m, 2H), 4.14 (q, 2H), 3.65 (m, 1H), 3.37-3.34 (m, 1H), 3.26-3.22 (m, 1H), 1.37 (s, 9H), 1.20 (t, 3H), 1.02 (d, 3H). Pale brown solid.
20	**9**		^{1}H NMR (500MHz; DMSO$_{d6}$) δ 11.13 (s, 1H), 8.25 (s, 1H), 6.73 (s, 1H), 5.99 (s, 1H), 4.68 (s, 2H), 4.12 (q, 2H), 3.67 (t, 2H), 3.48~3.27 (m, 10H), 3.04 (q, 2H), 2.78 (t, 2H), 1.38 (s, 9H), 1.36 (s, 1H), 1.19 (t, 3H). Brown solid.

[0101] Starting from pyrollocytosine derivatives **15**, **16**, **17**, and **20**, modified cytosine PNA monomers **21 ~ 24** were prepared by similarly following the procedures described in Examples 11 ~ 14. Spectral and physical data for compds **21 ~ 24** are provided in the table below.

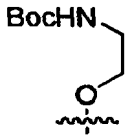
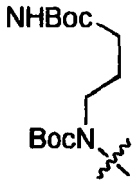
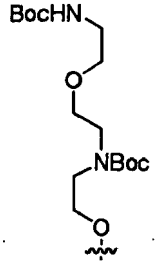
Examples 21 ~ 24: Analytical data for cytosine PNA monomers **21 ~ 24**.

[0102]



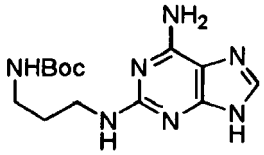
Compd	Starting Material	X	Spectral & Physical Data
21	**15**		^{1}H NMR (400MHz; DMSO$_{d6}$) δ 11.06 (s, 1H), 8.36 (m, 1H), 8.28 (m, 1H), 8.14 (s, 0.6H), 8.08 (2, 0.4H), 7.72 (m, 2H), 6.78 (t, 1H), 5.98 (s, 1H), 4.91 (s, 1.2H), 4.80 (s, 0.8H), 4.51 (s, 0.8H), 4.29 (s, 1.2H), 4.24 (m, 1.2H), 4.06 (m, 2H), 3.86 (m, 0.8H), 3.64 (t, *J* = 6.4 Hz, 2H), 3.38 (t, *J* = 6.0 Hz, 2H), 3.07 (m, 2H), 2.78 (m, 2H), 1.37 (s, 9H). MS/ESI (m+1) = 660.2 (observed), MW = 659.8 ($C_{28}H_{33}N_7O_8S_2$). Brown foam/solid.

(continued)

Compd	Starting Material	X	Spectral & Physical Data
22	**16**		^{1}H NMR (400MHz; DMSO$_{d6}$) δ 11.31 (s, 1H), 8.36 (m, 1H), 8.30-8.27 (m, 1.6H), 8.22 (s, 0.4H), 7.73 (m, 2H), 6.87 (t, *J* = 5.6 Hz, 1H), 6.20 (m, 1H), 4.94 (s, 1.2H), 4.83 (s, 0.8H), 4.52 (s, 0.7H), 4.41 (s, 2.1H), 4.30 (s, 1.1 H), 4.25 (m, 1.2H), 4.06 (m, 2H), 3.87 (m, 0.8H), 3.42 (t, 2H), 3.12 (m, 2H), 1.38 (s, 9H). MS/ESI (m+1) = 646.2 (observed), MW = 645.7 ($C_{27}H_{31}N_7O_8S_2$). Red foam/solid.
23	**17**		^{1}H NMR (400MHz; DMSO$_{d6}$) δ 11.16 (br s, 1H), 8.36 (m, 1H), 8.28 (m, 1H), 8.21 (s, 0.6H), 8.15 (s, 0.4H), 7.73 (m, 2H), 6.77 (br s, 1H), 6.00 (br s, 1H), 4.92 (s, 1.2H), 4.82 (s, 0.8H), 4.52 (s, 0.9H), 4.30 (s, 3.1H), 4.25 (m, 1.2H), 4.07 (m, 2H), 3.87 (m, 0.8H), 3.19 (m, 2H), 2.89 (m, 2H), 1.59 (m, 2H), 1.41-1.36 (m, 18H); MS/ESI (m+23/MNa$^+$) = 781.3 (observed), MW = 758.9 ($C_{33}H_{42}N_8O_9S_2$). Red foam/solid.
24	**20**		^{1}H NMR (500MHz; DMSO$_{d6}$) δ 11.10 (m,1H), 8.35 (m, 1H), 8.28 (m, 1H), 8.14 (s, 0.6H), 8.08 (s, 0.4H), 7.72 (m, 2H), 6.76 (m, 1H), 5.97-5.96 (s, 1H), 4.90 (s, 1.2H), 4.80 (s, 0.8H), 4.51 (s, 0.8H), 4.29 (s, 1.2H), 4.25 (t, 1.2H), 4.08-4.04 (m, 2H), 3.86 (t, 0.8H), 3.66 (m, 2H), 3.47 (m, 2H), 3.41 (m, 2H), 3.32-3.30 (m, 4H), 3.27 (m, 2H), 3.04 (m, 2H), 2.77 (m, 2H), 1.37 (s, 9H), 1.35 (s, 9H). MS/ESI (m+23/MNa$^+$) = 869.3 (observed), MW = 847.0 ($C_{37}H_{50}N_8O_{11}S_2$). Yellow solid.

Example 25: Preparation of 2-{3-(t-butoxycarbonylamino)propyl}amino-adenine (**25**).

[0103]

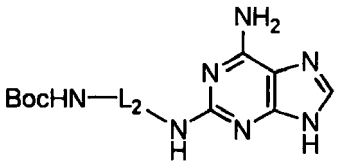


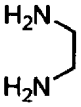
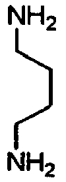
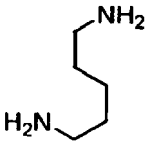
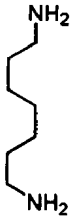
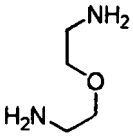
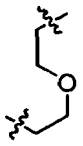
[0104] 6.8g of 2-chloroadenine dissolved in 68ml 1,3-diaminopropane and 68ml monomethoxyethanol was stirred at reflux for 24h, and the reaction mixture was concentrated in vacuo. The resulting residue was dissolved in 100ml THF and 100ml water, to which was slowly added 60g of BoC_2O dissolved in 70ml THF. The reaction mixture was stirred at RT for 6h, and then the organic solvent was removed under reduced pressure. The resulting aq layer was extracted twice with 100ml EA. The organic layer was washed with 0.5M aq citric acid and with brine, and dried over anhydrous magnesium sulfate. The organic layer was concentrated under reduced pressure and subjected to chromatographic separation (1:10 MeOH/MC) to obtain 4.07g of a compd protected with two Boc groups. This compound was dissolved in 100ml MeOH, to which was added slowly 45ml saturated aq sodium carbonate. The reaction solution was stirred at 50°C for 1h, and then concentrated in vacuo. The resulting residue was dissolved in 50ml MeOH and the insoluble material was filtered off. Then the filtrate was concentrated to afford 3.16g of compd **25** as a white solid. ^{1}H NMR (400MHz; DMSO$_{d6}$) δ 12.11 (br s, 1H), 7.63 (s, 1H), 6.78 (t, 1H), 6.55 (s, 2H), 6.07 (t, 1H), 3.20 (q, 2H), 2.96 (q, 2H), 1.60 (m, 2H), 1.37 (s, 9H).

[0105] Starting from 2-chloroadenine and a proper diamine, 2,6-diaminopurine derivatives **26** ~ **30** were prepared by similarly following the procedure described in Example 25. Spectral and physical data for compounds **26 ~ 30** are provided in the table below.

Examples 26 ~ 30: Analytical data for 2,6-diaminopurine derivatives **26** ~ **30**.

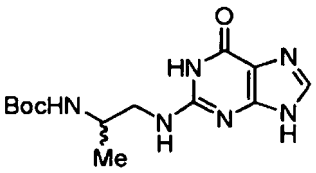
[0106]



Compd	Starting Diamine	L2	Spectral & Physical Data
26		-$(CH_2)_2$-	^{1}H NMR (400MHz; $DMSO_{d6}$) δ 12.20 (br s, 1H), 7.66 (s, 1H), 6.84 (t, 1H), 6.62 (s, 2H), 6.10 (t, 1H), 3.25 (q, 2H), 3.08 (q, 2H), 1.36 (s, 9H). Pale yellow solid.
27		-$(CH_2)_4$-	^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.07 (br s, 1H), 7.63 (s, 1H), 6.75 (s, 1H), 6.50 (s, 2H), 6.02 (s, 1H), 3.18 (q, 2H), 2.91 (q, 2H), 1.48-1.36 (m, 13H). Yellowish green solid.
28		-$(CH_2)_5$-	^{1}H NMR (400MHz; $DMSO_{d6}$) δ 12.14 (br s, 1H), 7.65 (s, 1H), 6.77 (t, 1H), 6.55 (s, 2H), 6.01 (s, 1H), 3.17 (m, 2H), 2.89 (q, 2H), 1.48 (m, 2H), 1.41-1.36 (m, 11H), 1.26 (m, 2H). Pale yellow solid.
29		-$(CH_2)_7$-	^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.11 (br s, 1H), 7.64 (s, 1H), 6.78 (t, *J* = 5.6 Hz, 1H), 6.56 (s, 2H), 6.04 (t, *J* = 5.5 Hz, 1H), 3.17 (td, *J* = 6.3, 6.3 Hz, 2H), 2.88 (td, *J* = 6.7, 6.7 Hz, 2H), 1.49-1.47 (m, 2H), 1.36-1.31 (m, 11H), 1.29-1.22 (m, 6H). Yellowish green solid.
30			^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.15 (s, 1H), 7.64 (s, 1H), 6.84 (t, 1H), 6.56 (s, 2H), 6.05 (t, 1H), 3.48 (t, 2H), 3.39-3.34 (m, 4H), 3.07 (q, 2H), 1.37 (s, 9H). Yellow foam.

Example 31: Preparation of 2-[2-{2-(t-butoxycarbonylamino)-2-methyl}ethyl]-amino-1H-purin-6(9H)-one (**31**).

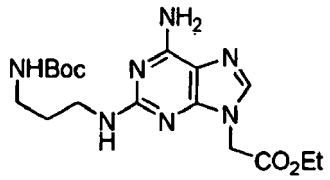
[0107]



[0108] 11g of 2-chlorohypoxanthine and 4.96ml 1,2-diaminopropane (racemic) were dispersed in 33ml monomethoxyethanol, and stirred for 24h at 130°C. The solvent was removed in vacuo, and the resulting residue was dissolved in 97ml THF and 97ml water, to which was slowly added 22.8g of Boc_2O dissolved in 64ml THF. The reaction mixture was stirred at RT for 6h, and EA was added to the solution. The resulting precipitate was collected by filtration to obtain compd **31** as a grey solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.42 (s, 1H), 10.44 (br s, 1H), 7.61 (s, 1H), 6.76 (d, 1H), 6.27 (m, 1H), 3.67 (m, 1H), 3.32 (m, 1H), 3.14 (m, 1H), 1.36 (s, 9H), 1.02 (d, 3H).

Example 32: Preparation of ethyl 2-[6-amino-2-{3-(t-butoxycarbonylamino)-propyl}amino-9H-purin-9-yl]acetate (**32**).

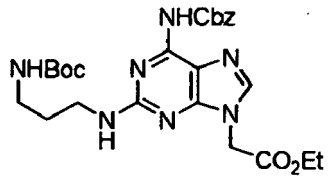
[0109]



[0110] To a stirred solution of 3.16g of compd **25** dissolved in 100ml DMF, was added 480mg of 55% NaH in mineral oil. The reaction solution was stirred for 2h, after which was slowly added 1.98ml ethyl bromoacetate. 2h later, the reaction mixture was concentrated in vacuo, and purified by column chromatography (1:10 EtOH/EA) to give 2.92g of diaminopurine analog **32** as a pale yellow solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 7.67 (s, 1H), 6.80 (t, 1H), 6.71 (s, 2H), 6.28 (t, 1H), 4.85 (s, 2H), 4.15 (q, 2H), 3.20 (q, 2H), 2.94 (q, 2H), 1.57 (m, 2H), 1.37 (s, 9H), 1.21 (t, 3H).

Example 33: Preparation of ethyl 2-[6-(benzyloxycarbonyl)amino-2-{3-(t-butoxy-carbonylamino)propyl}amino-9H-purin-9-yl]acetate (**33**).

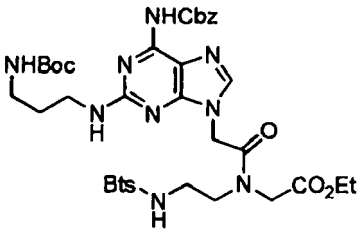
[0111]



[0112] To a stirred solution of 4.68g of compd **32** dissolved in 100ml DMF, was added at RT 13.2g of N-(benzyloxy-carbonyl)-N'-methyl-imidazolium triflate. 12h later the reaction mixture was concentrated under reduced pressure, and subjected to column chromatography (5% MeOH in MC) to yield 5.4g of compd **33** as a white solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.19 (s, 1H), 7.92 (s, 1H), 7.45-7.33 (m, 5H), 6.88 (t, 1H), 6.77 (t, 1H), 5.18 (s, 2H), 4.94 (s, 2H), 4.16 (q, 2H), 3.25 (q, 2H), 2.95 (q, 2H), 1.60 (m, 2H), 1.36 (s, 9H), 1.21 (t, 3H).

Example 34: Preparation of ethyl N-[2-{2-(benzo[d]thiazole)sulfonyl}amino-ethyl]-N-[2-[6-(benzyloxycarbonyl)amino-2-{3-{t-butoxycarbonylamino)-propyl}amino-9H-purin-9-yl]acetyl]glycinate (**34**).

[0113]

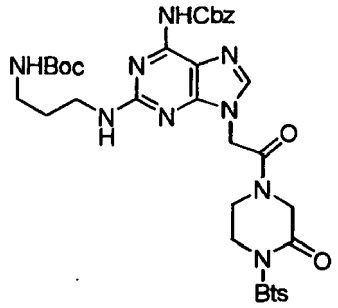


[0114] 5.4g of compd **33** and 950mg of LiOH were dissolved in 40ml THF and 40ml water, and stirred at RT for 1h. THF was removed in vacuo, and the resulting aq solution was acidified to pH 3 with 1M aq HCl, and then extracted with EA. The organic layer was dried over anhydrous sodium sulfate and concentrated under reduced pressure. The resulting residue and 2.92g of ethyl 2-N-[2-{(benzo[d]thiazole-2-sulfonyl)amino}ethyl]glycinate were dissolved in 240ml DMF, to which were added at RT 1.95g of EDCI and 1.38g of HOBt. The reaction mixture was stirred for 20h, concentrated under reduced pressure, and dissolved in MC. The MC solution was washed with 1M aq HCl, concentrated in vacuo, and then purified by column chromatography (5% MeOH/MC) to obtain 2.7g of compd **34** as a pale yellow foam. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.18 (m, 1H), 8.97 (br s, 0.6H), 8.80 (br s, 0.4H), 8.28 (d, 1H), 8.18 (m, 1H), 7.80 (s, 0.6H), 7.76 (s, 0.4H), 7.66 (m, 2H), 7.46-7.32 (m, 5H), 6.77 (m, 2H), 5.18 (s, 2H), 5.10 (s, 1.2H), 4.89 (s, 0.8H), 4.45 (s, 0.8H), 4.17 (q, 0.8H),

4.07-4.00 (m, 2.4H), 3.68 (m, 1.2H), 3.47 (m, 1.2H), 3.41 (m, 0.9H), 3.22 (m, 2.7H), 2.94 (m, 2H), 1.59 (m, 2H), 1.36 (s, 9H), 1.31-1.12 (m, 3H).

Example 35: Preparation of 1-(benzo[d]thiazole-2-sulfonyl)-2-oxo-4-[[6-(benzyl-oxycarbonyl)amino-2-{3-(t-butoxycarbonylamino)propylamino}-9H-purin-9-yl]-acetyl]piperazine (**35**).

[0115]

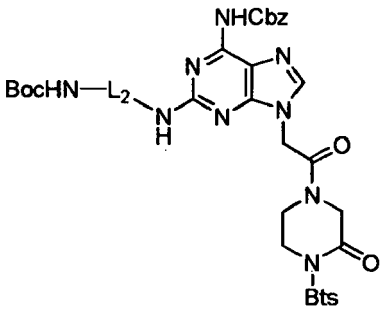


[0116] 2.7g of compd **34** and 340mg of LiOH were dispersed in 15ml THF and 20ml water, and stirred for 30 min at RT. THF was removed under reduced pressure. Then the resulting aq layer was acidified to pH 3 with 1M aq HCl, and extracted with EA. The EA layer was dried over anhydrous sodium sulfate and concentrated in vacuo to obtain 2.48g of a crude product. The crude product and 716mg of EDCI dissolved in 70ml DMF were stirred at RT for 20h. The solvent was removed under reduced pressure, and the resulting residue was dissolved in MC and washed with 1M aq HCl and then with water. The organic layer was concentrated in vacuo and purified by column chromatography (acetone) to obtain 1.4g of compd **35** as a white foam. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.16 (s, 1H), 8.35 (m, 1H), 8.26 (m, 1H), 7.81 (s, 0.6H), 7.77 (s, 0.4H), 7.72 (m, 2H), 7.45-7.31 (m, 5H), 6.78 (m, 2H), 5.18 (s, 2H), 5.12 (s, 1.2H), 5.01 (s, 0.8H), 4.55 (s, 0.8H), 4.29-4.27 (m, 2.4H), 4.09 (m, 2H), 3.88 (m, 0.8H), 3.26 (m, 2H), 2.95 (m, 2H), 1.61 (m, 2H), 1.36 (s, 9H); MS/ESI (m+1) = 779.2 (observed), MW = 778.9 ($C_{34}H_{38}N_{10}O_8S_2$).

[0117] Starting from 2,6-diaminopurine derivatives **26** ~ **30,** modified adenine PNA monomers **36** ~ **40** were prepared by similarly following the procedures described in Examples 32 ~ 35. Spectral and physical data for compds **36** ~ **40** are provided in the table below.

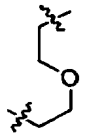
Examples 36 ~ 40: Analytical data for adenine PNA monomers **36** ~ **40.**

[0118]



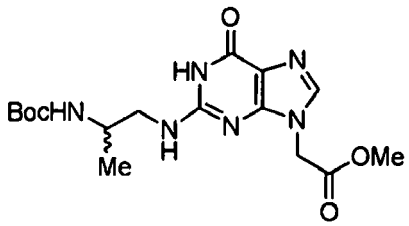
Compd	Starting Material	L_2	Spectral & Physical Data
36	**26**	$-(CH_2)_2-$	^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.17 (s, 1H), 8.36 (m, 1H), 8.26 (m, 1H), 7.82 (s, 0.6H), 7.78 (s,0.4H), 7.72 (m, 2H), 7.45-7.31 (m, 5H), 6.79 (2H), 5.18 (s, 2H), 5.12 (s, 1.2H), 5.01 (s, 0.8H), 4.55 (s, 0.8H), 4.29-4.25 (m, 2.4H), 4.09 (m, 2H), 3.87 (m, 0.8H), 3.29 (m, 2H), 3.11 (m, 2H), 1.33 (d, 9H). MS/ESI (m+1) = 765.2 (observed), MW = 764.8 ($C_{33}H_{36}N_{10}O_8S_2$). White foam.

(continued)

Compd	Starting Material	L_2	Spectral & Physical Data
37	**27**	$-(CH_2)_4-$	^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.10 (s, 1H), 8.36 (m, 1H), 8.26 (m, 1H), 7.80 (s, 0.6H), 7.76-7.71 (m, 2.4H), 7.46-7.31 (m, 5H), 6.81-6.73 (m, 2H), 5.18 (s, 2H), 5.12 (s, 1.2H), 5.01 (s, 0.8H), 4.55 (s, 0.8H), 4.30-4.25 (m, 2.4H), 4.09 (m, 2H), 3.88 (m, 0.8H), 3.26 (m, 2H), 2.90 (m, 2H), 1.50-1.36 (m, 13H); MS/ESI (m+1) = 793.3 (observed), MW = 792.9 ($C_{35}H_{40}N_{10}O_8S_2$). Yellowish red foam/solid.
38	**28**	$-(CH_2)_5-$	^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.09 (s, 1H), 8.35 (m, 1H), 8.26 (m, 1H), 7.80 (s, 0.6H), 7.76 (s, 0.4H), 7.74-7.72 (m, 2.0H), 7.46-7.31 (m, 5H), 6.79-6.72 (m, 2H), 5.18 (s, 2H), 5.12 (s, 1.2H), 5.01 (s, 0.8H), 4.56 (s, 0.8H), 4.30-4.27 (m, 2.4H), 4.09 (m, 2H), 3.88 (m, 0.8H), 3.25 (m, 2H), 2.89 (m, 2H), 1.49 (m, 2H), 1.36 (m, 11H), 1.25 (m, 2H); MS/ESI (m+1) = 807.3 (observed), MW = 806.9 ($C_{36}H_{42}N_{10}O_8S_2$)- Yellow foam/solid.
39	**29**	$-(CH_2)_7-$	^{1}H NMR (500MHz; $DMSO_{d6}$) δ 10.11 (d, *J* = 3.1 Hz, 1H), 8.37-8.34 (m, 1H), 8.28-8.24 (m, 1H), 7.80 (s, 0.6H), 7.76 (s, 0.4 Hz), 7.75-7.70 (m, 2H), 7.75-7.31 (m, 5H), 6.82-6.74 (m, 2H), 5.18 (s, 2H), 5.12 (s, 1.2H), 5.01 (s, 0.8H), 4.58 (s, 0.8H), 4.29 (m, 1.2H), 4.27 (q, *J* = 4.9 Hz, 1H), 4.06-4.03 (m, 2H), 3.88 (t, *J* = 5.2 Hz, 1H), 3.26-3.20 (m, 2H), 2.88-2.85 (m, 2H), 1.51-1.45 (m, 2H), 1.39-1.32 (m, 11H), 1.28-1.15 (m, 6H). MS/ESI (m+1) = 834.8 (observed), MW = 835.0 ($C_{38}H_{46}N_{10}O_8S_2$). Reddish yellow foam/solid.
40	**30**		^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.14 (s, 1H), 8.35 (m, 1H), 8.26 (m, 1H), 7.82 (s, 0.6H), 7.78 (s, 0.4H), 7.73 (m, 2H), 7.46-7.31 (m, 5H), 6.81-6.74 (m, 2H), 5.18 (s, 2H), 5.13 (s, 1.2H), 5.02 (s, 0.8H), 4.55 (s, 0.8H), 4.30-4.26 (m, 2.4H), 4.09 (m, 2H), 3.88 (m, 0.8H), 3.50 (m, 2H), 3.43-3.38 (m, 4H), 3.07 (m, 2H), 1.36 (s, 9H); MS/ESI (m+1) = 809.3 (observed), MW = 808.9 ($C_{35}H_{40}N_{10}O_9S_2$). Pale yellow foam.

Example 41: Preparation of ethyl 2-[2-[2-{2-(t-butoxycarbonyamino)-2-methyl}ethyl]amino-6-oxo-6,9-dihydro-1H-purin-2-yl]acetate (**41**).

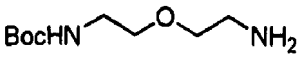
[0119]



[0120] To a stirred solution of 4.69g of compd **31** in 47ml DMF, was added 790mg of 55% NaH in mineral oil and the reaction solution was stirred for 2h. After 1.85ml ethyl bromoacetate was slowly added, the reaction solution was stirred for another 2h. The reaction mixture was concentrated in vacuo and purified by column chromatography (5:95 MeOH/MC) to obtain 5.04g of compd **41** as a pale yellow solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 10.55 (s, 1H), 7.67 (s, 1H), 6.74 (d, 1H), 6.40 (m, 1H), 4.87 (s, 2H), 4.17 (q, 2H), 3.65 (m, 1H), 3.28 (m, 1H), 3.16 (m, 1H), 1.36 (s, 9H), 1.21 (t, 3H), 1.01 (d, 3H).

Example 42: Preparation of 2-{2-(t-butoxycarbonylamino)ethoxy}ethylamine (**42**).

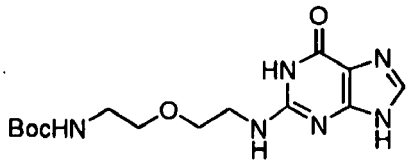
[0121]



[0122] To 146g of [2-{2-(t-butoxycarbonylamino)ethoxylethyl]methane sulfonate was dissolved in 500ml DMF, was added 134g of sodium azide. The reaction mixture was stirred at 70°C for 20h, and then concentrated under reduced pressure. The resulting residue was dissolved in 1,200ml water and extracted with EA. The organic layer was dried over anhydrous sodium sulfate and concentrated in vacuo. The resulting residue was dissolved in 2,000ml THF, to which was added 162g of triphenylphosphine. The reaction mixture was stirred at RT for 2h, after which was added 200ml water. The reaction mixture was stirred at RT for 18h and concentrated to 500ml under reduced pressure. Then the resulting precipitate was filtered off. The filtrate was further concentrated under reduced pressure to remove THF, and washed with MC. The aq layer was concentrated to obtain 86.2g of compd **42** as a liquid. ^{1}H NMR (400MHz; $CDCl_3$) δ 4.96 (br s, 1H), 3.54-3.48 (m, 4H), 3.34 (q, 2H), 2.88 (t, 2H), 1.48-1.46 (m, 11H).

Exmaple 43: Preparation of 2-[2-{2-(t-butoxycarbonylamino)-ethoxy}ethyl]amino-1H-purin-6(9H)-one (**43**).

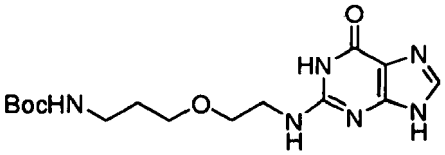
[0123]



[0124] 6.3g of compd **42** and 2.0g of 2-bromohypoxanthine were dispersed in 55ml monomethoxyethanol and 17.5ml water. The reaction mixture was stirred at reflux for 16h, and the solvent was removed under reduced pressure. Then the concentrate was stirred in 20ml MC and 10ml water for 30 min, and the resulting precipitate was collected by filtration to obtain 2.1g of compd **43** as a pale yellow solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.43 (br s, 1H), 10.45 (br s, 1H), 7.89 (s, 0.2H), 7.61 (s, 0.8H), 6.77 (m, 1H), 6.34 (s, 0.8H), 6.12 (s, 0.2H), 3.52 (t, 2H), 3.41 (m, 4H), 3.09 (q, 2H), 1.36 (s, 9H).

Example 44: Preparation of 2-[2-[3-(t-butoxycarbonylamino)propyloxy}-ethyl]]-amino-1H-purin-6(9H)-one (**44**).

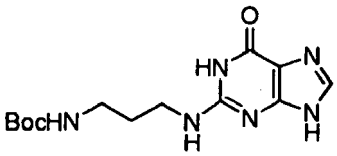
[0125]



[0126] 2-{3-(t-butoxycarbonylamino)propyloxy}ethylamine and 2-bromohypoxanthine were reacted by similarly following the procedure described in Example 43 to yield compound **44** as a white solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.43 (br s, 1H), 10.45 (br s 1H), 7.61 (m, 1H), 6.80 (t, 1H), 6.30 (s, 0.7H), 6.08 (s, 0.3H), 3.49 (t, 2H), 3.41 (t, 4H), 2.99 (q, 2H), 1.61 (m, 2H), 1.37 (s, 9H).

Example 45: Preparation of 2-{3-(t-butoxycarbonylamino)propyl}amino-1H-purin-6(9H)-one (**45**).

[0127]



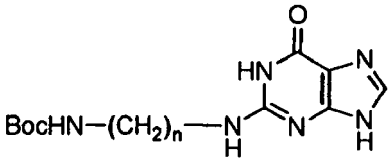
[0128] A mixture of 10g of chlorohypoxanthine and 19.6ml 1,3-diaminopropane dispersed in 40ml monomethoxyethanol was stirred at 130°C for 10h. Then the solvent was removed under reduced pressure and the resulting residue was

dissolved in 150ml THF and 150ml water, to which was added slowly 19.2g of Boc_2O dissolved in 100ml THF. The mixture was stirred at RT for 6h. After EA was added, the resulting precipitate was collected by filtration to obtain 6.31g of compd **45** as a dark green solid. ^1H NMR (400MHz; $DMSO_{d6}$) δ 11.13 (br s, 1H), 7.64 (s, 1H), 6.87 (s, 1H), 6.31 (s, 1H), 3.23 (q, 2H), 2.98 (m, 2H), 1.62 (m, 2H), 1.38 (s, 9H).

[0129] Guanine derivatives **46** ~ **47** were prepared using a proper diamine by similarly following the procedure described in Example 45. Spectral and physical data for compds **46** ~ **47** are provided in the table below.

Examples 46 ~ 47: Analytical data for guanine derivatives **46** ~ **47**.

[0130]

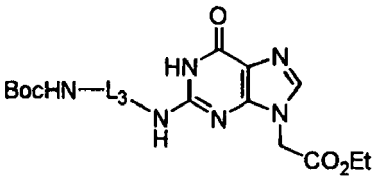


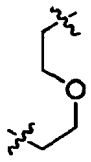
Compd	Diamine used	n	Spectral & Physical Data
46	Ethylene diamine	2	^1H NMR (500MHz; $DMSO_{d6}$) δ 12.43 (br s, 1H), 10.61 (br, 1H), 7.62 (s, 1H), 6.93 (t, 1H), 6.32 (s, 1H), 3.29 (q, 2H),3.10 (q, 2H), 1.37 (s, 9H). Grey solid.
47	Pentylene diamine	5	^1H NMR (500MHz; $DMSO_{d6}$) δ 12.44 (s, 1H), 10.35 (s, 1H), 7.60 (s, 1H), 6.80 (m, 1H), 6.29 (m, 1H), 3.21 (m, 2H), 2.90 (m, 2H), 1.49 (m, 2H), 1.39-1.35 (m, 11H), 1.27-1.23 (m, 2H). Pale brown solid.

[0131] Compds **43** ~ **46** were transformed into compds **48** ~ **51** by similarly following the procedure described in Example 32. Spectral and physical data for compounds **48** ~ **51** are provided in the table below.

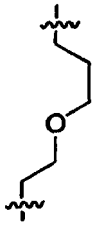
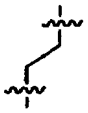
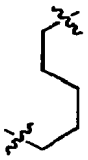
Examples 48 ~ 51: Analytical data for guanine derivatives **48** ~ **51.**

[0132]



Compd	Starting Material	L_3	Spectral & Physical Data
48	**43**		^1H NMR (500MHz; $DMSO_{d6}$) δ 10.67 (s, 1H), 7.69 (s, 1H), 6.78 (m, 1H), 6.15 (t, 1H), 4.87 (s, 2H), 4.15 (q, 2H), 3.51 (m, 2H), 3.41 (m, 4H), 3.10 (m, 2H), 1.37 (s, 9H), 1.20 (t, 3H). White foam/solid.

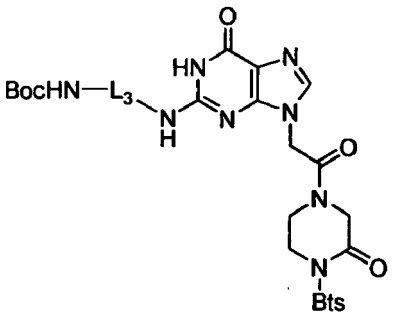
(continued)

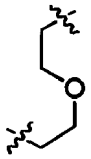
Compd	Starting Material	L_3	Spectral & Physical Data
49	**44**		^{1}H NMR (500MHz; $DMSO_{d6}$) δ 10.57 (s, 1H), 7.69 (s, 1H), 6.79 (m, 1H), 6.44 (m, 1H), 4.87 (s, 2H), 4.16 (q, 2H), 3.48 (t, 2H), 3.40 (m, 4H), 2.99 (q, 2H), 1.61 (m, 2H), 1.37 (s, 9H), 1.21 (t, 3H). Yellow foam/solid.
50	**45**		^{1}H NMR (500MHz; $DMSO_{d6}$) δ 10.64 (s, 1H), 7.68 (s, 1H), 6.91 (t, 1H), 6.47 (s, 1H), 4.88 (s, 2H), 4.16 (q, 2H), 3.28 (q, 2H), 3.08 (q, 2H), 1.36 (s, 9H), 1.21 (t, 3H). Dark red solid.
51	**46**		^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.44 (br s, 1H), 7.66 (s, 1H), 6.77 (m, 1H), 6.41 (m, 1H), 4.86 (s, 2H), 4.16 (q, 2H), 3.21 (q, 2H), 2.89 (q, 2H), 1.48 (m, 2H), 1.41-1.36 (m, 11H), 1.28-1.19 (m, 5H). Dark grey solid.

[0133] Starting from guanine derivatives **48, 49** and **51,** modified guanine PNA monomers **52** ~ **54** were prepared by similarly following the procedures described in Examples 34 ~ 35. Spectral and physical data for compds **52** ~ **54** are provided in the table below.

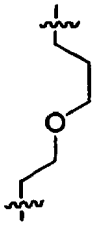
Examples 52 ~ 54: Analytical data for guanine PNA monomers **52** ~ **54.**

[0134]



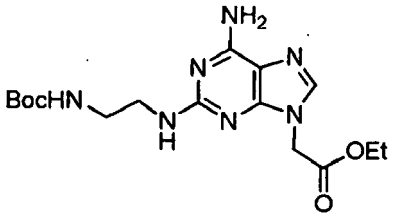
Compd	Starting Material	L_3	Spectral & Physical Data
52	**48**		^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.61 (m, 1H), 8.36 (m, 1H), 8.25 (m, 1H), 7.76-7.65 (m, 3H), 6.78 (t, 1H), 6.54 (m, 1H), 5.07 (s, 1.2H), 4.96 (s, 0.8H), 4.54 (s, 0.8H), 4.30 (s, 1.2H), 4.25 (m, 1.2H), 4.07 (m, 2H), 3.88 (m, 0.8H), 3.49 (m, 2.4H), 3.40 (m, 3.6H), 3.09 (m, 2H), 1.36 (s, 9H); MS/ESI (m+1) = 676.1 (observed), MW = 675.8 ($C_{27}H_{33}N_9O_8S_2$). Dark brown foam/solid.

(continued)

Compd	Starting Material	L_3	Spectral & Physical Data
53	**49**		^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.69 (s, 1H), 8.36 (m, 1H), 8.25 (m, 1H), 7.73 (m, 2H), 7.64-7.60 (m, 1H), 6.80 (t, 1H), 6.65 (br s, 1H), 5.05 (s, 1.2H), 4.94 (s, 0.8H), 4.54 (s, 0.8H), 4.29 (s, 1.2H), 4.24 (m, 1.2H), 4.07 (m, 2H), 3.87 (m, 0.8H), 3.46~3.39 (m, 6H), 2.97 (m, 2H), 1.60 (m, 2H), 1.36 (s, 9H); MS/ESI (m+1) = 689.8 (observed), MW = 689.8 ($C_{28}H_{35}N_9O_8S_2$). Yellow foam/solid.
54	**51**		^{1}H NMR (400MHz; $DMSO_{d6}$) δ 10.42-10.40 (m, 1H), 8.37-8.32 (m, 1H), 8.28-8.25 (m, 1H), 7.73-7.70 (m, 2H), 7.58-7.54 (m, 1H), 6.76 (t, 1H), 6.39-6.38 (m, 1H), 5.03 (s, 1.2H), 4.92 (s, 0.8H), 4.54 (s, 0.8H), 4.29 (s, 1.2H), 4.25 (m, 1.2H), 4.08-4.07 (m, 2H), 3.87 (m, 0.8H), 3.18 (m, 2H), 2.89 (m, 2H), 1.47 (m, 2H), 1.40-1.30 (m, 11H), 1.24 (m, 2H). MS/ESI (m+23/MNa^+) = 696.2 (observed), MW = 673.8 ($C_{28}H_{35}N_9O_7S_2$). Red foam/solid.

Example 55: Preparation of ethyl 2-[6-amino-2-{2-(t-butoxycarbonyl-amino)ethyl}-amino-9H-purin-9-yl]acetate (55).

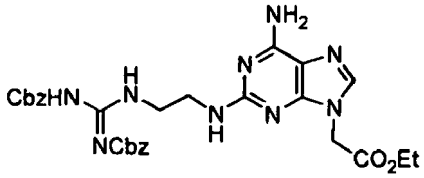
[0135]



[0136] Compd **55** was prepared from compd **26** by similarly following the procedure for Example 32. Pale yellow solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 7.70 (s, 1H), 6.84 (t, 1H), 6.79 (s, 2H), 6.30 (t, 1H), 4.87 (s, 2H), 4.16 (q, 2H), 3.25 (q, 2H), 3.08 (q, 2H), 1.37 (s, 9H), 1.22 (t, 3H).

Example 56: Preparation of ethyl 2-[6-amino-2-[2-{2,3-bis(benzyloxy-carbonyl)guanidino}ethyl]amino-9H-purin-9-yl]acetate (**56**).

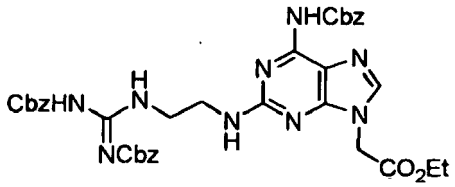
[0137]



[0138] To 4.42g of compd **55** dissolved in 22ml MC, was slowly added 22ml TFA at 0°C, and the solution was stirred for 2.5h. The reaction solution was concentrated under reduced pressure, to which was added 100ml diethyl ether. The resulting precipitate was collected by filtration to obtain 5.79g of a pale brown solid intermediate product. 3.9g of the intermediate was dissolved in 39ml MC, to which was added slowly 6.9ml TEA at 0°C. The solution was stirred for 15min at RT, to which was added 2.48g of 1,3-bis(benzyloxycarbonyl)-2-(methylthio)pseudourea. Then the reaction mixture was stirred for another 24h, and washed with 0.5M aq HCl The organic layer was dried over anhydrous magnesium sulfate and concentrated under reduced pressure to yield 4.58g of compd **56** as a pale yellow solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 11.59 (s, 1H), 8.56 (t, 1H), 7.69 (s, 1H), 7.39-7.29 (m, 10H), 6.75 (s, 2H), 6.53 (s, 1H), 5.15 (s, 2H), 5.02 (s, 2H), 4.86 (s, 2H), 4.13 (q, 2H), 3.50 (q, 2H), 3.37 (m, 2H), 1.19 (t, 3H).

Example 57: Preparation of ethyl 2-[6-(benzyloxycarbonylamino)-2-[2-{2,3-bis-(benzyloxycarbonyl)guanidino}ethyl]amino-9H-purin-9-yl]acetate (**57**).

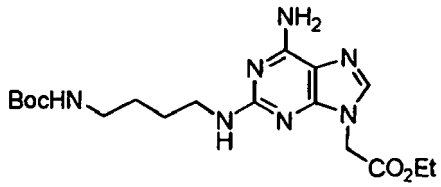
[0139]



[0140] 4.54g of compd **56** and 8.22g of N-(benzyloxycarbonyl)-N'-methylimidazolium triflate were dissolved in 90ml DMF, and stirred for 29h at RT. The solvent was removed under reduced pressure, and the resulting residue was purified by column chromatography (1:3 hexane/EA) to afford 3.06g of compd **57** as a white foam/solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 11.60 (s, 1H), 10.25 (s, 1H), 8.57 (t, 1H), 7.95 (s, 1H), 7.45-7.29 (m, 15H), 7.14 (t, 1H), 5.18 (s, 2H), 5.14 (s, 2H), 5.02 (s, 2H), 4.95 (s, 2H), 4.15 (q, 2H), 3.54 (q, 2H), 3.42 (q, 2H), 1.19 (t, 3H).

Example 58: Preparation of ethyl 2-[6-amino-2-{4-(t-butoxycarbonyl-amino)butyl}-amino-9H-purin-9-yl]acetate (**58**).

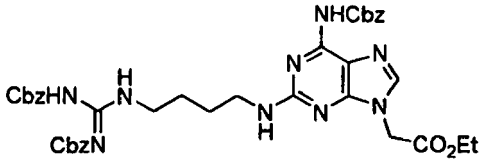
[0141]



[0142] Compd **58** was prepared from compd **27** as a reddish yellow foam/solid by similarly following the procedure described in Example 32. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 7.67 (s, 1H), 6.79 (t, 1H), 6.69 (s, 2H), 6.30 (m, 1H), 4.85 (s, 2H), 4.15 (q, 2H), 3.22-3.17 (m, 2H), 2.93-2.89 (m, 2H), 1.45 (m, 2H), 1.40-1.36 (m, 11H), 1.21 (t, 3H).

Example 59: Preparation of ethyl 2-[6-(benzyloxycarbonylamino)-2-[4-(2,3-bis-(benzyloxycarbonyl)guanidino}butyl]amino-9H-purin-9-yl]acetate (**59**).

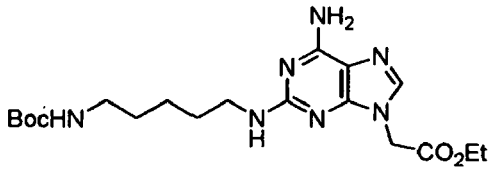
[0143]



[0144] Compd **59** was prepared from compd **58** as a pale yellow foam/solid by similarly following the procedures described in Examples 56 ~ 57. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 11.49 (s, 1H), 10.12 (s, 1H), 8.28 (t, 1H), 7.91 (s, 1H), 7.45-7.31 (m, 5H), 6.95 (t, 1H), 5.17 (s, 2H), 4.93 (s, 2H), 4.16 (q, 2H), 3.28 (m, 4H), 1.51 (m, 4H), 1.46 (s, 9H), 1.38 (s, 9H), 1.21 (t, 3H).

Example 60: Preparation of ethyl 2-[6-amino-2-{5-(t-butoxycarbonylamino)-pentyl}amino-9H-purin-9-yl]acetate (**60**).

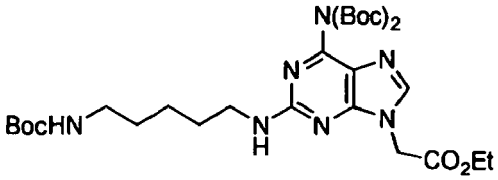
[0145]



[0146] Compd **60** was prepared from compd **28** as a reddish yellow foam/solid by similarly following the procedure described in Example 32. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 7.67 (s, 1H), 6.78 (t, 1H), 6.69 (s, 2H), 6.28 (m, 1H), 4.85 (s, 2H), 4.15 (q, 2H), 3.18 (q, 2H), 2.89 (q, 2H), 1.47 (m, 2H), 1.40-1.34 (m, 11H), 1.25 (m, 2H), 1.21 (t, 3H).

Example 61: Preparation of ethyl 2-[6-{di-(t-butoxycarbonyl))amino-2-[5-1(t-butoxycarbonyl)amino}pentyl]amino-9H-purin-9-yl]acetate (**61**).

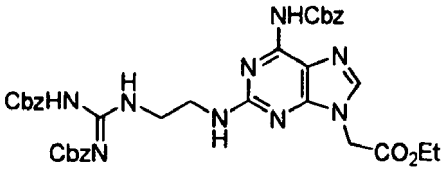
[0147]



[0148] To 6.98g of compd **60** dissolved in 100ml THF, were added 7.95g of Boc_2O and 186mg of 4-(N,N-dimethylamino)pyridine, and the solution was stirred for 10min. Then the solution was mixed with 4.62ml TEA, stirred for 30min, slowly heated to 50°C, and then stirred for another 24h at the temperature. The reaction solution was concentrated in vacuo, and the resulting residue was dissolved in 170ml EA and washed in series with 0.5M aq HCl and water. The organic layer was dried over anhydrous sodium sulfate, concentrated, and subjected to chromatographic separation (1:1 hexane/MC $\rightarrow$ MC) to obtain compd **61** as a yellow foam/solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 8.05 (s, 1H), 7.23 (t, 1H), 6.77 (t, 1H), 5.00 (s, 2H), 4.19 (q, 2H), 3.25 (q, 2H), 2.91 (q, 2H), 1.53 (m, 2H), 1.40-1.39 (m, 29H), 1.28 (m, 2H), 1.22 (t, 3H).

Example 62: Preparation of ethyl 2-[2-[2-{2,3-bis-(benzyloxycarbonyl)-guanidino}ethyl]amino-6-oxo-6,9-dihydro-1H-purin-2-yl]acetate (**62**).

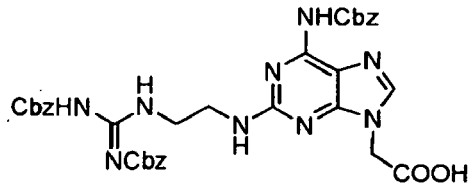
[0149]



[0150] Compd **50** was converted to compd **62** as a white solid by similarly following the procedure described in Example 57. ^{1}H NMR (500MHz; $DMSOd_6$) δ 11.59 (s, 1H), 10.68 (s, 1H), 8.50 (t, 1H), 7.68 (s, 1H), 7.42-7.29 (m, 10H), 6.58 (m, 1H), 5.13 (s, 2H), 5.02 (s, 2H), 4.86 (s, 2H), 4.12 (q, 2H), 3.50 (m, 2H), 3.46 (m, 2H), 1.18 (t, 3H).

Example 63: Preparation of 2-[6-(benzyloxycarbonylamino)-2-[2-12,3-bis-(benzyloxycarbonyl)guanidino}ethyl]amino-9H-purin-9-yl]acetic acid (**63**).

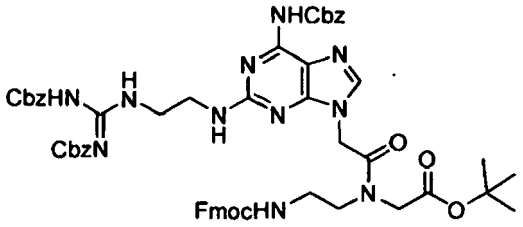
[0151]



[0152] To 2.57g of compd 57 dissolved in 7.1ml THF and 7.1ml water, was added 340mg of LiOH at 0°C, and the solution was stirred at RT for 40min. The reaction solution was acidified to pH 5~6 with 1N aq HCl at 0°C, and the resulting solid was collected by filtration to yield 2.33g of compd **63** as a white solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 11.59 (s, 1H), 10.21 (s, 1H), 8.57 (t, 1H), 7.93 (s, 1H), 7.45-7.28 (m, 15H), 7.12 (t, 1H), 5.17 (s, 2H), 5.13 (s, 2H), 5.02 (s, 2H), 4.83 (s, 2H), 3.53 (q, 2H), 3.42 (q, 2H).

Example 64: Preparation of t-butyl N-[2-{(9H-fluoren-9-yl)methoxycarbonyl-amino}ethyl)]-N-[2-{6-(benzyloxycarbonylamino)-2-[2-{2,3-bis-(benzyloxy-carbonyl)-guanidino}ethyl]amino-9H-purin-9-yl}acetyl]glycinate (**64**).

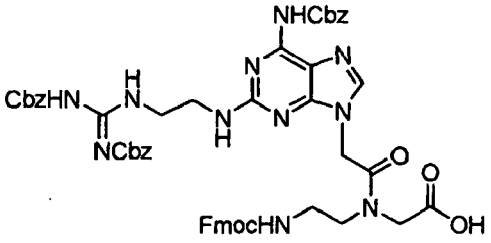
[0153]



[0154] To 1.6g of compd **63** dissolved in 30ml DMF, were added at 0°C 660mg of EDCI and 910mg of Fmoc-Aeg-OtBu. The reaction solution was stirred for 2h at RT and then concentrated under reduced pressure. The resulting residue was dissolved in 50ml MC and washed with 0.5M aq HCl, and the organic layer was dried over anhydrous sodium sulfate. Then the organic layer was concentrated and subjected to chromatographic separation (65:1 MC/MeOH) to obtain 500mg of compd **64** as a white solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ11.59 (s, 0.4H), 11.58 (s, 0.6H), 10.21 (s, 1H), 8.55 (m, 1H), 7.47-7.28 (m, 20H), 7.06 (br, 1H), 5.17-4.89 (m, 8H), 4.34-4.28 (m, 2.8H), 4.20 (m, 1H), 3.95 (s, 1.2H), 3.52 (m, 3.4H), 3.43 (m, 2.2H), 3.34 (m, 1.7H), 3.12 (m, 0.7H), 1.43 (s, 3H), 1.34 (s, 6H).

Example 65: Preparation of N-[2-{(9H-fluoren-9-yl)methoxycarbonylamino}-ethyl)]-N-[2-{6-(benzyloxycarbonylamino)-2-[2-{2,3-bis(benzyloxycarbonyl)-guanidino}ethyl]amino-9H-purin-9-yl}acetyl]glycine (**65**).

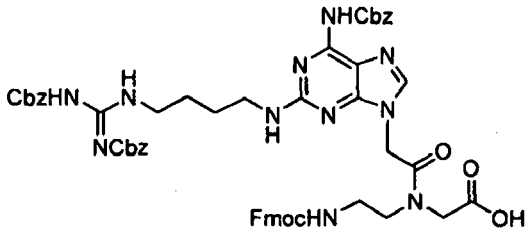
[0155]



[0156] To 460mg of compd **64** dissolved in 3.6ml MC, was slowly added 3.6ml TFA at 0°C. The reaction solution was stirred at RT for 3.5h, and then 50ml diethyl ether was added. The resulting precipitate was collected by filtration to yield 430mg of compd **65** as a white solid. ^{1}H NMR (400MHz; $DMSO_{d6}$) δ 11.57 (s, 1H), 10.77 (br s, 1H), 8.66 (s, 1H), 8.54 (s, 1H), 7.87 (m, 2H), 7.63 (m, 2H), 7.50-7.28 (m, 21H), 5.26-4.96 (m, 8H), 4.34-4.18 (m, 4H), 4.03 (s, 1H), 3.52-3.36 (m, 7H), 3.13 (m, 1H). MS/ESI (m+1) = 1019.4 (observed), MW = 1018.0 ($C_{53}H_{51}N_{11}O_{11}$).

Example 66: Preparation of N-[2-{(9H-fluoren-9-yl)methoxycarbonylamino}-ethyl)]-N-[2-{6-(benzyloxycarbonylamino)-2-[4-{2,3-bis(benzyloxycarbonyl)-guanidino}-butyl]amino-9H-purin-9-yl}acetyl]glycine (**66**).

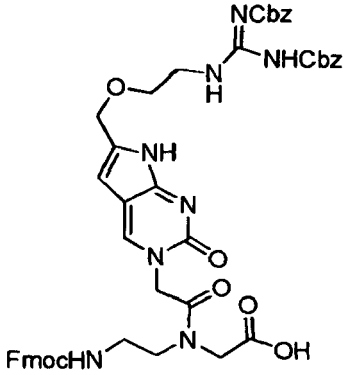
[0157]



[0158] Compd **59** was converted to compd **66** as a white foam/solid by similarly following the procedures described in Examples 63 ~ 65. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.84 (br s, 1H), 11.50 (s, 1H), 10.14-10.13 (m, 1H), 8.28 (m, 1H), 7.88 (m, 2H), 7.80-7.77 (m, 1H), 7.68-7.66 (m, 2H), 7.49 (t, 1H), 7.45-7.29 (m, 9H), 6.90 (m, 1H), 5.17 (s, 2H), 5.07 (s, 1.2H), 4.89 (s, 0.8H), 4.35-4.18 (m, 3H), 4.00 (s, 1H), 3.52 (m, 1H), 3.35-3.25 (m, 6H), 3.12 (m, 1H), 1.49 (m, 4H), 1.44 (d, 9H), 1.37 (d, 9H). MS/ESI (m+1) = 978.4 (observed), MW = 978.1 ($C_{49}H_{59}N_{11}O_{11}$).

Example 67: Preparation of N-[2-{(9H-fluoren-9-yl)methoxycarbonylamino}-ethyl)]-N-[2-[6-[2-{2,3-bis(benzyloxycarbonyl)guanidino}ethoxy]methyl-2-oxo-2H-pyrrolo[2,3-d]pyrimidin-3(7H)-yl]acetyl]glycine (**67**).

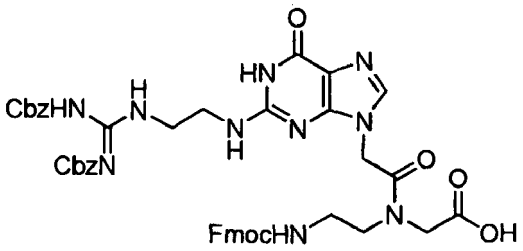
[0159]



[0160] Compd **18** was converted to compd **67** as a pale yellow solid by similarly following the procedures described in Examples 63 ~ 65. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 11.99 (br s, 1H), 11.57 (br, 1H), 8.56 (m, 1H), 8.48-8.45 (m, 1H), 7.89-7.87 (m, 2H), 7.70-7.65 (m, 2H), 7.49-7.26 (m, 15H), 6.36-6.33 (m, 1H), 5.20 (s, 2H), 5.03-5.01 (m, 3.3H), 4.83 (s, 0.7H), 4.49-4.17 (m, 5.7H), 4.01 (m, 1.3H), 3.57-3.11 (m, 8H); MS/ESI (m+1) = 899.7 (observed), MW = 898.9 ($C_{47}H_{46}N_8O_{11}$).

Example 68: Preparation of N-[2-{(9H-fluoren-9-yl)methoxycarbonylamino}-ethyl)]-N-{2-[2-{2,3-bis-(benzyloxycarbonyl)guanidino}ethyl]amino-6-oxo-6,9-dihydro-1H-purin-2-yl]acetyl}glycine (**68**).

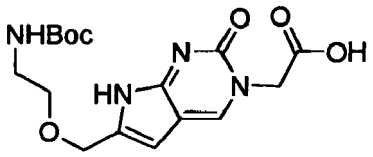
[0161]



[0162] Compd **62** was converted to compd **68** as a white foam/solid by following the procedures described in Examples 63 ~ 65. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 11.58 (s, 1H), 10.88 (s, 1H), 8.51 (m, 1H), 7.93 (m, 1H), 7.87 (m, 2H), 7.64 (m, 2H), 7.47 (t, 1H), 7.41-7.26 (m, 14H), 6.66 (br, 1H), 5.16-4.89 (m, 8H), 4.34-4.18 (m, 3.8H), 4.00 (m, 1.2H), 3.50-3.35 (m, 7H), 3.13 (m, 1H); MS/ESI (m+1) = 885.3 (observed), MW = 884.9 ($C_{45}H_{44}N_{10}O_{10}$).

Example 69: Preparation of 2-[6-{2-(t-butoxycarbonylamino)ethoxy}methyl-2-oxo-2H-pyrrolo-[2,3-d]pyrimidin-3(7H)-yl]acetic acid (**69**).

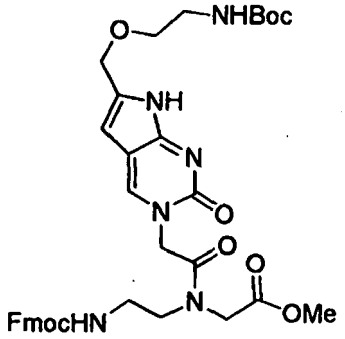
[0163]



[0164] Compound **16** was hydrolyzed to compound **69** as a pale brown solid by similarly following the procedure described in Example 11. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 13.03 (br s, 1H), 11.31 (s, 1H), 8.37 (s, 1H), 6.85 (t, 1H), 6.19 (s, 1H), 4.63 (s, 2H), 4.40 (s, 2H), 3.42 (t, 2H), 3.11 (q, 2H), 1.37 (s, 9H).

Example 70: Preparation of methyl N-[2-{(9H-fluoren-9-yl)methoxycarbonyl-amino}ethyl)]-N-{2-[6-{2-(t-butoxycarbonylamino)ethoxy}methyl-2-oxo-2H-pyrrolo-[2,3-d]pyrimidin-3(7H)-yl]acetyl}glycinate (**70**).

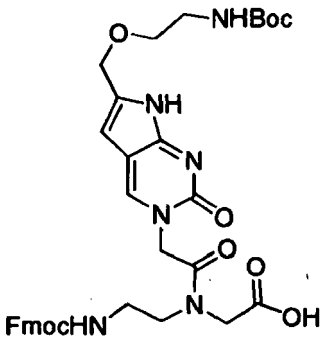
[0165]



[0166] 3.6g of compd **69**, 3.6g of Fmoc-Aeg-OMe, 2.5g of EDCI 1.73g of HOBt, and 2.24ml DIEA were dissolved in 70ml DMF, and stirred at RT for 1.5h. The reaction solvent was removed under reduced pressure, and the resulting residue was dissolved in 100ml MC and washed in series with 1M aq HCl, distilled water, and brine. The organic layer was dried over anhydrous sodium sulfate, concentrated in vacuo, and purified by column chromatography (100:2 MC/MeOH) to afford 2.5g of compd **70** as a yellow foam/solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 11.30 (s, 1H), 8.24 (s, 0.65H), 8.21 (s, 0.35H), 7.89-7.87 (m, 2H), 7.71-7.67 (m, 2H), 7.48-7.25 (m, 5H), 6.87 (t, 1H), 6.17 (s, 0.7H), 6.15 (s, 0.3H), 4.93 (s, 1.3H), 4.74 (s, 0.7H), 4.40-4.39 (m, 2.7H), 4.35-4.21 (m, 3H), 4.08 (s, 1.3H), 3.73 (s, 0.8H), 3.62 (s, 2.2H), 3.51 (t, 1.4H), 3.43-3.30 (m, 3.6H), 3.13-3.10 (m, 3H), 1.37 (s, 9H).

Example 71: Preparation of N-[2-{(9H-fluoren-9-yl)methoxycarbonylamino}-ethyl)]-N-{2-[6-{2-(t-butoxycarbonylamino)ethoxy}methyl-2-oxo-2H-pyrrolo-[2,3-d]pyrimidin-3(7H)-yl]acetyl}glycine (**71**).

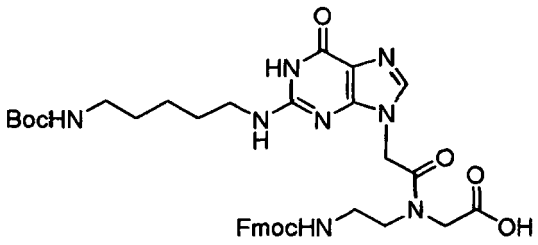
[0167]



[0168] To 5.0g of compd **70** dissolved in 75ml 1:1:1 acetonitrile/acetone/water, was slowly added at 0°C 28.5ml 2.5N aq LiOH. The reaction solution was stirred for 10min and neutralized with 20% aq citric acid. After the solution pH was adjusted to 8 with saturated aq sodium bicarbonate, 516mg of Fmoc-OSu was added to the solution and the solution was stirred for 2h at RT. Then the solution was acidified to pH 3 with 20% aq citric acid and stirred for 90min at 0°C. The resulting precipitate was collected by filtration to give 4.0g of compd **71** as a yellowish green solid. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.02 (br, 1H), 8.51-8.49 (m, 1H), 7.89-7.88 (d, 2H), 7.70-7.50 (m, 2H), 7.49 (t, 1H), 7.42-7.28 (m, 4H), 6.87 (t, 1H), 6.36 (s, 0.7H), 6.33 (s, 0.3H), 5.02 (s, 1.2H), 4.84 (0.8H), 4.43-4.42 (m, 2.4H), 4.34-4.19 (m, 3.2H), 4.01 (s, 1.4H), 3.48 (t, 1.2H), 3.44-3.41 (m, 2.1H), 3.37-3.29 (m, 2H), 3.12-3.10 (m, 2.7H), 1.37 (s, 9H); MS/ESI (m+1) = 689.3 (observed), MW = 688.7 ($C_{35}H_{40}N_6O_9$).

Example 72: Preparation of N-[2-{(9H-fluoren-9-yl)methoxycarbonylamino}-ethyl)]-N-{2-[5-{(t-butoxycarbonyl)amino}pentyl]amino-6-oxo-6,9-dihydro-1H-purin-2-yl]acetyl}glycine (72).

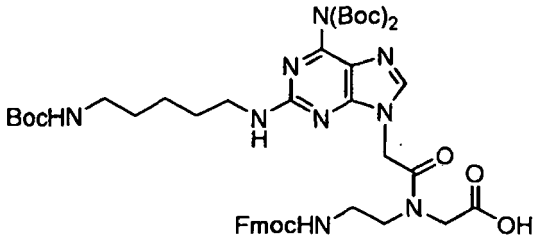
[0169]



[0170] Compd **51** was converted to compd **72** as a white foam/solid by similarly following the procedures described in Examples 69 ~ 71. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 13.01 (br, 1H), 10.52-10.46 (m, 1H), 7.88 (d, 2H), 7.65 (d, 2H), 7.54 (s, 0.5H), 7.50 (s, 0.5H), 7.48 (m, 1H), 7.40 (t, 2H), 7.31 (m, 2H), 6.81 (t, 0.5H), 6.72 (t, 0.5H), 6.52-6.48 (m, 1H), 4.98 (s, 1H), 4.77 (s, 1H), 4.33 (d, 1H), 4.23-4.21 (m, 2H), 4.05 (m, 1H), 3.96 (s, 1H), 3.50 (m, 1H), 3.35 (m, 2H), 3.21 (m, 2H), 3.14 (q, 1H), 2.88 (m, 2H), 1.46 (q, 2H), 1.39-1.35 (m, 11H), 1.23 (m, 2H); MS/ESI (m+1) = 717.4 (observed), MW = 716.8 ($C_{36}H_{44}N_8O_8$)

Example 73: Preparation of N-[2-{(9H-fluoren-9-yl)methoxycarbonylamino}-ethyl)]-N-[2-[6-{bis(t-butoxycarbonyl)amino}-2-{5-(t-butoxycarbonylamino)-pentyl}amino-9H-purin-9-yl]acetyl]glycine (**73**).

[0171]



[0172] Compd **61** was converted to compd **73** as a white foam/solid by similarly following the procedures described

in Examples 69 ~ 71. ^{1}H NMR (500MHz; $DMSO_{d6}$) δ 12.71 (br s, 1H), 7.90-7.87 (m, 3H), 7.67 (m, 2H), 7.44-7.39 (m, 3H), 7.31 (m, 2H), 7.07 (m, 1H), 6.69 (m, 1H), 5.11 (s, 1.2H), 4.93 (s, 0.8H), 4.37-4.21 (m, 3.8H), 4.01 (s, 1.2H), 3.52 (m, 1H), 3.36 (m, 2H), 3.23 (m, 2H), 3.13 (m, 1H), 2.88 (m, 2H), 1.49 (m, 2H), 1.38-1.35 (m, 27H), 1.27-1.25 (m, 4H); MS/ESI (m+1) = 916.5 (observed), MW = 916.0 ($C_{46}H_{61}N_9O_{11}$).

[0173] **Preparation of PNA Oligomers:** PNA monomers **o,** which were synthesized according to Scheme 4, were sent to Panagene, Inc (www.panagene.com, Daejon, South Korea) to prepare PNA oligomers of **Formula I** by Panagene according to the method described in the literature or with minor modification(s) thereof. (Org. Lett. vol 9, 3291-3293, 2006) PNA oligomers were received from Panagene as characterized by MALDI-TOF and analyzed by C_{18}-reverse phase HPLC. PNA oligomers received from Panagene were used without further purification.

[0174] PNA monomers **q** of Scheme 5 were used to synthesize PNA oligomers of **Formula I** according to the method disclosed in the prior art or with minor modification(s) thereof. (USP 6,133,444) Those PNA oligomers were purified by C_{18}-reverse phase HPLC (aq acetonitrile with 0.1% TFA) and characterized by MALDI-TOF. Figure 1 provides HPLC chromatograms before and after purification of Oligo 17 by reverse phase HPLC. Figure 2 provides a MALDI-TOF mass spectrum for a purified batch of Oligo 17. Figures 1 and 2 are provided for illustrative purposes only and should not be interpreted as a restriction to this invention.

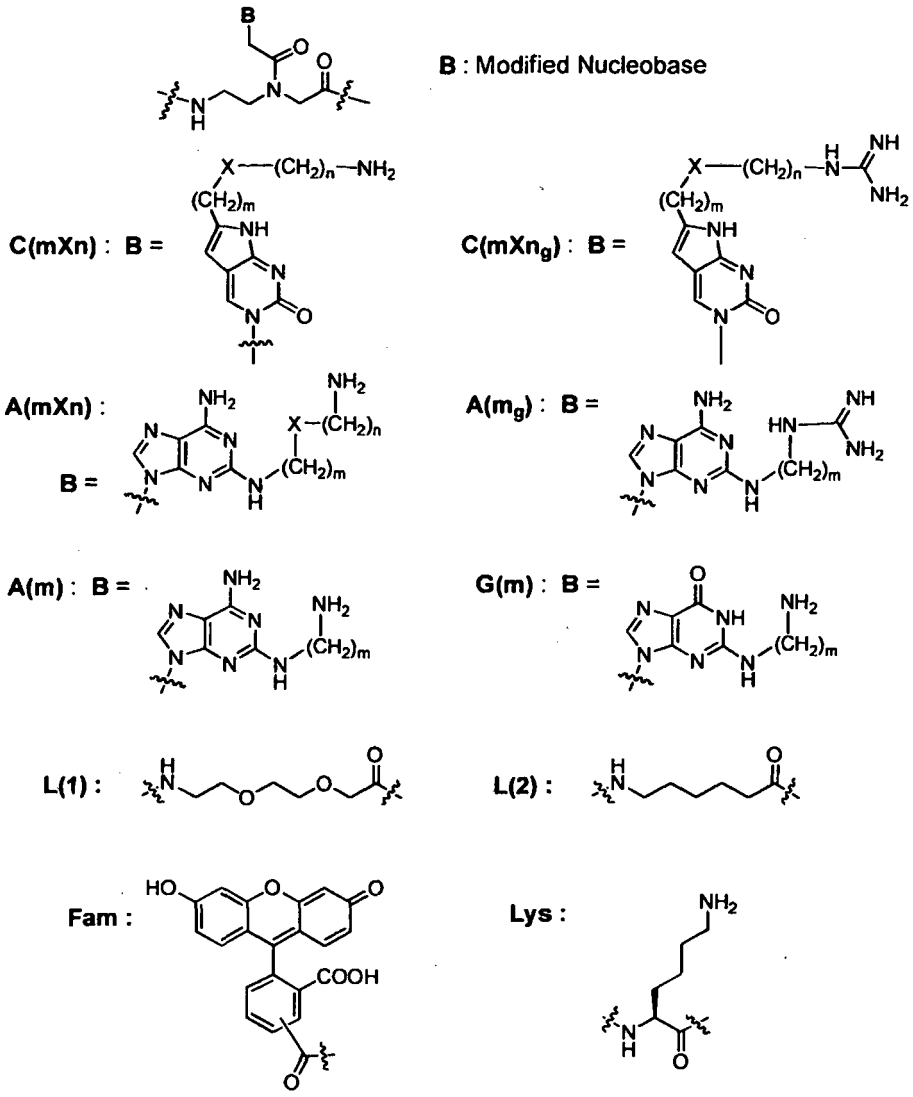
[0175] PNA oligomers synthesized for this invention are provided in Table 1 along with their molecular weight data by MALDI-TOF. Of the abbreviations used in Table 1, A, T, G, and C refer to unmodified nucleobase adenine, thymine, guanine, and cytosine, respectively. Modified nucleobases C(mXn), C(mXn_g), A(mXn), A(m), A(m_g), and G(m) are as defined below Table 1 along with Lys, Fam, L(1), and L(2). These PNA oligomers are presented for illustrative purposes only and should not be interpreted as a restriction to the present invention.

Table 1. PNA oligomers of this invention and mass spectral data thereof.[a]

Entry	Sequence (N → C)	MW	(m+1)[b]
Oligo 1	Fam-L(1)L(1)-TGC(1O3)-TAC(1O3)-TAC(1O3)-TG-Lys-NH_2	4079.0	4078.3
Oligo 2	Fam-L(1)L(1)-TGC-TAC-TAC-TG-Lys-NH_2	3745.6	3745.5
Oligo 3	TGC(1O3)-TAC-TAC(1O3)-TG-Lys-NHz	3319.4	3318.5
Oligo 4	TGC-TAC(1O3)-TAC-TG-Lys-NH_2	3208.3	3208.3
Oligo 5	TGC-TAC-TAC-TG-Lys-NH_2	3097.2	3097.8
Oligo 6	Fam-L(1)L(1)-TC(1O3)T-CC(1O3)C-AGC(1O3)-GTG-C(1O3)GC-C(1O3)AT-Lys-NH2	6140.1	6141.8
Oligo 7	Fam-L(1)L(1)-TCT-CCC-AGC-GTG-CGC-CAT-Lys-NH_2	5584.4	5583.1
Oligo 8	TGC(2O2)-TAC-TAC(202)-TG-Lys-NH_2	3319.4	3318.9
Oligo 9	GC(2O2)A-C(2O2)AT-TTG-C(2O2)CT-NH_2	3553.7	3552.7
Oligo 10	GC(1O2)A-C(1O2)AT-TTG-C(1O2)CT-NH_2	3511.6	3511.1
Oligo 11	GCA-CAT-TTG-CCT-Lys-NH_2	3348.3	3345.8
Oligo 12	CA(3)T-A(3)GT-A(3)TA-A(3)GT-NH_2	3580.8	3580.9
Oligo 13	CA(4)T-A(4)GT-A(4)TA-A(4)GT-NH_2	3636.9	3634.9
Oligo 14	CA(5)T-A(5)GT-A(5)TA-A(5)GT-NH_2	3693.0	3691.5
Oligo 15	CA(7)T-A(7)GT-A(7)TA-A(7)GT-NH_2	3805.0	3803.4
Oligo 16	CAT-AGT-ATA-AGT-Lys-NH_2	3420.3	3418.3
Oligo 17	CA(5)T-A(5)GT-A(5)TA-A(5)GT-Lys-NH_2	3820.9	3819.8
Oligo 18	CA(2O2)T-A(2O2)GT-A(2O2)TA-A(2O2)GT-NH_2	3700.7	3701.4
Oligo 19	L(1)-TAG(2O3)-CTG(2O3)-CTG-ATT-Lys-NH_2	3746.9	3748.9
Oligo 20	TG(5)G-C(1O2)AA-C(1O2)TG-A(5)T-Lys-NH_2	3525.6	3523.8
Oligo 21	Fam-L(2)-TG(5)G-C(102)AA-C(102)TG-A(5)T-Lys-NH_2	3997.0	3996.1
Oligo 22	Fam-L(2)-TT-C(1O2)AT-A(5)GT-A(5)TA-AG(5)T-Lys-NH_2	4806.9	4806.7
Oligo 23	Fam-L(2)L(2)-TC(1O2)A-GA(5)A-C(1O2)TT-A(5)T-Lys-NH_2	4084.2	4083.8

(continued)

Entry	Sequence (N → C)	MW	(m+1)[b]
Oligo 24	Fam-L(2)-CA(5)T-A(4_g)GT-A(4_g)TA(5)-AGT-Lys-NH_2	4348.5	4347.4
Oligo 25	TT-C(1O2$_g$)AT-A(5)GT-A(5)TA-AG(5)T-Lys-NH_2	4377.4	4375.6
Oligo 26	GC(1N3)A-C(1N3)AT-TTG-C(1N3)CT-NH_2	3550.8	3550.9
Oligo 27	CAT-AGT-ATA-AGT-NH_2	3292.3	3292.5
Oligo 28	Fam-L(2)-TGG-CAA-CTG-AT-Lys-NH_2	3617.5	3616.3
a. The employed abbreviations for monomers are defined as below. b. Observed ion peak for MH^+ unless noted otherwise.			



[0176] **Binding Affinity for DNA**: PNA oligomers of this invention were evaluated for their binding affinity for DNA by measuring T_m values as follows.

[0177] 4μM PNA oligomer and 4μM DNA were mixed in aq buffer (pH 7.16, 10mM sodium phosphate, 100mM NaCl), and incubated at 90°C for a few minutes and slowly cooled down to RT. Then the solution was transferred into a 4ml quartz cuvette and the cuvette was tightly sealed. The cuvette was mounted on an Agilent 8453 UV/Visible spectrophotometer and absorbance changes at 260nm were recorded with increasing the temperature of the cuvette by either 0.5 or 1.0°C per minute. From the absorbance vs temperature curve, the temperature showing the largest increase rate in absorbance was read out as the melting temperature T_m between PNA and DNA. DNAs for T_m measurement were

purchased either from Bioneer, Inc. (www.bioneer.com, Daejon, South Korea) or from Ahram Biosystems (www.ahram-bio.com, Seoul, South Korea), and used without further purification.

[0178] Figure 3 provides graphs of absorbance changes with temperature for Oligo 17 against complementary or mismatch DNA. For sequences of the mismatch DNAs against Oligo 17, refer to Table 2. In Figure 3, there is a transition temperature in each curve, which was read out as the T_m value for the curve.

[0179] T_m values are provided in Table 2 for PNA oligomers of this invention. These T_m values are presented for illustrative purposes only and should not be interpreted as a restriction to this invention.

Table 2. T_m values between PNA and complementary or mismatch DNA.

Entry	DNA Sequence (5' → 3')	T_m, °C	Remark
Oligo 5	CAG-TAG-TAG-CA	55	unmodified PNA oligomer
Oligo 3		65	C(1O3) x 2
Oligo 4		61	C(1O3) x 1
Oligo 8		68	C(2O2) x 2
Oligo 10	AGG-CAA-TTG-TGC	> 85	C(1O2) x 3
Oligo 11		59	unmodified PNA oligomer
Oligo 12	ACT-TAT-ACT-ATG	60	A(3) x 4
Oligo 13		64	A(4) x 4
Oligo 14		69	A(5) x 4
Oligo 15		71	A(7) x 4
Oligo 18		66	A(2O2) x 4
Oligo 27		55	unmodified PNA oligomer
Oligo 16	ACT-TAT-ACT-ATG	56	unmodified PNA oligomer
Oligo 17	ACT-TAT-ACT-ATG	72	complementary
	ACT-TA**C**-ACT-ATG	61	mismatch (T → C)
	ACT-T**AA**-ACT-ATG	59	mismatch (T → A)
	ACT-TA**G**-ACT-ATG	58	mismatch (T → G)
Oligo 24	ACT-TAT-ACT-ATG	70	A(5) x 2 plus $A(4_g)$ x 2
Oligo 20	ATC-AGT-TGC-CA	84	complementary
	ATC-A**T**T-TGC-CA	62	mismatch (G → T)
	ATC-A**A**T-TGC-CA	65	mismatch (G → A)

[0180] Replacement of cytosine with an unnatural nucleobase pyrrolocytosine derivative of this invention markedly increased PNA oligomer's affinity for complementary DNA. For example, Oligo 10 having three 'modified' cytosine 'C(1O2) monomers showed a T_m exceeding 85°C, while the corresponding 'unmodified' Oligo 11 showed a T_m of 58°C. Other modified cytosine monomers such as 'C(1O3) or 'C(2O2)' also significantly increased PNA oligomer's affinity for complementary DNA, as exemplified with Oligo 3 and Oligo 8.

[0181] 'Modified' adenine nucleobases of this invention also significantly increased PNA oligomer's affinity for complementary DNA. For example, Oligo 15 having four 'modified' adenine A(7) monomers showed a T_m of 71°C, which is significantly higher than the T_m of 55°C observed with 'unmodified' Oligo 27. Other 'modified' adenine monomers such as A(4), and A(5) also markedly increased affinity for complementary DNA.

[0182] 'Modified' PNA monomers of this invention were found to be quite sensitive to base mismatch. For example, decreases of 11 ~ 14°C in T_m were observed with single base mismatches for an A(5) monomer in Oligo 17. Single base mismatches for a C(102) monomer in Oligo 20 resulted in decreases of 19 ~ 22°C in T_m.

[0183] **Cell Penetration:** In order to evaluate the cell penetration ability of PNA oligomers of this invention, cancer cells of human origin were treated with PNA oligomers covalently tagged with fluorescein. The applied method is provided in brief as follows.

[0184] To each cover glass (autoclaved) placed in each well of a 24-well plate, were seeded 20,000 ~ 100,000 cells depending on the growth rate of the cell line used, and the cells were cultured at 37°C and 5% CO_2 for 16 to 24h. Then the medium was replaced with 500μl fresh Opti-MEM medium (with or without 1% FBS), to which was added an aliquot of aq stock solution of a PNA oligomer covalently tagged with fluorescein. After cells were cultured for a designated interval, the cells were washed with PBS, and fixed by incubating in 3.7% or 4% paraformaldehyde. The cells were thoroughly washed several times with PBS or PBS containing 0.1% Tween-20. Then the cover glass was mounted onto a slide glass using a drop of mounting solution and sealed with nail polish for confocal fluorescence microscopy. Fluorescence images were taken either on a Zeiss LSM 510 confocal microscope (Germany) at 63X objective or on a Nikon C1Si confocal microscope at 40X objective.

[0185] The cell penetration images in Figures 4~8 are provided for illustrative purposes only and should not be interpreted as a restriction to the present invention.

[0186] In Figure 4(a) and 4(b), are provided confocal microscopy images (at 63x objective) 1, 2, 3 and 24h after HeLa cells were treated with Oligo 1 and Oligo 2 at 5μM, respectively (without FBS). While fluorescence intensity is clear and becomes intense over 24h in Figure 4(a), fluorescence intensity is faint in Figure 4(b), indicating that Oligo 1 penetrates HeLa cells significantly faster than 'unmodified' Oligo 2.

[0187] In Figure 5(a) and 5(b), are provided confocal microscopy images (at 63x objective) 0.5 and 1h after MCF-7 cells were treated with Oligo 6 and Oligo 7 at 2.5μM, respectively (without FBS). While fluorescence intensity is clear and becomes intense over 1h in Figure 5(a), fluorescence intensity is faint in Figure 5(b), indicating that Oligo 6 penetrates MCF-7 cells significantly faster than 'unmodified' Oligo 7.

[0188] In Figure 6(a) and 6(b), are provided confocal microscopy pictures (at 40x objective) 6 or 24h after HeLa cells were treated with Oligo 1 and Oligo 6 at 1μM, respectively (with 1% FBS). While fluorescence intensity is faint even at 24h in Figure 6(a), fluorescence intensity is clear and becomes intense over 24h in Figure 6(b), suggesting that Oligo 6 penetrate HeLa Cells significantly faster than Oligo 1.

[0189] In Figure 7(a) and 7(b), are provided confocal microscopy pictures (40x objective) 24h after JAR cells were treated with Oligo 21 and Oligo 28 at 2μM, respectively (without FBS). While fluorescence intensity is strong in Figure 7(a), there is no significant fluorescence intensity in Figure 7(b), suggesting that Oligo 21 penetrate JAR cells significantly faster than 'unmodified' Oligo 28.

[0190] In Figure 7(c) and 7(d), are provided confocal microscopy pictures (at 40x objective) 24h after A549 cells were treated with Oligo 21 and Oligo 28 at 2μM, respectively (without FBS). While fluorescence intensity is strong in Figure 7(c), there is no significant fluorescence intensity in Figure 7(d), suggesting that Oligo 21 penetrate A549 cells significantly faster than 'unmodified' Oligo 28.

[0191] In Figure 7(e) and 7(f), are provided confocal microscopy pictures (at 40x objective) 12h after HeLa cells were treated with Oligo 21 and Oligo 28 at 2μM, respectively (without FBS). While fluorescence intensity is apparent in Figure 7(e), there is no significant fluorescence intensity in Figure 7(f), suggesting that Oligo 21 penetrate HeLa cells significantly faster than 'unmodified' Oligo 28.

[0192] In Figure 7(g), are provided confocal microscopy pictures (at 40x objective) 24h after HeLa cells were treated with Oligo 21 at 2μM (without FBS). Given that the celluar fluorescence in Figure 7(g) is significantly stronger than that in Figure 7(e), Oligo 21 appears to penetrate over 24h rather than 12h.

[0193] Figure 8(a), 8(b) and 8(c) provide confocal microscopy images (40x objective) 24h after HeLa, A549, and JAR cells were treated with 2μM Oligo 22, respectively (without FBS). All the images are associated with fluorescence within cell, indicating that Oligo 22 possesses good cell penetration in the tested cells.

[0194] **Antisense Example:** Oligo 9 and Oligo 12 possess the same base sequences as T1-12 and T5-12, respectively, which were reported to inhibit the ribosomal synthesis of mdm2 in the literature. *(*Nucleic Acids Res. vol 32, 4893-4902, 2004) Oligo 9 and Oligo 12 were evaluated for their ability to inhibit the ribosomal synthesis of mdm2 in JAR cells as follows. The following antisense example is presented for illustrative purposes only and should not be interpreted as a restriction to the present invention.

[0195] JAR cells (ATCC catalog # HTB-144) were grown in RPMI-1640 medium supplemented with 10% FBS and 1% penicillin-streptomycin at 37°C and 5% CO_2. Cells were then seeded into each well of a 12-well plate containing 1ml of the same medium, and treated with an aliquot of an aqueous stock solution of Oligo 9 or Oligo 12 of a designated concentration. Then the cells were incubated at 37°C and 5% CO_2 for 15h.

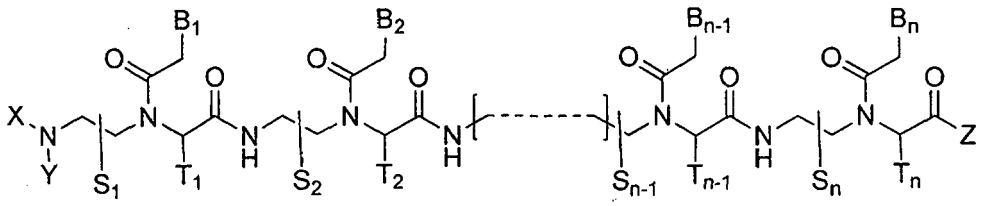
[0196] The cells in each well were washed with cold PBS and treated with 80μl RIPA buffer containing 1% protease inhibitors cocktail, and the plate was incubated at 4°C and agitated slowly for 15min. The content of each well was scraped out into a microtube. The microtube was incubated in ice for 10min and centrifuged at 10,000g. The resulting supernatant was collected and subjected to protein quantification by Bradford assay and western blot analysis. For electrophoresis, 20μg of protein was loaded onto each lane of the gel in a minigel apparatus, separated and transferred onto a PVDF membrane (0.45μ, Millipore). The primary mdm2 antibody used for western blotting was SC-965 (Santa Cruz Biotechnology).

[0197] Figure 9 provides western blotting results for JAR cells treated with 5μM or 10μM Oligo 9, 5μM or 10μM Oligo

10, cotreatment with the oligomers at 5μM or 10μM each, and blank (no oligomer treatment). In Figure 9, treatment with Oligo 9 or Oligo 10, or cotreatment with Oligo 9 and Oligo 10 significantly inhibited ribosomal synthesis of mdm2 in JAR cells both at 5μM and 10μM.

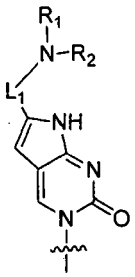
Claims

1. A peptide nucleic acid derivative of Formula I or a pharmaceutically acceptable salt thereof:

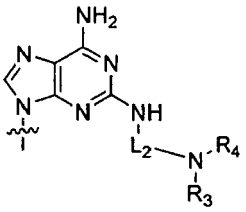


Formula I

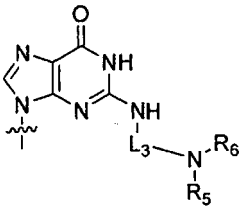
wherein,
n is an integer equal to or larger than 5;
S_1, S_2, ... S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n independently represent hydrogen, deuterium, substituted or non-substituted alkyl, or substituted or non-substituted aryl radical;
X and Y independently represent hydrogen, deuterium, substituted or non-substituted alkyl, substituted or non-substituted acyl, substituted or non-substituted sulfonyl, or substituted or non-substituted aryl radical;
Z represents hydroxy, substituted or non-substituted alkyloxy, substituted or non-substituted aryloxy, substituted or non-substitued amino, radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases; and,
at least one of B_1, B_2, ..., B_{n-1}, and B_n is independently selected from unnatural nucleobases represented by **Formula II, Formula III, or Formula IV:**



Formula II

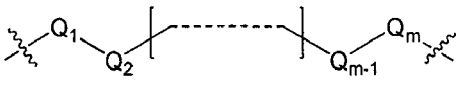


Formula III



Formula IV

wherein,
R_1, R_2, R_3, R_4, R_5 and R_6 are independently selected from substituted or non-substituted alkyl, and hydrogen radical; and,
L_1, L_2 and L_3 are a covalent linker represented by **Formula V** connecting a basic amino group to the moiety responsible for nucleobase pairing properties:



Formula V

wherein,

Q_1 and Q_m are substituted or non-substituted methylene ($-CH_2-$) radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and O_{m-1} are independently selected from substituted or non-substituted methylene, oxygen (-O-), sulfur (-S-), and substituted or non-substituted amino radical [-N(H)-, or -N(substituent)-]; and,
m is an integer from 2 to 15.

2. The peptide nucleic acid derivative according to Claim 1 or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer from 5 to 30;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, substituted or non- substituted alkyl, substituted or non-substituted acyl, substituted or non- substituted sulfonyl radical;
Z represents hydroxy, substituted or non-substituted alkyloxy, substituted or non-substituted aryloxy, substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases; and,
at least one of B_1, B_2, ..., B_{n-1}, and B_n is independently selected from unnatural nucleobases represented by **Formula II, Formula III, or Formula IV.**

3. The peptide nucleic acid derivative according to Claim 1 or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer from 8 to 25;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ... T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, substituted or non-substituted alkyl, substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases;
at least two of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III, or Formula IV;**
R_1, R_2, R_3, R_4, R_5 and R_6 are independently selected from substituted or non-substituted alkyl, and hydrogen radical;
Q_1 and Q_m are substituted or non-substituted methylene radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen, and amino radical; and,
m is an integer from 2 to 12.

4. The peptide nucleic acid derivative according to Claim 1 or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer from 10 to 25;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, and substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases;
at least three of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III, or Formula IV;**
R_1, R_2, R_3, R_4, R_5 and R_6 are independently selected from substituted or non-substituted alkyl, and hydrogen radical;
Q_1 and Q_m are methylene radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from methylene, oxygen, and amino radical; and,
m is an integer from 2 to 10.

5. The peptide nucleic acid derivative according to Claim 1 or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer from 10 to 20;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, and substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from natural nucleobases including adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases;
at least three of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II**, **Formula III,** or **Formula IV;**
R_1, R_3, and R_5 are hydrogen radical, and R_2, R_4 and R_6 are independently represent hydrogen, or substituted or non-substituted amindinly radical;
Q_1 and Q_m are methylene radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from methylene, oxygen, and amino radical; and,
m is an integer from 2 to 10.

6. The peptide nucleic acid derivative according to Claim 1 or a pharmaceutically acceptable salt thereof:

wherein,
n is an integer from 10 to 20;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, and T_n are hydrogen radical;
X and Y are independently selected from hydrogen, and substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., b_{n-1}, and B_n are independently selected from adenine, thymine, guanine, cytosine and uracil, and unnatural nucleobases;
at least three of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III,** or **Formula IV**;
R_1, R_3, and R_5 are hydrogen radical, and R_2, R_4, and R_6 independently represent hydrogen, or amidinyl radical;
Q_1 and Q_m are methylene radical, and Q_m is directly linked to the basic amino group;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from methylene, and oxygen radical; and,
m is an integer from 2 to 8.

7. The peptide nucleic acid derivative according to Claim 1 or a pharmaceutically acceptable salt thereof:

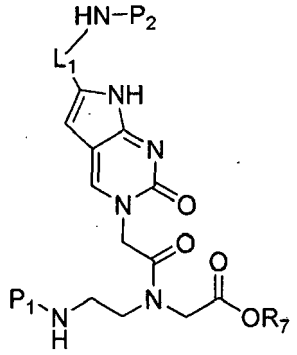
wherein,
n is an integer from 8 to 20;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, T_{n-1}, and T_n are hydrogen radical;
X is hydrogen radical;
Y represents hydrogen, or substituted or non-substituted acyl radical;
Z represents hydroxy, or substituted or non-substituted amino radical;
B_1, B_2, ..., B_{n-1}, and B_n are independently selected from adenine, thymine, guanine, cytosine, and unnatural nucleobases;
at least three of B_1, B_2, ..., B_{n-1}, and B_n are independently selected from unnatural nucleobases represented by **Formula II, Formula III,** or **Formula IV;**
R_1, R_3, and R_5 are hydrogen radical, and R_2, R_4, and R_6 independently represents hydrogen or amidinyl radical;
L_1 represents $-(CH_2)_2-O-(CH_2)_2-$, $-CH_2-O-(CH_2)_2-$, or $-CH_2-O-(CH_2)_3-$ with the right end is directly linked to the basic amino group; and,
L_2 and L_3 are independently selected from $-(CH_2)_2-O-(CH_2)_2-$, $-(CH_2)_3-O-(CH_2)_2-$, $-(CH_2)_2-O-(CH_2)_3-$, $-(CH_2)_2-$, $-(CH_2)_3-$, $-(CH_2)_4-$, $-(CH_2)_5-$, $-(CH_2)_6-$, $-(CH_2)_7-$, and $-(CH_2)_8-$ with the right end is directly linked to the basic amino group.

8. A pharmaceutical composition containing a therapeutically effective amount of the peptide nucleic acid derivative of any one of Claims 1 ~ 7 or a pharmaceutically acceptable salt thereof for a therapeutic purpose.

9. A method to use the peptide nucleic acid derivative of any one of Claims 1 ~ 7 or a salt thereof for a diagnostic purpose.

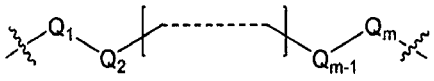
10. A method to use the peptide nucleic acid derivative of any one of Claims 1 ~ 7 or a salt thereof for in vitro modulation of cellular protein expression.

11. A compound of **Formula VI:**



Formula VI

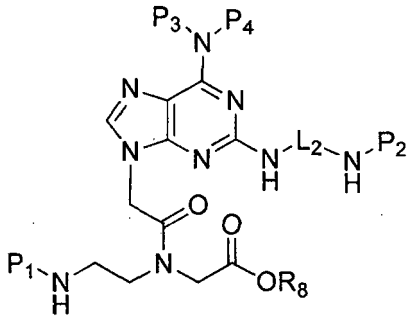
wherein,
R_7 is hydrogen, N-succinyl, or substituted or non-substituted alkyl radical;
P_1 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, and substituted or non-substituted arylsulfonyl radical;
P_2 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, substituted alkyloxycarbonyl, substituted or non-substituted alkyl, amidinyl, 1,3-bis(t-butoxy-carbonyl)amidinyl, 1,3-bis-(benzyloxycarbonyl)amidinyl radical; and,
L_1 is a linker represented by **Formula V**:



Formula V

wherein,
Q_1 and Q_m are substituted or non-substituted methylene radical, and Q_m is directly linked to the amino radical;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen, sulfur, and substituted or non-substituted amino radical; and,
m is an integer from 2 to 15.

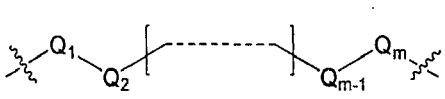
12. A compound of **Formula VII:**



Formula VII

wherein,
R_8 is hydrogen, N-succinyl, or substituted or non-substituted alkyl radical;
P_1 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, and substituted or non-substituted arylsulfonyl radical;
P_2 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, substituted alkyloxycarbonyl, substituted or non-substituted alkyl, amidinyl, 1,3-bis(t-butoxy-carbonyl)amidinyl, 1,3-bis-(benzyl-oxycarbonyl)amidinyl radical;
P_3 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl radical;

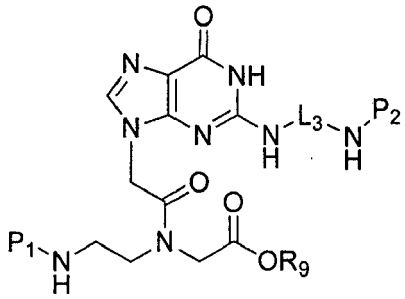
P_4 is selected from hydrogen, and t-butoxycarbonyl radical; and,
L_2 is a linker represented by **Formula V**:



Formula V

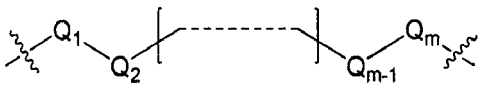
wherein,
Q_1 and Q_m are substituted or non-substituted methylene radical, and Q_m is directly linked to the amino radical;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen, sulfur, and substituted or non-substituted amino radical; and,
m is an integer from 2 to 15.

13. A compound of **Formula VIII:**



Formula VIII

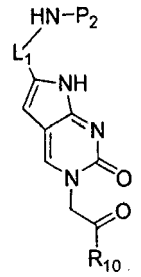
wherein,
R_9 is hydrogen, N-succinyl, or substituted or non-substituted alkyl radical;
P_1 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, and substituted or non-substituted arylsulfonyl radical;
P_2 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, substituted alkyloxycarbonyl, substituted or non-substituted alkyl, amidinyl, 1,3-bis(t-butoxy-carbonyl)amidinyl, 1,3-bis-(benzyl-oxycarbonyl)amidinyl radical; and,
L_3 is a linker represented by **Formula V**:



Formula V

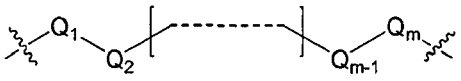
wherein,
Q_1 and Q_m are substituted or non-substituted methylene radical, and Q_m is directly linked to the amino radical;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen, sulfur, and substituted or non-substituted amino radical; and,
m is an integer from 2 to 15.

14. A compound of **Formula IX:**



Formula IX

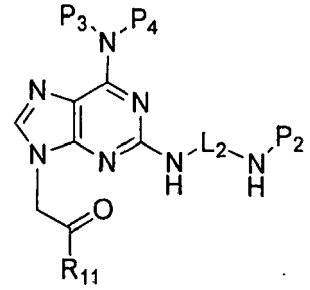
wherein,
R_{10} is hydroxy, substituted or non-substituted alkyloxy, or substituted or non-substituted amino radical;
P_2 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, substituted alkyloxycarbonyl, substituted or non-substituted alkyl, amidinyl, 1,3-bis(t-butoxy-carbonyl)amidinyl, 1,3-bis-(benzyloxycarbonyl)amidinyl radical; and,
L_1 is a linker represented by **Formula V:**



Formula V

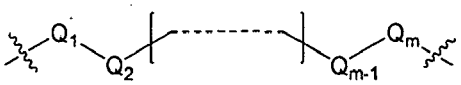
wherein,
Q_1 and Q_m are substituted or non-substituted methylene radical, and Q_m is directly linked to the amino radical;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen, sulfur, and substituted or non-substituted amino radical; and,
m is an integer from 2 to 15.

15. A compound of **Formula X:**



Formula X

wherein,
R_{11} is hydroxy, substituted or non-substituted alkyloxy, or substituted or non-substituted amino radical;
P_2 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, substituted alkyloxycarbonyl, substituted or non-substituted alkyl, amidinyl, 1,3-bis(t-butoxy-carbonyl)amidinyl, 1,3-bis-(benzyl-oxycarbonyl)amidinyl radical;
P_3 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl radical;
P_4 is selected from hydrogen, and t-butoxycarbonyl radical; and,
L_2 is a linker represented by **Formula V**:

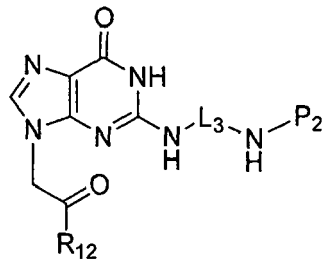


Formula V

wherein,
Q_1 and Q_m are substituted or non-substituted methylene radical, and Q_m is directly linked to the amino radical;

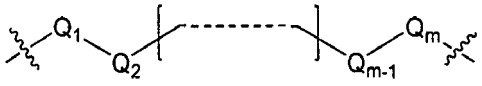
Q_2, Q_3 ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen, sulfur, and substituted or non-substituted amino radical; and,
m is an integer from 2 to 15.

16. A compound of **Formula XI:**



Formula XI

wherein,
R_{12} is hydroxy, substituted or non-substituted alkyloxy, or substituted or non-substituted amino radical;
P_2 is selected from hydrogen, t-butoxycarbonyl, (9H-fluoren-9-yl)methoxy-carbonyl, substituted or non-substituted benzyloxycarbonyl, substituted alkyloxycarbonyl, substituted or non-substituted alkyl, amidinyl, 1,3-bis(t-butoxy-carbonyl)amidinyl, 1,3-bis-(benzyl-oxycarbonyl)amidinyl radical; and,
L_3 is a linker represented by **Formula V:**

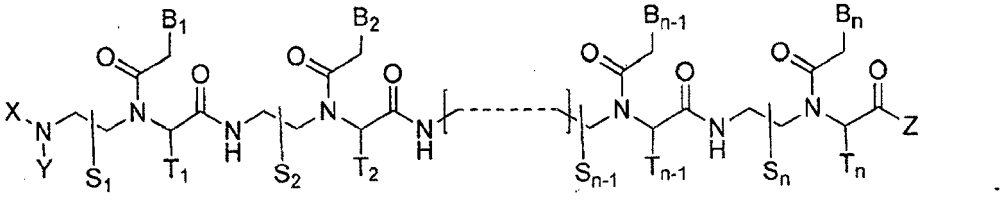


Formula V

wherein,
Q_1 and Q_m are substituted or non-substituted methylene radical, and Q_m is directly linked to the amino radical;
Q_2, Q_3, ..., and Q_{m-1} are independently selected from substituted or non-substituted methylene, oxygen, sulfur, and substituted or non-substituted amino radical; and,
m is an integer from 2 to 15.

Patentansprüche

1. Peptidnukleinsäurederivat der **Formel I** oder ein pharmazeutisch annehmbares Salz davon:

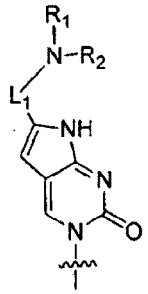


Formel I

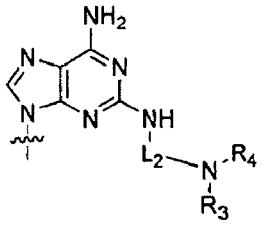
worin

n eine ganze Zahl größer oder gleich 5 ist;
S_1, S_2, S_{n-1}, S_n, T_1, T_2, ..., T_{n-1} und T_n unabhängig für Wasserstoff, Deuterium, substituierten oder unsubstituierten Alkyl- oder substituierten oder unsubstituierten Arylrest stehen;
X und Y unabhängig für Wasserstoff, Deuterium, substituierten oder unsubstituierten Alkyl-, substituierten oder

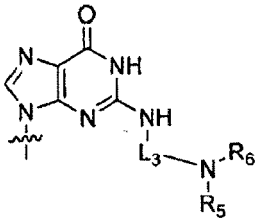
unsubstituierten Acyl-, substituierten oder unsubstituierten Sulfonyl- oder substituierten oder unsubstituierten Arylrest stehen;
Z für Hydroxy-, substituierten oder unsubstituierten Alkyloxy-, substituierten oder unsubstituierten Aryloxy-, substituierten oder unsubstituierten Aminorest steht;
B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt sind aus natürlichen Nukleinbasen einschließlich Adenin, Thymin, Guanin, Cytosin und Uracil, und nicht-natürlichen Nukleinbasen; und
mindestens eines von B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt ist aus nicht-natürlichen Nukleinbasen, die von **Formel II, Formel III** oder **Formel IV** dargestellt werden:



Formel II

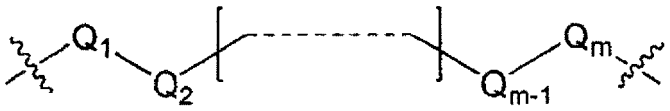


Formel III



Formel IV

worin
R_1, R_2, R_3, R_4, R_5 und R_6 unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Alkyl- und Wasserstoffrest; und
L_1, L_2 und L_3 eine kovalente Verknüpfungsgruppe sind, die von der **Formel V** dargestellt wird und die eine basische Aminogruppe mit der Einheit verbindet, die für Nukleinbasenpaarungseigenschaften verantwortlich ist:



Formel V

worin
Q_1 und Q_m substituierter oder unsubstituierter Methylen (-CH_2-)-Rest sind und Q_m direkt mit der basischen Aminogruppe verknüpft ist;
Q_2, Q_3, ... und Q_{m-1} unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Methylen-, Sauerstoff- (-O-), Schwefel- (-S-) und substituiertem oder unsubstituiertem Aminorest [-N(H)- oder -N(Substituent)-]; und m eine ganze Zahl von 2 bis 15 ist.

2. Peptidnukleinsäurederivat nach Anspruch 1 oder ein pharmazeutisch annehmbares Salz davon:

worin
n eine ganze Zahl von 5 bis 30 ist;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1} und T_n Wasserstoffrest sind;
X und Y unabhängig ausgewählt sind aus Wasserstoff, substituiertem oder unsubstituiertem Alkyl-, substituiertem oder unsubstituiertem Acyl-, substituiertem oder unsubstituiertem Sulfonylrest;
Z für Hydroxy-, substituierten oder unsubstituierten Alkyloxy-, substituierten oder unsubstituierten Aryloxy-, substituierten oder unsubstituierten Aminorest steht;
B_1, B_2, B_{n-1} und B_n unabhängig ausgewählt sind aus natürlichen Nukleinbasen einschließlich Adenin, Thymin, Guanin, Cytosin und Uracil, und nicht-natürlichen Nukleinbasen; und
mindestens eines von B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt ist aus nicht-natürlichen Nukleinbasen, die von **Formel II, Formel III** oder **Formel IV** dargestellt werden.

3. Peptidnukleinsäurederivat nach Anspruch 1 oder ein pharmazeutisch annehmbares Salz davon, wobei
n eine ganze Zahl von 8 bis 25 ist;
S_1, S_2 S_{n-1}, S_n, T_1, T_2, ..., T_{n-1} und T_n Wasserstoffrest sind;
X und Y unabhängig ausgewählt sind aus Wasserstoff, substituiertem oder unsubstituiertem Alkyl-, substituiertem oder unsubstituiertem Acylrest;
Z für Hydroxy- oder substituierten oder unsubstituierten Aminorest steht;
B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt sind aus natürlichen Nukleinbasen einschließlich Adenin, Thymin, Guanin, Cytosin und Uracil, und nicht-natürlichen Nukleinbasen;
mindestens zwei von B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt ist aus nicht-natürlichen Nukleinbasen, die von **Formel II**, **Formel III** oder **Formel IV** dargestellt werden;
R_1, R_2, R_3, R_4, R_5 und R_6 unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Alkyl- und Wasserstoffrest;
Q_1 und Q_m substituierter oder unsubstituierter Methylenrest sind und Q_m direkt mit der basischen Aminogruppe verknüpft ist;
Q_2, Q_3, ..., Q_{m-1} unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Methylen-, Sauerstoff- und Aminorest; und m eine ganze Zahl von 2 bis 12 ist.

4. Peptidnukleinsäurederivat nach Anspruch 1 oder ein pharmazeutisch annehmbares Salz davon, wobei
n eine ganze Zahl von 10 bis 25 ist;
S_1, S_2, S_{n-1}, S_n, T_1, T_2, T_{n-1} und T_n Wasserstoffrest sind;
X und Y unabhängig ausgewählt sind aus Wasserstoff- und substituiertem oder unsubstituiertem Acylrest;
Z für Hydroxy- oder substituierten oder unsubstituierten Aminorest steht;
B_1, B_2, ... B_{n-1} und B_n unabhängig ausgewählt sind aus natürlichen Nukleinbasen einschließlich Adenin, Thymin, Guanin, Cytosin und Uracil, und nicht-natürlichen Nukleinbasen;
mindestens drei von B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt sind aus nicht-natürlichen Nukleinbasen, die von **Formel II, Formel III** oder **Formel IV** dargestellt werden;
R_1, R_2, R_3, R_4, R_5 und R_6 unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Alkyl- und Wasserstoffrest;
Q_1 und Q_m Methylenrest sind und Q_m direkt mit der basischen Aminogruppe verknüpft ist; Q_2, Q_3 und Q_{m-1} unabhängig ausgewählt sind aus Methylen-, Sauerstoff- und Aminorest; und
m eine ganze Zahl von 2 bis 10 ist.

5. Peptidnukleinsäurederivat nach Anspruch 1 oder ein pharmazeutisch annehmbares Salz davon:

worin
n eine ganze Zahl von 10 bis 20 ist;
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, T_{n-1} und T_n Wasserstoffrest sind;
X und Y unabhängig ausgewählt sind aus Wasserstoff- und substituiertem oder unsubstituiertem Acylrest;
Z für Hydroxy- oder substituierten oder unsubstituierten Aminorest steht;
B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt sind aus natürlichen Nukleinbasen einschließlich Adenin, Thymin, Guanin, Cytosin und Uracil, und nicht-natürlichen Nukleinbasen;
mindestens drei von B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt sind aus nicht-natürlichen Nukleinbasen, die von **Formel II, Formel III** oder **Formel IV** dargestellt werden;
R_1, R_3 und R_5 Wasserstoffrest sind und R_2, R_4 und R_6 unabhängig für Wasserstoff oder substituierten oder unsubstituierten Amidinylrest stehen;
Q_1 und Q_m Methylenrest sind und Q_m direkt mit der basischen Aminogruppe verknüpft ist;
Q_2, Q_3, ..., und Q_{m-1} unabhängig ausgewählt sind aus Methylen, Sauerstoff und Aminorest; und
m eine ganze Zahl von 2 bis 10 ist.

6. Peptidnukleinsäurederivat nach Anspruch 1 oder ein pharmazeutisch annehmbares Salz davon:

worin
n eine ganze Zahl von 10 bis 20 ist;
S_1, S_2, S_{n-1}, S_n, T_1, T_2, T_{n-1} und T_n Wasserstoffrest sind;
X und Y unabhängig ausgewählt sind aus Wasserstoff und substituiertem oder unsubstituiertem Acylrest;
Z für Hydroxy- oder substituierten oder unsubstituierten Aminorest steht;
B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt sind aus Adenin, Thymin, Guanin, Cytosin und Uracil und nicht-

natürlichen Nukleinbasen;
mindestens drei von B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt sind aus nicht-natürlichen Nukleinbasen, die von **Formel II, Formel III** oder **Formel IV** dargestellt werden;
R_1, R_3 und R_5 Wasserstoffrest sind und R_2, R_4 und R_6 unabhängig für Wasserstoff- oder substituierten oder unsubstituierten Amidinylrest stehen;
Q_1 und Q_m Methylenrest sind und Q_m direkt mit der basischen Aminogruppe verknüpft ist;
Q_2, Q_3, ..., und Q_{m-1} unabhängig ausgewählt sind aus Methylen- und Sauerstoffrest; und
m eine ganze Zahl von 2 bis 8 ist.

7. Peptidnukleinsäurederivat nach Anspruch 1 oder ein pharmazeutisch annehmbares Salz davon:

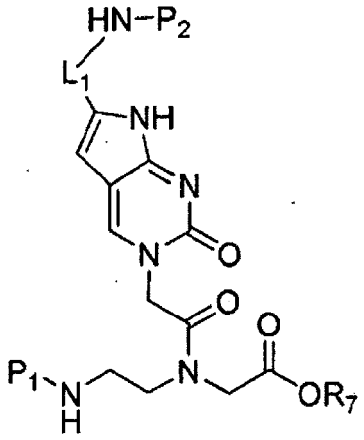
worin
n eine ganze Zahl von 8 bis 20 ist;
Si, S_2, ... S_{n-1}, S_n, T_1, T_2, ... T_{n-1} und T_n Wasserstoffrest sind;
X Wasserstoffrest ist;
Y für Wasserstoff- oder substituierten oder unsubstituierten Acylrest steht;
Z für Hydroxy- oder substituierten oder unsubstituierten Aminorest steht;
B_1, B_2, ..., B_{n-1} und B_n unabhängig ausgewählt sind aus Adenin, Thymin, Guanin, Cytosin und nicht-natürlichen Nukleinbasen;
mindestens drei von B_1, B_2, ... B_{n-1} und B_n unabhängig ausgewählt sind aus nicht-natürlichen Nukleinbasen, die von Formel II, Formel **III** oder Formel IV dargestellt werden;
R_1, R_3 und R_5 Wasserstoffrest sind und R_2, R_4 und R_6 unabhängig Wasserstoff- oder Amidinylrest darstellen;
L_1 für $-(CH_2)_2-O-(CH_2)_2-$, $-CH_2-O-(CH_2)_2-$ oder $-CH_2-O-(CH_2)_3-$ steht, wobei das rechte Ende direkt mit der basischen Aminogruppe verknüpft ist; und
L_2 und L_3 unabhängig ausgewählt sind aus $-(CH_2)_2-O-(CH_2)_2-$, $-(CH_2)_3-O-(CH_2)_2-$, $-(CH_2)_2-O-(CH_2)_3-$, $-(CH_2)_2-$, $-(CH_2)_3-$, $-(CH_2)_4-$, $-(CH_2)_5-$, $-(CH_2)_6-$, $-(CH_2)_7-$ und $-(CH_2)_8-$, wobei das rechte Ende direkt mit der basischen Aminogruppe verknüpft ist.

8. Pharmazeutische Zusammensetzung, eine therapeutisch wirksame Menge des Peptidnukleinsäurederivats nach einem der Ansprüche 1-7 oder ein pharmazeutisch annehmbares Salz davon enthaltend, für einen therapeutischen Zweck.

9. Verfahren zur Verwendung des Peptidnukleinsäurederivats nach einem der Ansprüche 1-7 oder eines Salzes davon für einen therapeutischen Zweck.

10. Verfahren zur Verwendung des Peptidnukleinsäurederivats nach einem der Ansprüche 1-7 oder eines Salzes davon für eine in-vitro-Modulation von zellulärer Proteinexpression.

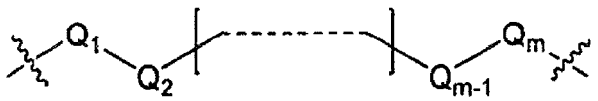
11. Verbindung der **Formel VI:**



Formel VI

worin

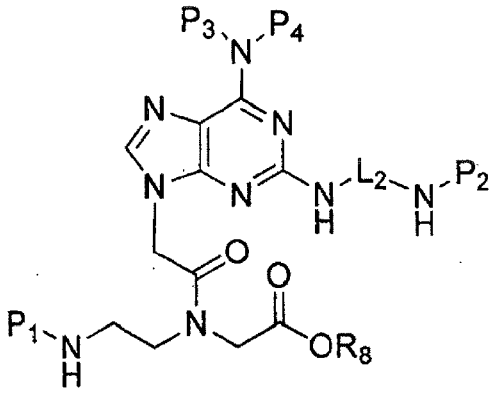
R_7 für Wasserstoff-, N-Succinyl- oder substituierten oder unsubstituierten Alkylrest steht; P_1 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl- und substituiertem oder unsubstituiertem Arylsulfonylrest;
P_2 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl-, substituiertem Alkyloxycarbonyl-, substituiertem oder unsubstituiertem Alkyl-, Amidinyl-, 1,3-Bis(t-butoxycarbonyl)amidinyl-, 1,3-Bis-(benzyloxycarbonyl)amidinylrest; und
L_1 eine Verknüpfungsgruppe ist, die von **Formel V** dargestellt wird:



Formel V

worin
Q_1 und Q_m substituierter oder unsubstituierter Methylenrest sind und Q_m direkt mit dem Aminorest verknüpft ist; Q_2, Q_3, ..., und Q_{m-1} unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Methylen-, Sauerstoff-, Schwefel- und substituiertem oder unsubstituiertem Aminorest; und m eine ganze Zahl von 2 bis 15 ist.

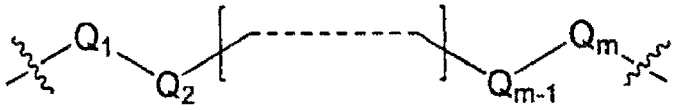
12. Verbindung der **Formel VII:**



Formel VII

worin

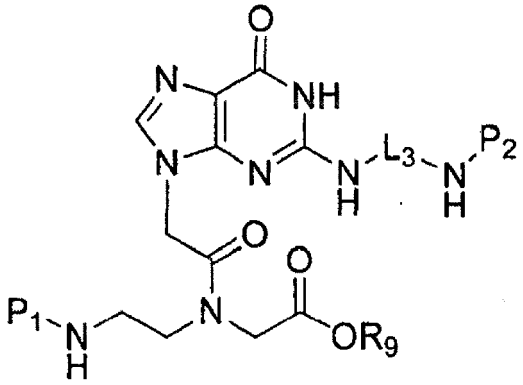
R_8 für Wasserstoff-, N-Succinyl- oder substituierten oder unsubstituierten Alkylrest steht; P_1 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl- und substituiertem oder unsubstituiertem Arylsulfonylrest;
P_2 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl-, substituiertem Alkyloxycarbonyl-, substituiertem oder unsubstituiertem Alkyl-, Amidinyl-, 1,3-Bis(t-butoxycarbonyl)amidinyl-, 1,3-Bis-(benzyloxycarbonyl)amidinylrest;
P_3 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonylrest;
P_4 ausgewählt ist aus Wasserstoff- und t-Butoxycarbonylrest; und
L_2 eine Verknüpfungsgruppe ist, die von **Formel V** dargestellt wird:



Formel V

worin
Q_1 und Q_m substituierter oder unsubstituierter Methylenrest sind und Q_m direkt mit dem Aminorest verknüpft ist;
Q_2, Q_3 und Q_{m-1} unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Methylen-, Sauerstoff-, Schwefel- und substituiertem oder unsubstituiertem Aminorest; und
m eine ganze Zahl von 2 bis 15 ist.

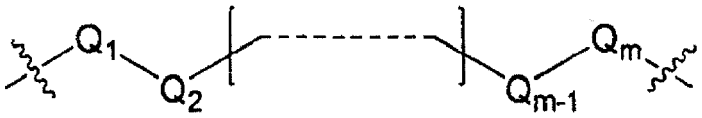
13. Verbindung der **Formel VIII:**



Formel VIII

worin

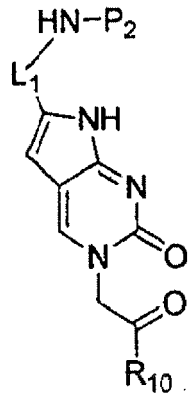
R_9 für Wasserstoff-, N-Succinyl- oder substituierten oder unsubstituierten Alkylrest steht; P_1 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl- und substituiertem oder unsubstituiertem Arylsulfonylrest;
P_2 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)methoxy-carbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl-, substituiertem Alkyloxycarbonyl-, substituiertem oder unsubstituiertem Alkyl-, Amidinyl-, 1,3-Bis-(t-butoxycarbonyl)amidinyl-, 1,3-Bis-(benzyloxycarbonyl)amidinylrest; und
L_3 eine Verknüpfungsgruppe ist, die dargestellt wird durch die **Formel V:**



Formel V

worin
Q_1 und Q_m substituierter oder unsubstituierter Methylenrest sind und Q_m direkt mit dem Aminorest verknüpft ist;
Q_2, Q_3 und Q_{m-1} unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Methylen-, Sauerstoff-, Schwefel- und substituiertem oder unsubstituiertem Aminorest; und
m eine ganze Zahl von 2 bis 15 ist.

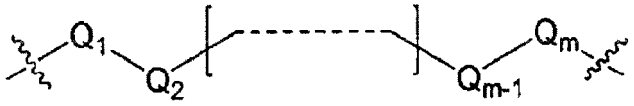
14. Verbindung der **Formel X:**



Formel IX

worin

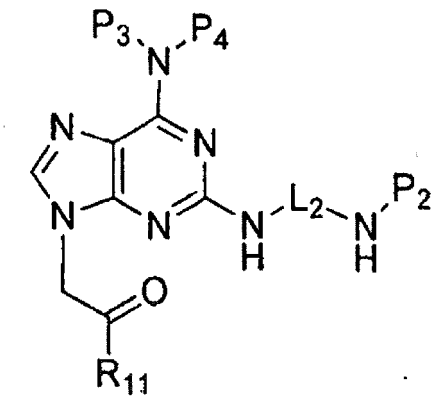
R_{10} Hydroxy-, substituierter oder unsubstituierter Alkyloxy- oder substituierter oder unsubstituierter Aminorest ist;
P_2 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl-, substituiertem Alkyloxycarbonyl-, substituiertem oder unsubstituiertem Alkyl-, Amidinyl-, 1,3-Bis(t-butoxycarbonyl)amidinyl-, 1,3-Bis-(benzyloxycarbonyl)amidinylrest; und,
L_1 eine Verknüpfungsgruppe ist, die von **Formel V** dargestellt wird:



Formel V

worin
Q_1 und Q_m substituierter oder unsubstituierter Methylenrest sind und Q_m direkt mit dem Aminorest verknüpft ist;
Q_2, Q_3 und Q_{m-1} unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Methylen-, Sauerstoff-, Schwefel- und substituiertem oder unsubstituiertem Aminorest; und
m eine ganze Zahl von 2 bis 15 ist.

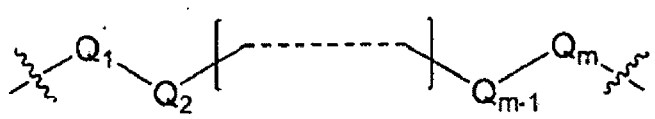
15. Verbindung der **Formel X:**



Formel X

worin

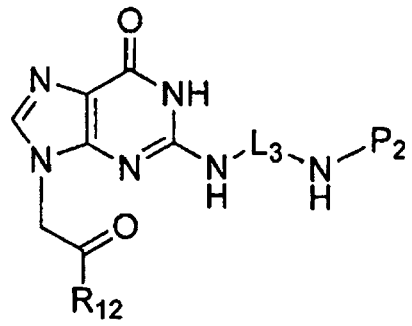
R_{11} Hydroxy-, substituierter oder unsubstituierter Alkyloxy- oder substituierter oder unsubstituierter Aminorest ist;
P_2 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl-, substituiertem Alkyloxycarbonyl-, substituiertem oder unsubstituiertem Alkyl-, Amidinyl-, 1,3-Bis(t-butoxycarbonyl)amidinyl-, 1,3-Bis-(benzyloxycarbonyl)amidinylrest;
P_3 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)-methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonylrest;
P_4 ausgewählt ist aus Wasserstoff- und t-Butoxycarbonylrest; und
L_2 eine Verknüpfungsgruppe ist, die dargestellt wird durch die **Formel V:**



Formel V

worin
Q_1 und Q_m substituierter oder unsubstituierter Methylenrest sind und Q_m direkt mit dem Aminorest verknüpft ist;
Q_2, Q_3, ..., und Q_{m-1} unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Methylen-, Sauerstoff-, Schwefel- und substituiertem oder unsubstituiertem Aminorest; und
m eine ganze Zahl von 2 bis 15 ist.

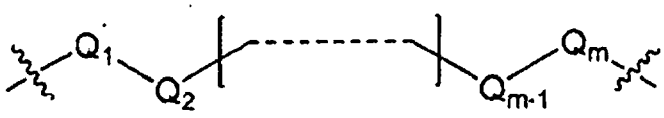
16. Verbindung der **Formel XI:**



Formel XI

worin

R_{12} Hydroxy-, substituierter oder unsubstituierter Alkyloxy- oder substituierter oder unsubstituierter Aminorest ist;
P_2 ausgewählt ist aus Wasserstoff-, t-Butoxycarbonyl-, (9H-Fluoren-9-yl)methoxycarbonyl-, substituiertem oder unsubstituiertem Benzyloxycarbonyl-, substituiertem Alkyloxycarbonyl-, substituiertem oder unsubstituiertem Alkyl-, Amidinyl-, 1,3-Bis(t-butoxycarbonyl)amidinyl-, 1,3-Bis-(benzyloxycarbonyl)amidinylrest; und,
L_3 eine Verknüpfungsgruppe ist, die von **Formel V** dargestellt wird:



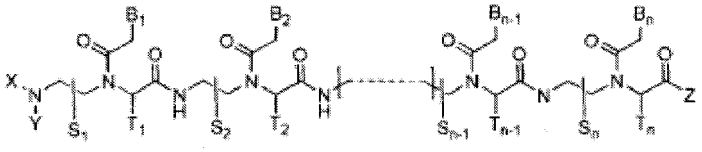
Formel V

worin
Q_1 und Q_m substituierter oder unsubstituierter Methylenrest sind und Q_m direkt mit dem Aminorest verknüpft ist;
Q_2, Q_3, ..., und Q_{m-1} unabhängig ausgewählt sind aus substituiertem oder unsubstituiertem Methylen-, Sauerstoff-, Schwefel- und substituiertem oder unsubstituiertem Aminorest; und

m eine ganze Zahl von 2 bis 15 ist.

Revendications

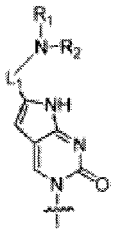
1. Un dérivé d'acide nucléique peptidique de la **Formule I** ou un sel pharmaceutiquement acceptable de celui-ci :



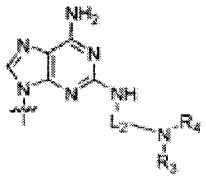
Formule I

où,

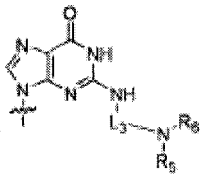
n est un entier égal ou supérieur à 5,
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, et T_n représentent indépendamment hydrogène, deutérium, alkyle substitué ou non substitué ou un radical d'aryle substitué ou non substitué,
X et Y représentent indépendamment hydrogène, deutérium, alkyle substitué ou non substitué, acyle substitué ou non substitué, sulfonyle substitué ou non substitué ou un radical d'aryle substitué ou non substitué,
Z représente hydroxy, alkyloxy substitué ou non substitué, aryloxy substitué ou non substitué, un radical d'amino substitué ou non substitué,
B_1, B_2, ..., B_{n-1}, et B_n sont indépendamment sélectionnés parmi des nucléobases naturelles comprenant adénine, thymine, guanine, cytosine et uracile, et des nucléobases non naturelles, et, au moins un élément parmi B_1, B_2, ..., B_{n-1} et B_n est indépendamment sélectionné parmi des nucléobases non naturelles représentées par la **Formule II,** la **Formule III** ou la **Formule IV** :



Formule II



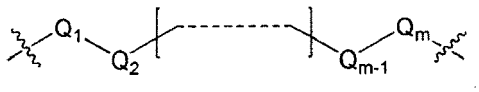
Formule III



Formule IV

où,

R_1, R_2, R_3, R_4, R_5 et R_6 sont indépendamment sélectionnés parmi alkyle substitué ou non substitué et un radical d'hydrogène, et,
L_1, L_2 et L_3 sont un lieur covalent représenté par la **Formule V** raccordant un groupe amino basique à la fraction responsable des propriétés d'appariement de nucléobases :



Formule V

où,

Q_1 et Q_m sont un radical de méthylène substitué ou non substitué ($-CH_2-$) et Q_m est directement lié au groupe amino basique,
Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène substitué ou non substitué, oxygène (-O-), soufre (-S-), et un radical d'amino substitué ou non substitué [-N(H)- ou -N(substituant)-], et,
m est un entier de 2 à 15.

2. Le dérivé d'acide nucléique peptidique selon la Revendication 1 ou un sel pharmaceutiquement acceptable de celui-ci :

où,
n est un entier de 5 à 30,
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1} et T_n sont un radical d'hydrogène,
X et Y sont indépendamment sélectionnés parmi hydrogène, alkyle substitué ou non substitué, acyle substitué ou non substitué, un radical de sulfonyle substitué ou non substitué,
Z représente hydroxy, alkyloxy substitué ou non substitué, aryloxy substitué ou non substitué, un radical d'amino substitué ou non substitué,
B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi des nucléobases naturelles comprenant adénine, thymine, guanine, cytosine et uracile, et des nucléobases non naturelles, et,
au moins un élément parmi B_1, B_2, ..., B_{n-1} et B_n est indépendamment sélectionné parmi des nucléobases non naturelles représentées par la **Formule II,** la **Formule III** ou la **Formule IV.**

3. Le dérivé d'acide nucléique peptidique selon la Revendication 1 ou un sel pharmaceutiquement acceptable de celui-ci :

où,
n est un entier de 8 à 25,
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1} et T_n sont un radical d'hydrogène,
X et Y sont indépendamment sélectionnés parmi hydrogène, alkyle substitué ou non substitué et un radical d'acyle substitué ou non substitué,
Z représente hydroxy ou un radical d'amino substitué ou non substitué, B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi des nucléobases naturelles comprenant adénine, thymine, guanine, cytosine et uracile, et des nucléobases non naturelles,
au moins deux éléments parmi B_1, B_2, ..., B_{n-1}, et B_n sont indépendamment sélectionnés parmi des nucléobases non naturelles représentées par la **Formule II,** la **Formule III** ou la **Formule IV,**
R_1, R_2, R_3, R_4, R_5 et R_6 sont indépendamment sélectionnés parmi alkyle substitué ou non substitué et un radical d'hydrogène,
Q_1 et Q_m sont un radical de méthylène substitué ou non substitué et Q_m est directement lié au groupe amino basique,
Q_2, Q_3, ..., et O_{m-1} sont indépendamment sélectionnés parmi méthylène substitué ou non substitué, oxygène et un radical d'amino, et,
m est un entier de 2 à 12.

4. Le dérivé d'acide nucléique peptidique selon la Revendication 1 ou un sel pharmaceutiquement acceptable de celui-ci :

où,

n est un entier de 10 à 25,
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, et T_n sont un radical d'hydrogène,
X et Y sont indépendamment sélectionnés parmi hydrogène et un radical d'acyle substitué ou non substitué,
Z représente hydroxy ou un radical d'amino substitué ou non substitué, et, B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi des nucléobases naturelles comprenant adénine, thymine, guanine, cytosine et uracile, et des nucléobases non naturelles,
au moins trois éléments parmi B_1, B_2, ..., B_{n-1}, et B_n sont indépendamment sélectionnés parmi des nucléobases non naturelles représentées par la Formule **II,** la Formule **III** ou la **Formule IV,**
R_1, R_2, R_3, R_4, R_5 et R_6 sont indépendamment sélectionnés parmi alkyle substitué ou non substitué et un radical d'hydrogène,
Q_1 et Q_m sont un radical de méthylène et Q_m est directement lié au groupe amino basique, Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène, oxygène et un radical d'amino, et,
m est un entier de 2 à 10.

5. Le dérivé d'acide nucléique peptidique selon la Revendication 1 ou un sel pharmaceutiquement acceptable de celui-ci :

où,
n est un entier de 10 à 20,
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1}, et T_n sont un radical d'hydrogène,
X et Y sont indépendamment sélectionnés parmi hydrogène et un radical d'acyle substitué ou non substitué,
Z représente hydroxy ou un radical d'amino substitué ou non substitué, B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi des nucléobases naturelles comprenant adénine, thymine, guanine, cytosine et uracile, et des nucléobases non naturelles,
au moins trois éléments parmi B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi des nucléobases non naturelles représentées par la **Formule II,** la **Formule III** ou la **Formule IV,**
R_1, R_3, et R_5 sont un radical d'hydrogène et R_2, R_4, et R_6 représentent indépendamment hydrogène ou un radical d'amidinyle substitué ou non substitué,
Q_1 et Q_m sont un radical de méthylène et Q_m est directement lié au groupe amino basique, Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène, oxygène et un radical d'amino, et,
m est un entier de 2 à 10.

6. Le dérivé d'acide nucléique peptidique selon la Revendication 1 ou un sel pharmaceutiquement acceptable de celui-ci :

où,
n est un entier de 10 à 20,
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1} et T_n sont un radical d'hydrogène,
X et Y sont indépendamment sélectionnés parmi hydrogène et un radical d'acyle substitué ou non substitué,
Z représente hydroxy ou un radical d'amino substitué ou non substitué, B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi adénine, thymine, guanine,
cytosine et des nucléobases non naturelles,
au moins trois éléments parmi B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi des nucléobases non naturelles représentées par la Formule **II,** la **Formule III** ou la **Formule IV,**
R_1, R_3, et R_5 sont un radical d'hydrogène et R_2, R_4, et R_6 indépendamment représente hydrogène ou un radical d'amidinyle,
Q_1 et Q_m sont un radical de méthylène et Q_m est directement lié au groupe amino basique, Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène, et un radical d'oxygène, et,
m est un entier de 2 à 8.

7. Le dérivé d'acide nucléique peptidique selon la Revendication 1 ou un sel pharmaceutiquement acceptable de celui-ci :

où,
n est un entier de 8 à 20,
S_1, S_2, ..., S_{n-1}, S_n, T_1, T_2, ..., T_{n-1} et T_n sont un radical d'hydrogène,
X est un radical d'hydrogène,
Y représente hydrogène ou un radical d'acyle substitué ou non substitué,

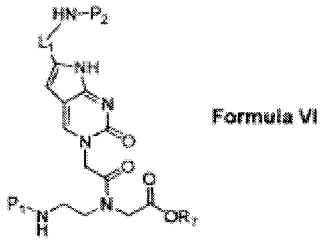
Z représente hydroxy ou un radical d'amino substitué ou non substitué, B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi adénine, thymine, guanine,
cytosine et des nucléobases non naturelles,
au moins trois éléments parmi B_1, B_2, ..., B_{n-1} et B_n sont indépendamment sélectionnés parmi des nucléobases non naturelles représentées par la **Formule II,** la **Formule III** ou la **Formule IV,**
R_1, R_3, et R_5 sont un radical d'hydrogène et R_2, R_4, et R_6 représentent indépendamment hydrogène ou un radical d'amidinyle,
L_1 représente $-(CH_2)_2-O-(CH_2)_2-$, $-CH_2-O-(CH_2)_2-$ ou $-CH_2-O-(CH_2)_3-$ avec l'extrémité droite directement liée au groupe amino basique, et,
L_2 et L_3 sont indépendamment sélectionnés parmi $-(CH_2)_2-O-(CH_2)_2-$, $-(CH_2)_3-O-(CH_2)_2-$, $-(CH_2)_2-O-(CH_2)_3-$, $-(CH_2)_2-$, $-(CH_2)_3-$, $-(CH_2)_4-$, $-(CH_2)_5-$, $-(CH_2)_6-$, $-(CH_2)_7-$ et $-(CH_2)_8-$ avec l'extrémité droite directement liée au groupe amino basique.

8. Une composition pharmaceutique contenant une quantité thérapeutiquement efficace du dérivé d'acide nucléique peptidique selon l'une quelconque des Revendications 1 à 7 ou un sel pharmaceutiquement acceptable de celui-ci dans un but thérapeutique.

9. Un procédé d'utilisation du dérivé d'acide nucléique peptidique selon l'une quelconque des Revendications 1 à 7 ou un sel de celui-ci dans un but de diagnostic.

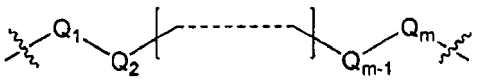
10. Un procédé d'utilisation du dérivé d'acide nucléique peptidique selon l'une quelconque des Revendications 1 à 7 ou un sel de celui-ci pour une modulation in vitro d'une expression de la protéine cellulaire.

11. Un composé de la **Formule VI** :



Formula VI

où,
R_7 est hydrogène, N-succinyl ou un radical d'alkyle substitué ou non substitué,
P_1 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué et un radical d'arylsulfonyle substitué ou non substitué,
P_2 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué, alkyloxycarbonyle substitué, alkyle substitué ou non substitué, amidinyle, 1,3-bis(t-butoxy-carbonyle)amidinyle, un radical de 1,3-bis-(benzyloxycarbonyle)amidinyle, et,
L_1 est un lieur représenté par la **Formule V :**

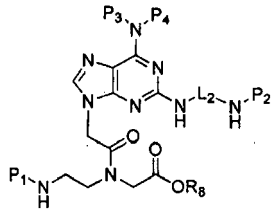


Formule V

où,
Q_1 et Q_m sont un radical de méthylène substitué ou non substitué et Q_m est directement lié au radical d'amino,

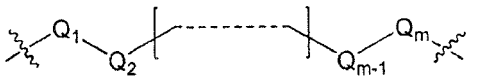
Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène substitué ou non substitué, oxygène, soufre et un radical d'amino substitué ou non substitué, et,
m est un entier de 2 à 15.

12. Un composé de la **Formule VII** :



Formule VII

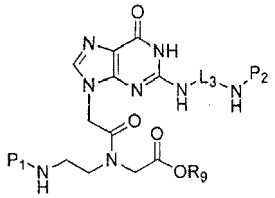
où,
R_8 est hydrogène, N-succinyl ou un radical d'alkyle substitué ou non substitué,
P_1 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué et un radical d'arylsulfonyle substitué ou non substitué,
P_2 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué, alkyloxycarbonyle substitué, alkyle substitué ou non substitué, amidinyle, 1,3-bis(t-butoxy-carbonyle)amidinyle, un radical de 1,3-bis-(benzyle-oxycarbonyle)amidinyle,
P_3 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle un radical de benzyloxycarbonyle substitué ou non substitué et benzyloxycarbonyle substitué,
P_4 est sélectionné parmi hydrogène et un radical de t-butoxycarbonyle, et,
L_2 est un lieur représenté par la **Formule V :**



Formule V

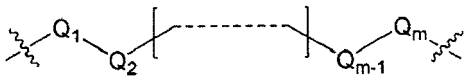
où,
Q_1 et Q_m sont un radical de méthylène substitué ou non substitué et Q_m est directement lié au radical d'amino,
Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène substitué ou non substitué, oxygène, soufre et un radical d'amino substitué ou non substitué, et,
m est un entier de 2 à 15.

13. Un composé de la **Formule VIII :**



Formule VIII

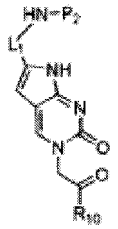
où,
R_9 est hydrogène, N-succinyl ou un radical d'alkyle substitué ou non substitué,
P_1 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-y)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué et un radical d'arylsulfonyle substitué ou non substitué,
P_2 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué, alkyloxycarbonyle substitué, alkyle substitué ou non substitué, amidinyle, 1,3-bis(t-butoxy-carbonyle)amidinyle, un radical de 1,3-bis-(benzyle-oxycarbonyle)amidinyle, et,
L_3 est un lieur représenté par la **Formule V :**



Formule V

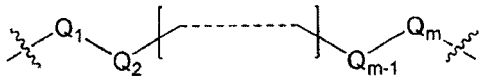
où,
Q_1 et Q_m sont un radical de méthylène substitué ou non substitué et Q_m est directement lié au radical d'amino,
Q_2, Q_3, ... , et Q_{m-1} sont indépendamment sélectionnés parmi méthylène substitué ou non substitué, oxygène, soufre et un radical d'amino substitué ou non substitué, et,
m est un entier de 2 à 15.

14. Un composé de la **Formule IX :**



Formule IX

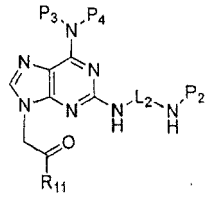
où,
R_{10} est hydroxy, alkyloxy substitué ou non substitué ou un radical d'amino substitué ou non substitué,
P_2 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué, alkyloxycarbonyle substitué, alkyle substitué ou non substitué, amidinyle, 1,3-bis(t-butoxy-carbonyle)amidinyle, un radical de 1,3-bis-(benzyloxycarbonyle)amidinyle, et,
L_1 est un lieur représenté par la **Formule V :**



Formule V

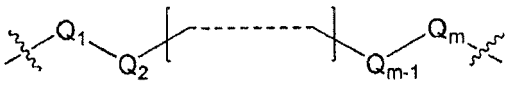
où,
Q_1 et Q_m sont un radical de méthylène substitué ou non substitué et Q_m est directement lié au radical d'amino,
Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène substitué ou non substitué, oxygène, soufre et un radical d'amino substitué ou non substitué, et,

15. Un composé de la **Formule X** :



Formule X

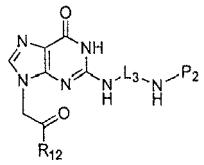
où,
R_{11} est hydroxy, alkyloxy substitué ou non substitué ou un radical d'amino substitué ou non substitué,
P_2 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué, alkyloxycarbonyle substitué, alkyle substitué ou non substitué, amidinyle, 1,3-bis(t-butoxy-carbonyle)amidinyle, un radical de 1,3-bis-(benzyle-oxycarbonyle)amidinyle,
P_3 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, un radical de benzyloxycarbonyle substitué ou non substitué, et ,
P_4 est sélectionné parmi hydrogène et un radical de t-butoxycarbonyle, et,
L_2 est un lieur représenté par la **Formule V :**



Formule V

où,
Q_1 et Q_m sont un radical de méthylène substitué ou non substitué et Q_m est directement lié au radical d'amino,
Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène substitué ou non substitué, oxygène, soufre et un radical d'amino substitué ou non substitué, et,
m est un entier de 2 à 15.

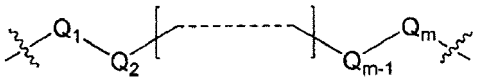
16. Un composé de la **Formule XI :**



Formule XI

où,

R_{12} est hydroxy, alkyloxy substitué ou non substitué ou un radical d'amino substitué ou non substitué,
P_2 est sélectionné parmi hydrogène, t-butoxycarbonyle, (9H-fluorène-9-yl)méthoxy-carbonyle, benzyloxycarbonyle substitué ou non substitué, alkyloxycarbonyle substitué, alkyle substitué ou non substitué, amidinyle, 1,3-bis(t-butoxy-carbonyle)amidinyle, un radical de 1,3-bis-(benzyle-oxycarbonyle)amidinyle, et,
L_3 est un lieur représenté par la **Formule V :**



Formule V

où,
Q_1 et Q_m sont un radical de méthylène substitué ou non substitué et Q_m est directement lié au radical d'amino,
Q_2, Q_3, ..., et Q_{m-1} sont indépendamment sélectionnés parmi méthylène substitué ou non substitué, oxygène, soufre et un radical d'amino substitué ou non substitué, et,
m est un entier de 2 à 15.

Figure 1

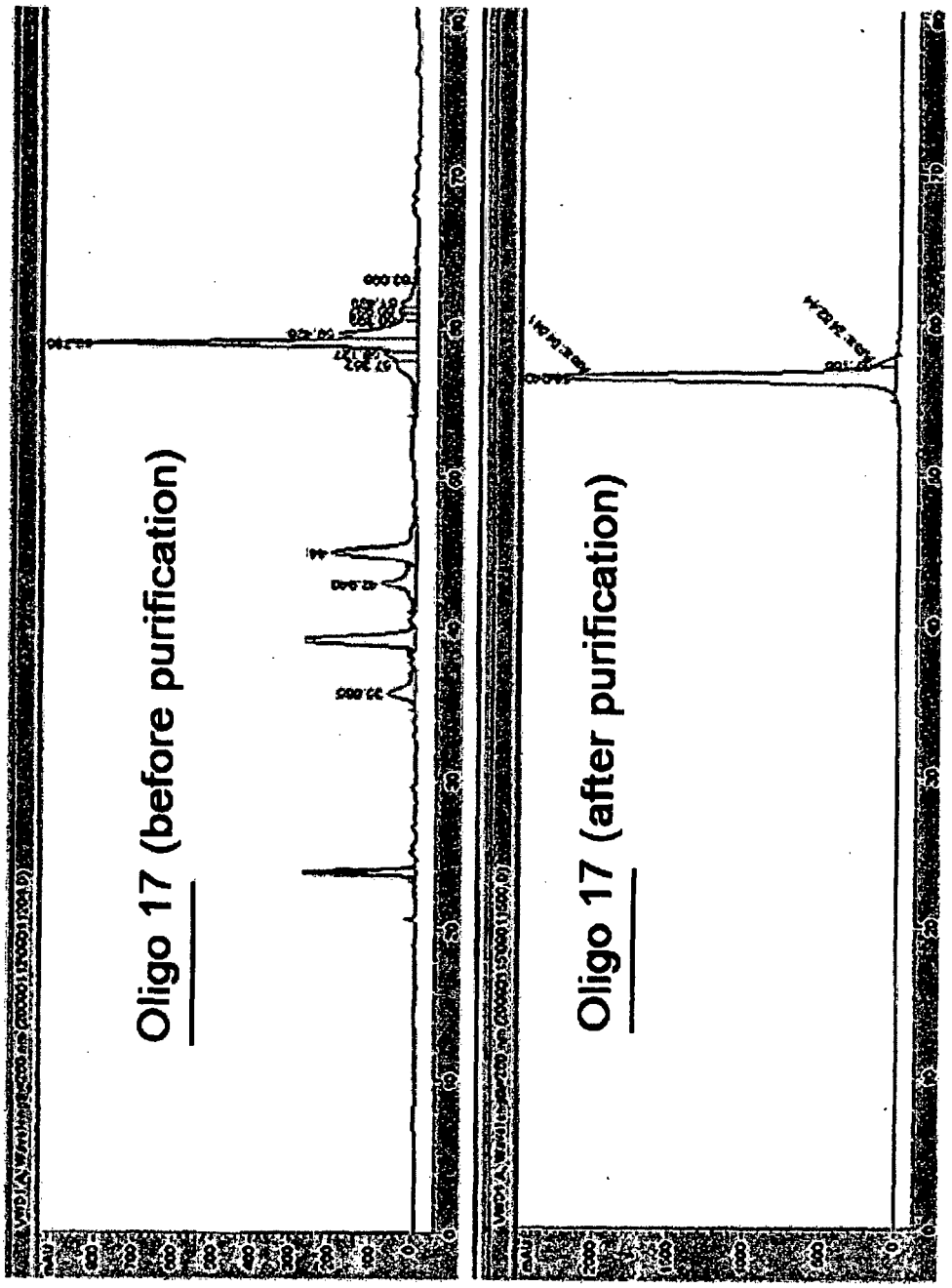


Figure 2

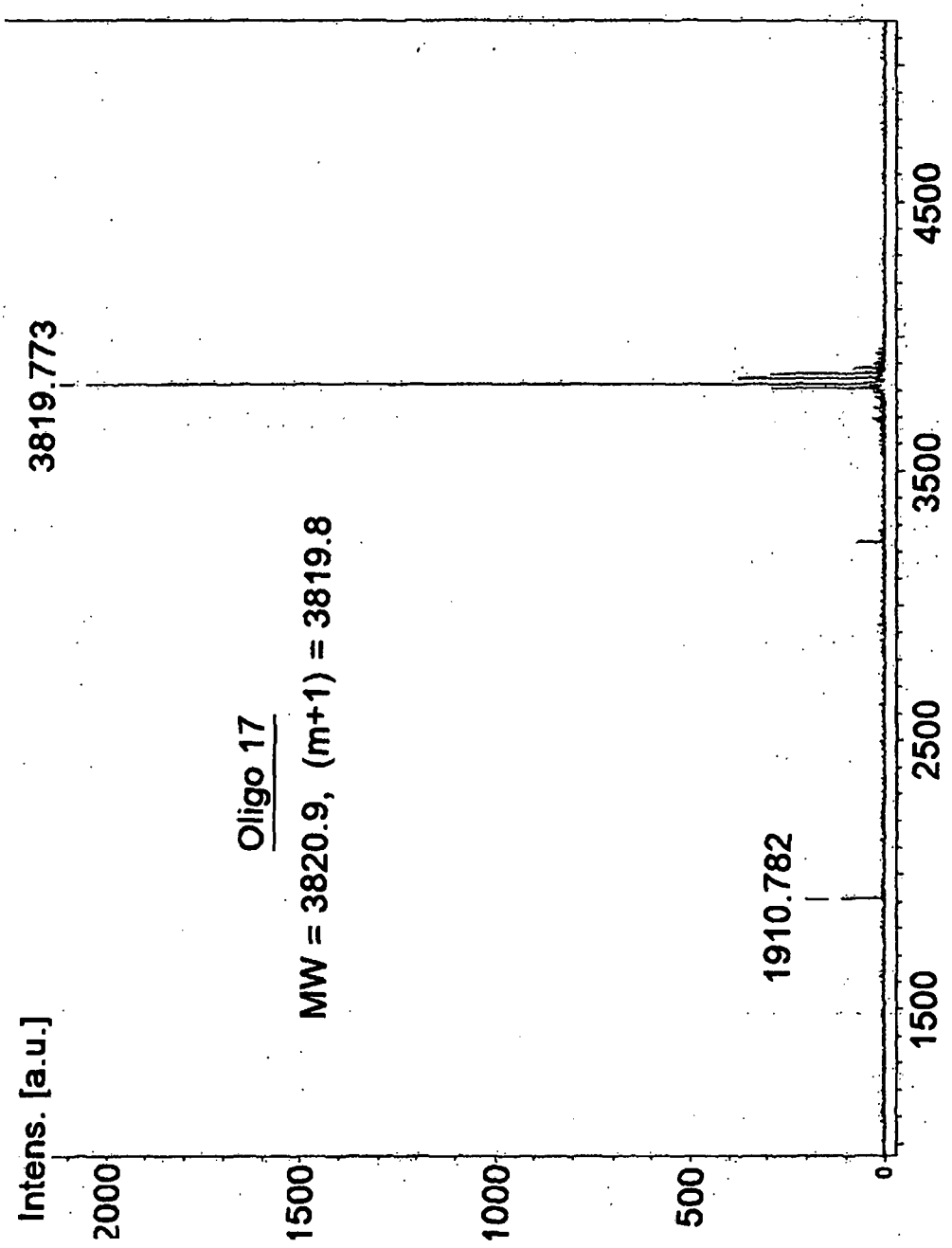

Intens. [a.u.]
2000
1500
1000
500
0
1500
2500
3500
4500
3819.773
1910.782
Oligo 17
MW = 3820.9, (m+1) = 3819.8

Figure 3

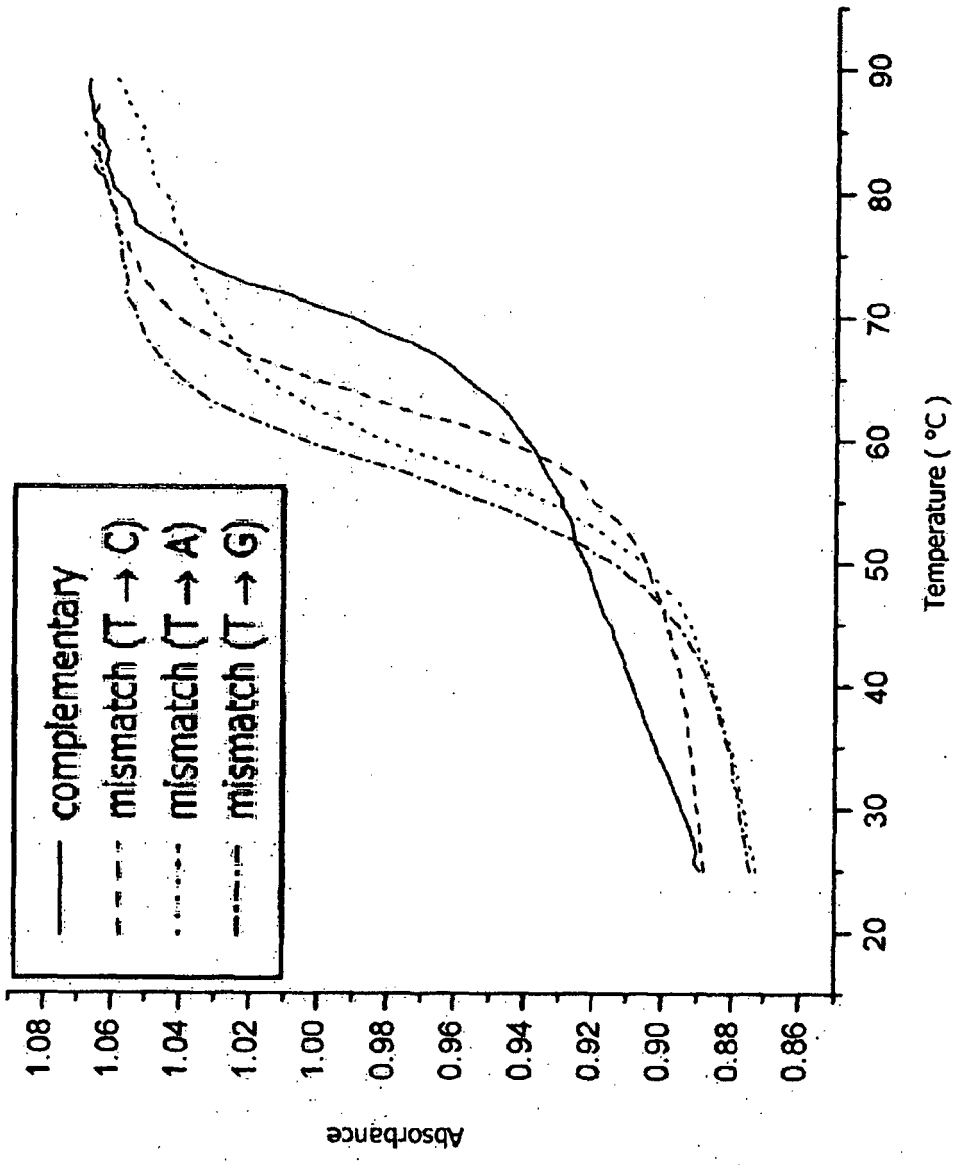

complementary
mismatch (T → C)
mismatch (T → A)
mismatch (T → G)
Absorbance
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
20
30
40
50
60
70
80
90
Temperature (°C)

Figure 4

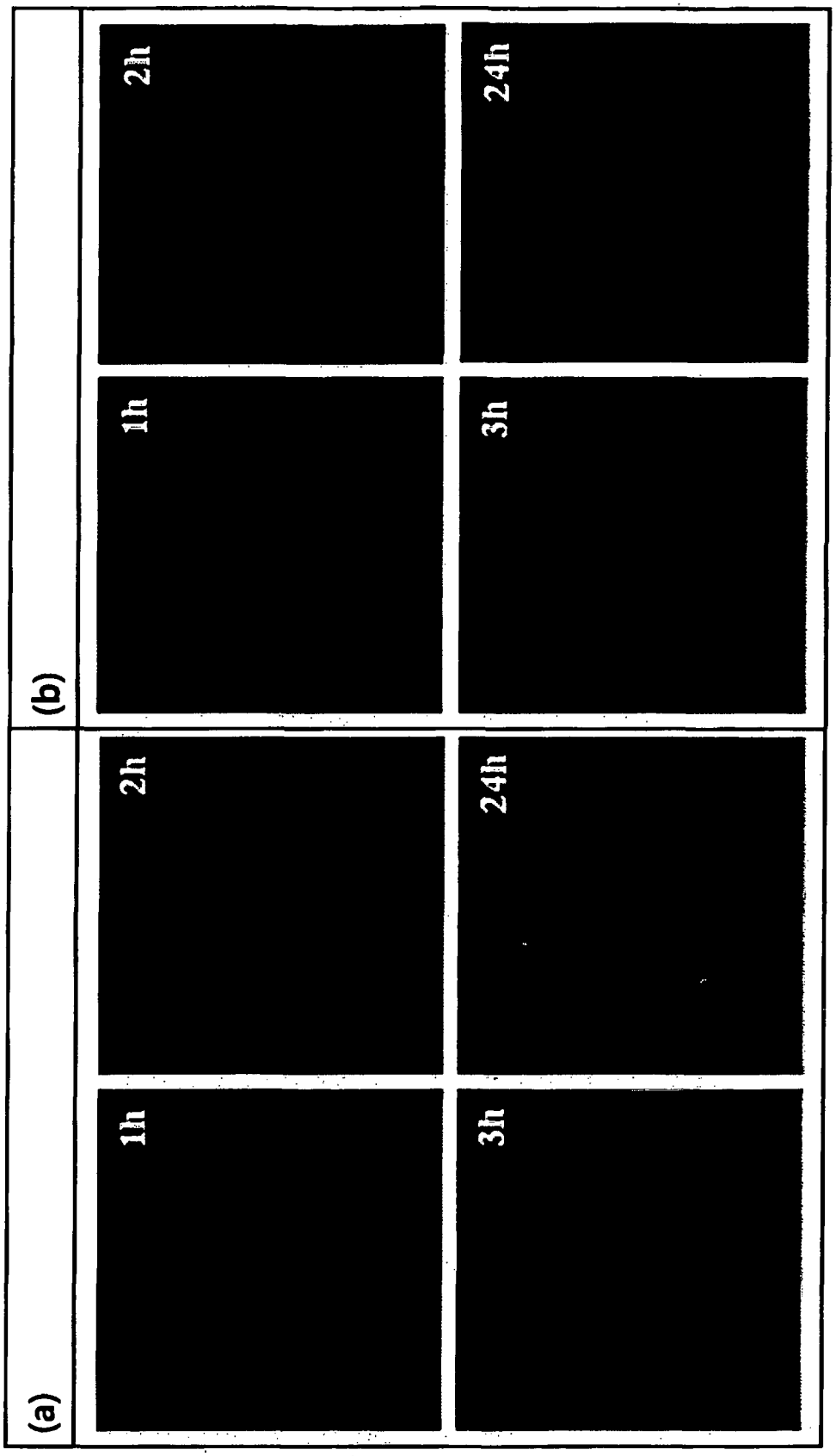


Figure 5

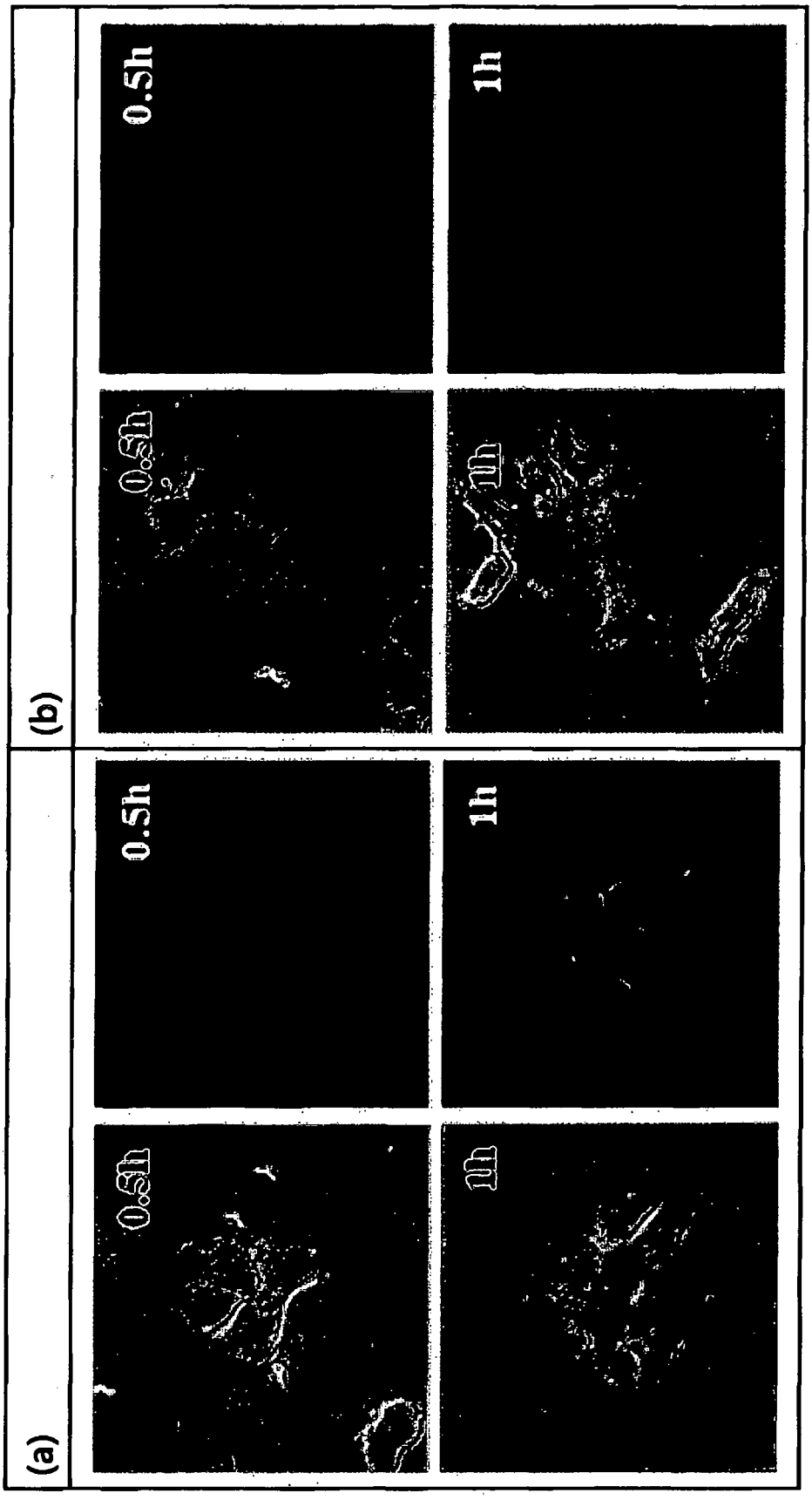


Figure 6

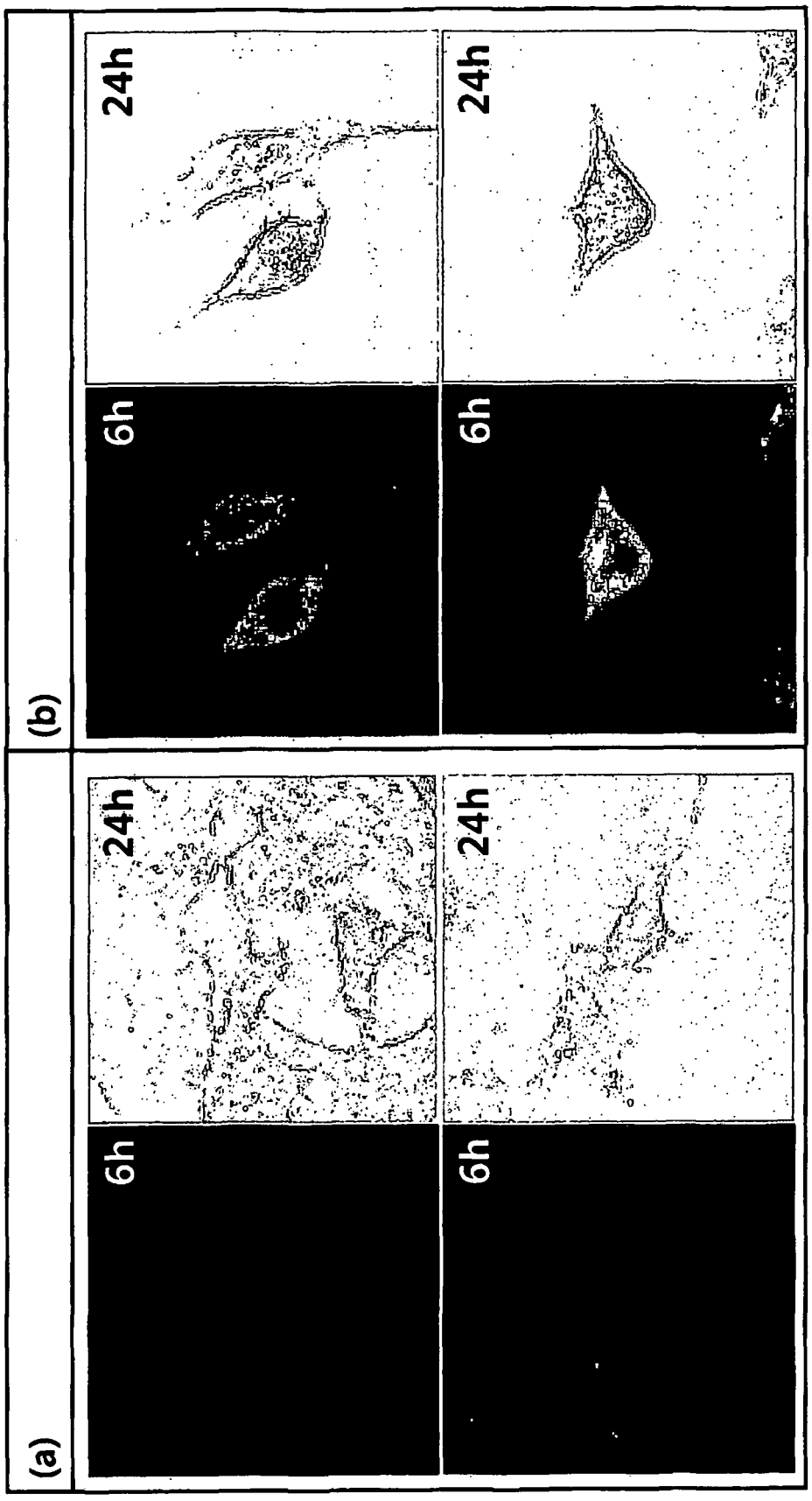


Figure 7

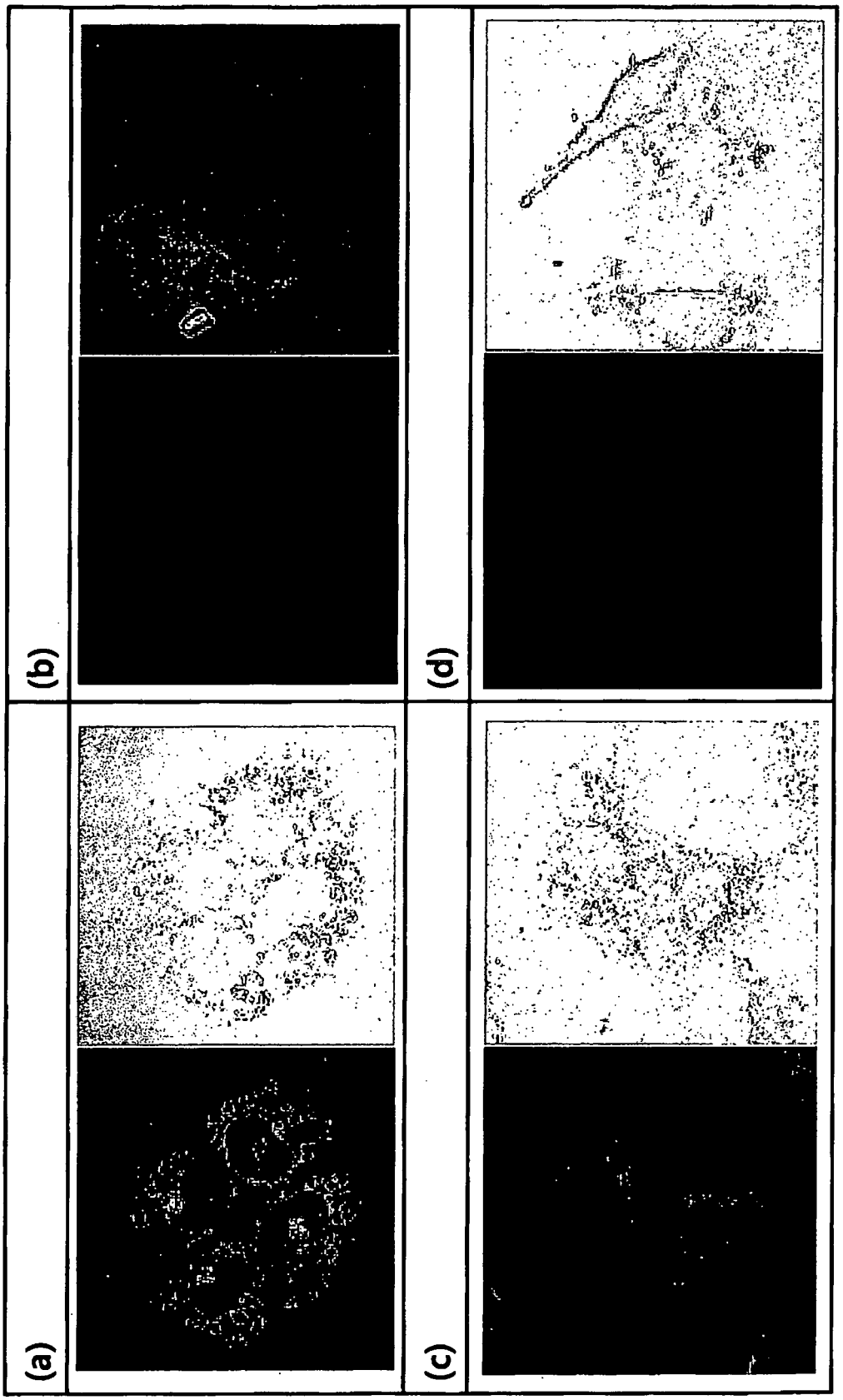


Figure 7 (continued from previous page)

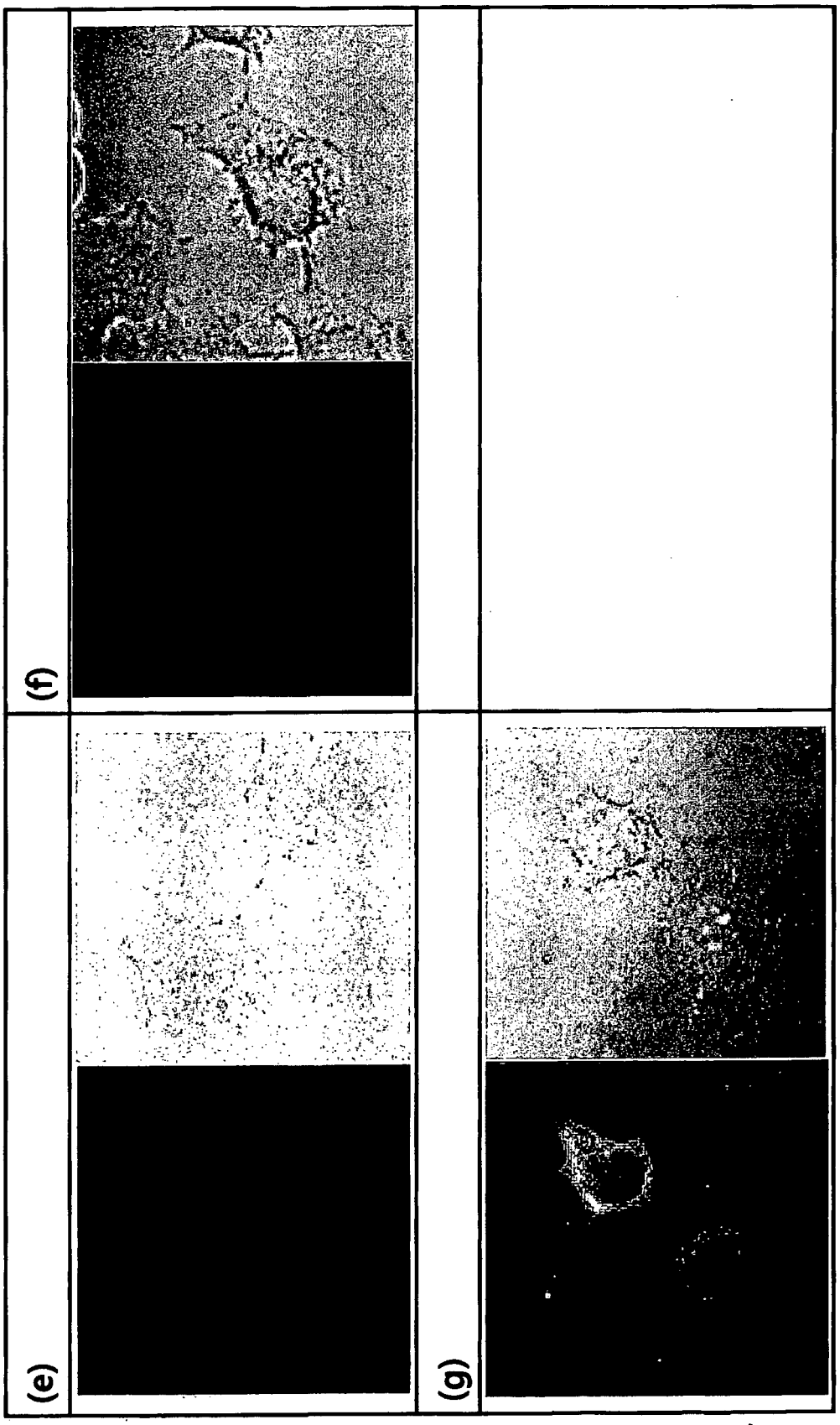


Figure 8

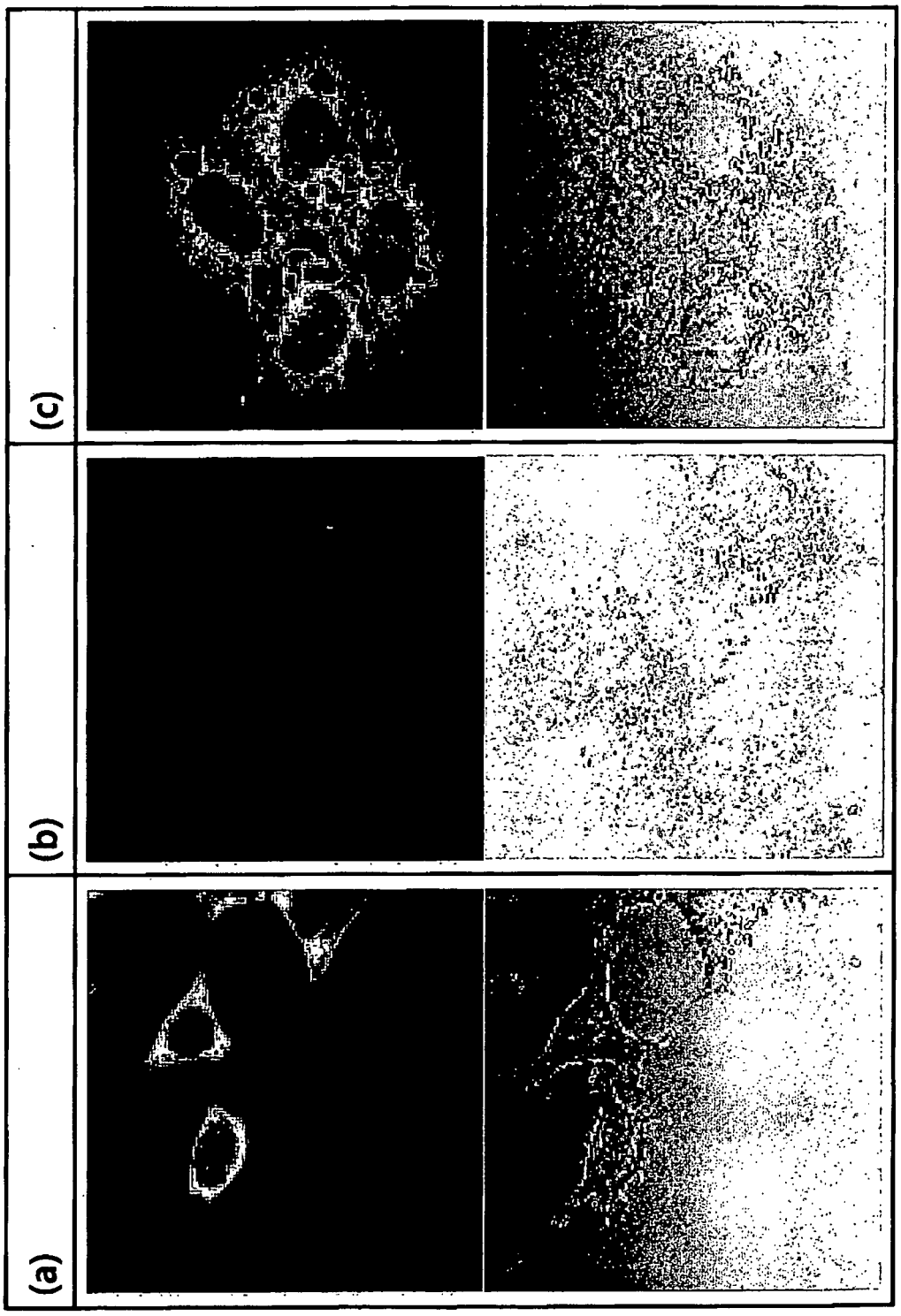


Figure 9

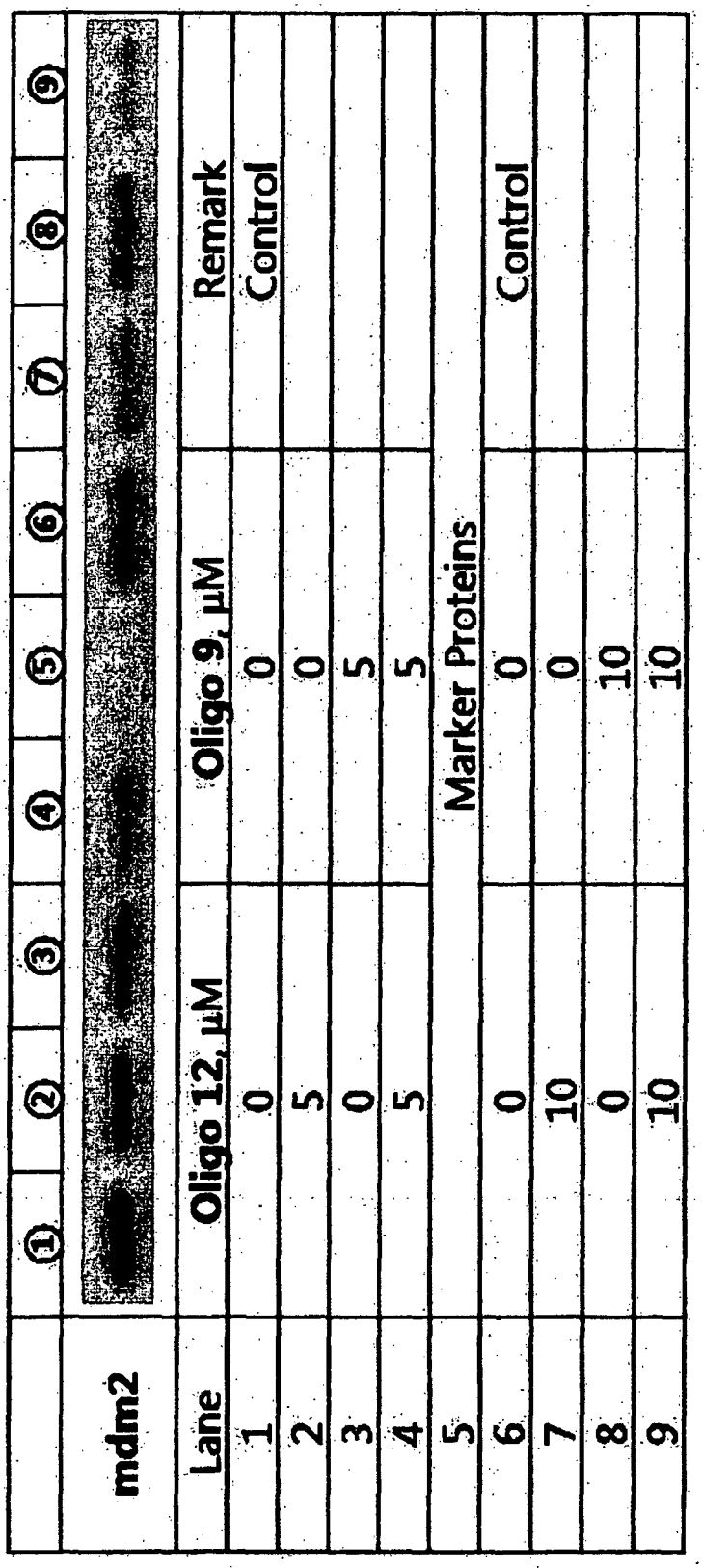
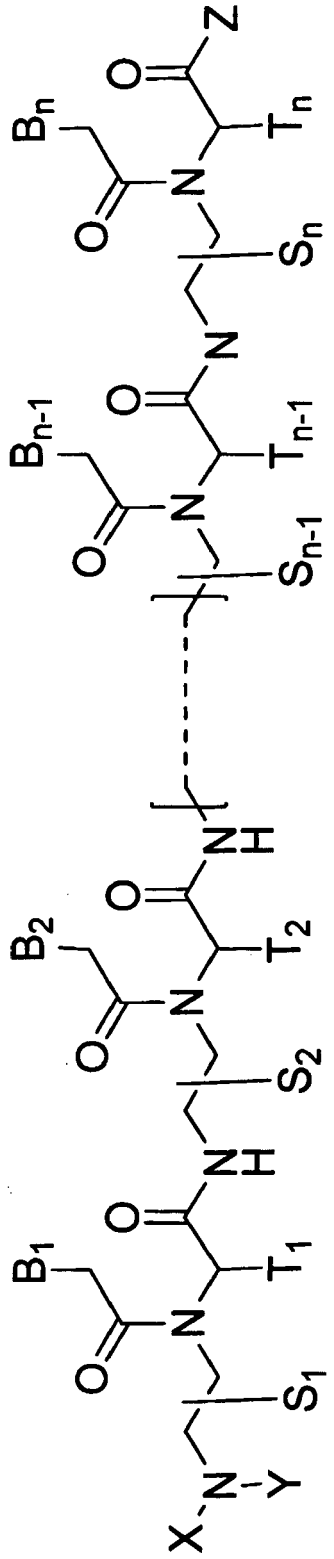

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
mdm2
Lane
Oligo 12, µM
Oligo 9, µM
Remark
1 0 0 Control
2 5 0
3 0 5
4 5 5
5 Marker Proteins
6 0 0 Control
7 10 0
8 0 10
9 10 10

Figure 10



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