



- (51) **International Patent Classification:**
C07H 19/06 (2006.01)
- (21) **International Application Number:**
PCT/EP2017/054841
- (22) **International Filing Date:**
2 March 2017 (02.03.2017)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
16161089.4 18 March 2016 (18.03.2016) EP
- (71) **Applicant:** ROCHE INNOVATION CENTER COPENHAGEN A/S [DK/DK]; Fremtidsvej 3, 2970 Hørsholm (DK).
- (72) **Inventors:** ALBAEK, Nanna; c/o Roche Innovation Center Copenhagen A/S, Fremtidsvej 3, 2970 Hørsholm (DK). FUNDER, Erik; c/o Roche Innovation Center Copenhagen A/S, Fremtidsvej 3, 2970 Hørsholm (DK). RAVN, Jacob; c/o Roche Innovation Center Copenhagen A/S, Fremtidsvej 3, 2970 Hørsholm (DK).
- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

(54) **Title:** ACYL-PROTECTED L-LNA-GUANOSINE MONOMERS

(57) **Abstract:** The present invention relates to the field of stereodefined phosphorothioate oligonucleotides and to nucleoside monomers and methods of synthesis thereof. Herein are disclosed acyl protected L-LNA-G monomers which have improved solubility and stability characteristics, and result in improved efficacy in oligonucleotide synthesis.



STEREODEFINING L-MONOMERS

FIELD OF THE INVENTION

The present invention relates to the field of stereodefined phosphorothioate oligonucleotides and to nucleoside monomers and methods of synthesis thereof. Herein are disclosed acyl protected L-LNA-G monomers which have improved solubility and stability characteristics, and thus results in improved efficiency in oligonucleotide synthesis.

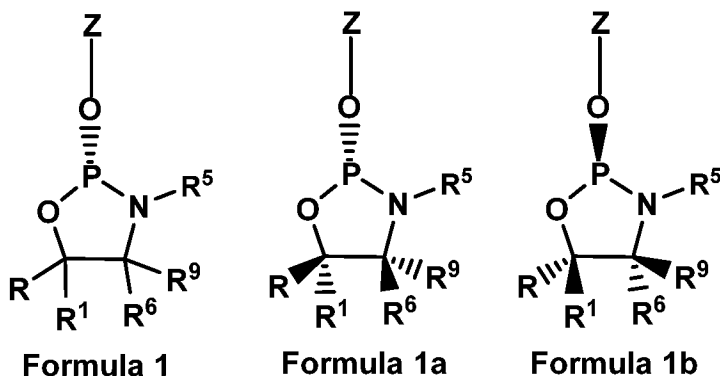
BACKGROUND TO THE INVENTION

Recently, we have discovered that the use of stereodefined phosphorothioate internucleoside linkages in LNA oligonucleotides allow for the optimisation of the pharmacological profile of LNA oligonucleotides. The manufacture of stereodefined phosphorothioate oligonucleotides is at present comparatively inefficient as compared to non stereodefined phosphorothioate oligonucleotides. There is therefore a need to improve the efficiency of synthesis of stereodefined oligonucleotides.

WO2014/010250 discloses nucleoside monomers which when incorporated into an oligonucleotide provide a chirally defined stereocenter at the corresponding phosphorothioate internucleoside linkage position. Whilst LNA monomers are considered, none have been made or tested. The present invention is based upon the surprising observation that guanine monomers (referred to as L-XNA-G monomers) are insoluble and/or unstable in many solvents. The present invention is based upon the provision of L-XNA-G monomers where the exocyclic nitrogen of the guanine residue is protected with an acyl protection group rather than the standard DMF protecting group. Such monomers are remarkable soluble and stable in solution.

STATEMENT OF INVENTION

The invention provides for a compound of formula 1, 1a or 1b



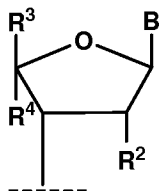
wherein

Z is a guanine nucleoside wherein the guanine nucleobase group comprises an acyl protecting group on the guanine exocyclic nitrogen group, wherein the exocyclic oxygen of Formula I is covalently attached to the 3' carbon of the nucleoside Z;
 R^5 and R^6 are independently selected from the group consisting of hydrogen, alkyl, cyclo-alkyl, aryl, heteroaryl, substituted alkyl, substituted cyclo-alkyl, substituted aryl, and substituted heteroaryl, or R^5 and R^6 together form a heterocyclic ring comprising 3 – 16 carbon atoms, together with the N atom of formula 1;
 R^9 is hydrogen;
 R^1 is selected from the groups consisting of hydrogen and C_{1-3} alkyl; and,
 R is selected from the groups consisting of aryl, heteroaryl, substituted aryl, substituted heteroaryl, nitro, halogen, cyano, silyl, substituted silyl, sulfone, substituted sulfone (aryl substituted sulfone), fluorene, and substituted fluorene.

when substituted, R may be substituted with a group selected from the group consisting of: C_{1-4} alkyl group, C_{6-14} aryl group C_{1-4} , alkoxy group, C_{7-14} aralkyl group, C_{1-4} alkyl, C_{6-14} aryl group, C_{1-4} alkoxy, C_{6-14} aryl group, or C_{6-14} aryl C_{1-4} alkyl group. Multiple substitutions may be dependently or independently selected from the group consisting of: C_{1-4} alkyl group, C_{6-14} aryl group C_{1-4} , alkoxy group, C_{7-14} aralkyl group, C_{1-4} alkyl, C_{6-14} aryl group, C_{1-4} alkoxy, C_{6-14} aryl group, or C_{6-14} aryl C_{1-4} alkyl group.

The compound of formula 1 may be in either of the alternative diastereoisomers, as shown in formula 1a and formula 1b, or in some embodiments may be a mixture of the diastereoisomers.

In some embodiments Z is

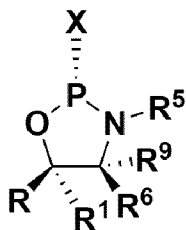


wherein B is a guanine nucleobase group comprising an acyl protecting group on the guanine exocyclic nitrogen group, and R^2 , R^3 and R^4 are as described herein. In some embodiments R^4 and R^2 form a biradicle bridge to form a bicyclic nucleoside (see under LNA herein). The dotted line represents the linkage to the non cyclic oxygen in the compound of formula 1, 1a or 1b. Representative nucleosides groups Z are illustrated in the nucleosides of formulas 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73 & 74 as disclosed herein, with the exception that the 3'OH group is replaced with the bond to the exocyclic oxygen group shown in formulas 1, 1a and 1b. In some embodiments, when R is substituted aryl, R may be substituted with halide, such as iodide, fluoride, bromide or chloride.

The invention provides for a solution (composition) comprising the compound of formula 1 and a solvent. The invention provides for a solution (composition) comprising the compound of formula 1a and a solvent. The invention provides for a solution (composition) comprising the compound of formula 1b and a solvent. The solution may be a stable solution, *i.e.* it is stable for at least 24hours at room temperature (e.g. using the assay provided in example 6). It should be recognised that in some embodiments, a stable solution may result in some degradation of the compound of the invention in the solution during the 24hours, but, for example at least 20% (such as at least 30%, at least 40%, at least 50%, at least 60% or at least 70%, or at least 75%) of the initial amount of compound 1 is present in the solution after 24hours.

The invention provides for the use of the compound or the composition of the invention in the synthesis or manufacture of an oligonucleotide.

The invention provides for a method for the synthesis of a compound according to formula I (1a), said method comprising the step of reacting a guanine nucleoside comprising a 3' -OH group; with a compound of formula 8:



Formula 8

Wherein X is halide, such as iodide, bromide or chloride, and wherein the guanine nucleobase group on the guanine nucleoside comprises an acyl protecting group on the guanine exocyclic nitrogen group, and wherein R, R¹, R⁹, R⁵ and R⁶ are as per the compound of the invention, and wherein the guanine nucleobase group on the guanine nucleoside comprises an acyl protecting group on the guanine exocyclic nitrogen group.

The invention provides mixtures of compounds of formula 1a and 1b. The invention provides a composition which comprises the compound of formula 1a. In some embodiments the mixtures may be a diastereomeric mixture. As is shown herein, the solubility of L and D stereoisomers of the monomers disclosed herein, such as the LNA monomers, can exhibit remarkably different solubilities and stabilities in different solvents.

The invention provides for a method for the synthesis of a stereodefined phosphorothioate oligonucleotide, said method comprising the step of coupling the compound of the invention (the guanine nucleoside monomer of the invention) to the 5'-OH group of a nucleoside to a -OH group attached to a solid support, followed by a sulfurization step. The method may further comprise a capping step which may be performed prior to or subsequent to the sulfurization step. The acyl protection group may be subsequently removed after chain elongation is completed, for example during global deprotection and cleavage of the oligonucleotide from the solid support. The monomer of the invention may therefore be used in phosphoramidite oligonucleotide synthesis to introduce a stereodefined chiral center within the oligonucleotide.

FIGURES

Figure 1: Solubility of various L and D nucleoside monomers in a selection of solvents.

Figure 2: Stability of various L and D nucleoside monomers in a selection of solvents.

3 = Comparatively unstable, 2 = intermediate stability, 1 = Comparatively stable

Figure 3: Stability of L-LNA-G-iBu monomer (3a) and L-LNA-G-DMF monomer as measured after 24 hours in various solvents (see example 6). Figure 3a - I-bu-control refers to the starting material (L-LNA G-I-bu) at t = 0 h. Figure 3b - DMF-control refers to the starting material (L-LNA G-DMF) at t = 0 h.

DETAILED DESCRIPTION

As used herein, the term "aryl" refers to an aromatic ring wherein each of the atoms forming the ring is a carbon atom. Aryl rings are formed by five, six, seven, eight, nine, or more than nine carbon atoms. Aryl groups are a substituted or unsubstituted. In one aspect, an aryl is a phenyl or a naphthalenyl. Depending on the structure, an aryl group can be a monoradical or a diradical (*i.e.*, an arylene group). In one aspect, an aryl is a C₆₋₁₀ aryl. In some embodiments aryl is phenyl. When substituted aryl may be substituted with a group selected from the group consisting of: C₁₋₄ alkyl group, C₆₋₁₄ aryl group C₁₋₄, alkoxy group, C₇₋₁₄ aralkyl group, C₁₋₄ alkyl, C₆₋₁₄ aryl group, C₁₋₄ alkoxy, C₆₋₁₄ aryl group, or C₆₋₁₄ aryl C₁₋₄ alkyl group. Multiple substitutions may be dependently or independently selected from the group consisting of: C₁₋₄ alkyl group, C₆₋₁₄ aryl group C₁₋₄, alkoxy group, C₇₋₁₄ aralkyl group, C₁₋₄ alkyl, C₆₋₁₄ aryl group, C₁₋₄ alkoxy, C₆₋₁₄ aryl group, or C₆₋₁₄ aryl C₁₋₄ alkyl group; or a group selected from the group consisting of halide, such as iodide, fluoride, bromide or chloride, such as phenyl substituted with halide, such as iodide, fluoride, bromide or chloride.

An "alkyl" group refers to an aliphatic hydrocarbon group. The alkyl moiety may be a saturated alkyl group (which means that it does not contain any units of unsaturation, e.g. carbon-carbon double bonds or carbon-carbon triple bonds) or the alkyl moiety may be an unsaturated alkyl group (which means that it contains at least one unit of unsaturation). The alkyl moiety, whether saturated or unsaturated, may be branched, straight chain, or include a cyclic portion. The point of attachment of an alkyl is at a carbon atom that is not part of a ring. The "alkyl" moiety may have 1 to 10 carbon atoms (whenever it appears herein, a numerical range such as "1 to 10" refers to each integer in the given range; e.g., "1 to 10 carbon atoms" means that the alkyl group may consist of 1 carbon atom, 2 carbon atoms, 3 carbon atoms, etc., up to and including 10 carbon atoms, although the present definition also covers the occurrence of the term "alkyl" where no numerical range is designated). Alkyl includes both branched and

straight chain alkyl groups. The alkyl group of the compounds described herein may be designated as "C₁₋₆ alkyl" or similar designations. By way of example only, "C₁₋₆ alkyl" indicates that there are one, two, three, four, five, or six carbon atoms in the alkyl chain, i.e., the alkyl chain is selected from the group consisting of methyl, ethyl, propyl, iso-propyl, n-butyl, isobutyl, sec-butyl, and tert-butyl. Typical alkyl groups include, but are in no way limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, tertiary butyl, pentyl, hexyl, allyl, cyclopropylmethyl, cyclobutylmethyl, cyclopentylmethyl, cyclohexylmethyl, and the like. In one aspect, an alkyl is a C₁₋₆ or C₁₋₄ alkyl or C₁₋₃ alkyl. C₁₋₃ alkyl group means straight or branched alkyl group that has 1 to 3 carbon atoms. Examples of C₁₋₄ alkyl group are methyl, ethyl, propyl and isopropyl. C₁₋₃ alkyl group means straight or branched alkyl group that has 1 to 4 carbon atoms. Examples of C₁₋₃ alkyl groups are methyl, ethyl, propyl, isopropyl, butyl, isobutyl, and tert-butyl.

"Alkenyl" groups are straight chain, branch chain, and cyclic hydrocarbon groups containing at least one carbon-carbon double bond. Alkenyl groups can be substituted.

"Alkynyl" groups are straight chain, branch chain, and cyclic hydrocarbon groups containing at least one carbon-carbon triple bond. Alkynyl groups can be substituted.

An "alkoxy" group refers to an alkyl group linked to oxygen i.e. (alkyl)-O- group, where alkyl is as defined herein. Examples include methoxy (-OCH₃) or ethoxy (-OCH₂CH₃) groups.

An "alkenyloxy" group refers to an alkenyl group linked to oxygen i.e. (alkenyl)-O- group, where alkenyl is as defined herein.

An "alkynyloxy" group refers to an alkynyl group linked to oxygen i.e. (alkynyl)-O- group, where alkynyl is as defined herein.

An "aryloxy" group refers to an aryl group linked to oxygen i.e. (aryl)-O- group, where the aryl is as defined herein. An example includes phenoxy (-OC₆H₅) group.

"Silyl" refers to H₃Si-. "Substituted silyl" as used herein, refers to a moiety which has one or more the the hydrogen of silyl substituted. Examples include, but are not limited to, TBDMS {tert-butyldimethylsilyl}, TBDPS (tert-butyldiphenylsilyl) or TMS {trimethylsilyl} group.

The term "halogen" is intended to include fluorine, chlorine, bromine and iodine. The term "halide" includes fluoride, bromide, iodide and chloride.

An "acyl protection group" comprises an acyl group $-C(=O)-R^7$, wherein R^7 is a terminal group, for example a group selected from, alkyl-, alkyl-, alkenyl-, alkynyl-, cycloalkyl- and aryl-group; or a group selected from, unsubstituted alkyl-, unsubstituted alkenyl-, unsubstituted alkynyl-, unsubstituted cycloalkyl- or unsubstituted aryl-group; or a group selected from substituted alkyl-, substituted alkenyl-, substituted alkynyl-, substituted cycloalkyl- or substituted aryl-group. In some embodiments R^7 may be selected from the group consisting of unsubstituted C_{1-6} -alkyl-, unsubstituted C_{2-6} -alkenyl-, unsubstituted C_{2-6} -alkynyl-, unsubstituted C_{3-7} -cycloalkyl- or unsubstituted phenyl-group or substituted C_{1-6} -alkyl-, substituted C_{2-6} -alkenyl-, substituted C_{2-6} -alkynyl-, substituted C_{3-7} -cycloalkyl- or substituted phenyl-group; wherein when substituted, the substituent group may be mono or poly substituted, e.g. with one or more substituents selected from the group consisting of halogen, C_{1-6} -alkyl, C_{2-6} -alkenyl, C_{2-6} -alkynyl, C_{1-6} -alkoxy, optionally substituted aryloxy or optionally substituted aryl. In some embodiments the acyl protection group is isobutyryl ($-C(=O)CH(CH_3)_2$) (also referred to herein as iBu). The term isobutyryl may also be spelt isobutyryl.

The invention provides a nucleoside monomer of formula 1, such as formula 1a or 1b, and a solvent composition (a solution) comprising the nucleoside monomer, and their use in the synthesis of an oligonucleotide.

The R and R^1 (R/R^1) groups of the nucleoside of formula 1a provide a stereocenter (L) which results in the formation of a Sp stereodefined phosphorothioate group 3' to the nucleoside when incorporated into an oligonucleotide. The monomer comprising the stereocenter created by the R and R^1 groups as shown in formula 1a is referred to as an L monomer herein which results in the formation of a Sp stereocenter. In some embodiments, the invention is based upon a surprising observation that DMF protected guanine L monomers, such as L-LNA-G monomers, are difficult to solubilize in many solvents, and even when solubilized are so unstable as to limit the ability to make stereodefined oligonucleotides to a commercially relevant scale. The problem is less severe for L- DNA-G monomers as compared to sugar modified nucleosides, such as bicyclic nucleosides, such as L-LNA-G nucleosides. Indeed a side by side comparison of the solubility of DMF protected L-LNA-G and D-LNA-G (where the stereochemistry of the stereocenters R/R^1 and R^6/R^9 of formula 1 is reversed as shown in formula 1b), shows that whereas the DMF protected D-LNA-G is soluble and stable

in most solvents, the DMF protected L-LNA-G is very difficult to solubilise and has a stability in solution of less than 24hours.

The R and R¹ (R/R¹) groups of the nucleoside of formula 1b provide a stereocenter (D) which results in the formation of a Rp stereodefined phosphorothioate group 3' to the nucleoside when incorporated into an oligonucleotide. The monomer comprising the stereocenter created by the R and R¹ groups as shown in formula 1b is referred to as an D monomer herein which results in the formation of a Rp stereocenter.

Mixtures of Diastereoisomers

The invention provides a composition which comprises the compound of formula 1a. In some embodiments, said composition does not comprise the compound of formula 1b. In some embodiments, the composition does not comprise more than 1% of the compound of formula 1b (as measured by molar ratio of the compound of formula 1a). In some embodiments, the composition does not comprise more than 2% of the compound of formula 1b (as measured by molar ratio of the compound of formula 1a). In some embodiments, the composition does not comprise more than 3% of the compound of formula 1b (as measured by molar ratio of the compound of formula 1a). In some embodiments, the composition does not comprise more than 4% of the compound of formula 1b (as measured by molar ratio of the compound of formula 1a). In some embodiments, the composition does not comprise more than 5% of the compound of formula 1b (as measured by molar ratio of the compound of formula 1a). In some embodiments, the composition does not comprise more than 10% of the compound of formula 1b (as measured by molar ratio of the compound of formula 1a). In some embodiments, the composition does not comprise more than 20% of the compound of formula 1b (as measured by molar ratio of the compound of formula 1a). The composition may be in the form of the solution (composition) as described herein.

The invention provides a composition which comprises the compound of formula 1b. In some embodiments, said composition does not comprise the compound of formula 1a. In some embodiments, the composition does not comprise more than 1% of the compound of formula 1a (as measured by molar ratio of the compound of formula 1b). In some embodiments, the composition does not comprise more than 2% of the compound of formula 1a (as measured by molar ratio of the compound of formula 1b).

In some embodiments, the composition does not comprise more than 3% of the compound of formula 1a (as measured by molar ratio of the compound of formula 1b).

In some embodiments, the composition does not comprise more than 4% of the compound of formula 1a (as measured by molar ratio of the compound of formula 1b).

In some embodiments, the composition does not comprise more than 5% of the compound of formula 1a (as measured by molar ratio of the compound of formula 1b).

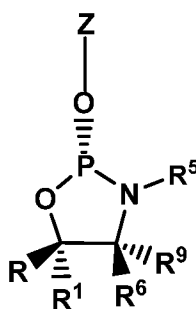
In some embodiments, the composition does not comprise more than 10% of the compound of formula 1a (as measured by molar ratio of the compound of formula 1b).

In some embodiments, the composition does not comprise more than 20% of the compound of formula 1a (as measured by molar ratio of the compound of formula 1b).

The composition may be in the form of the solution (composition) as described herein.

L-Monomers

In some embodiments, the invention provides for a compound of formula 1a



Formula 1a

wherein

Z is a guanine nucleoside wherein the guanine nucleobase group comprises an acyl protection group on the guanine exocyclic nitrogen group, wherein the exocyclic oxygen of Formula 1a is covalently attached to the 3' carbon of the nucleoside Z;

R⁵ and R⁶ are independently selected from the group consisting of hydrogen, alkyl, cyclo-alkyl, aryl, heteroaryl, substituted alkyl, substituted cyclo-alkyl, substituted aryl, and substituted heteroaryl, or R⁵ and R⁶ together form a heterocyclic ring comprising 3 – 16 carbon atoms, together with the N atom of formula 1a;

R⁹ is hydrogen;

R¹ is selected from the groups consisting of hydrogen and C₁₋₃ alkyl; and,

R is selected from the groups consisting of aryl, heteroaryl, substituted aryl, substituted heteroaryl, nitro, halogen, cyano, silyl, substituted silyl, sulfone, substituted sulfone (aryl substituted sulfone), fluorene, and substituted fluorene.

The description of the groups R, R¹, R⁶, R⁹ and R⁵ herein may apply generally to the compounds described here, including both L and D stereoisomers.

When substituted, R may be substituted with a group selected from the group consisting of: C₁₋₄ alkyl group, C₆₋₁₄ aryl group, C₁₋₄ alkoxy group, C₇₋₁₄ aralkyl group, C₁₋₄ alkyl, C₆₋₁₄ aryl group, C₁₋₄ alkoxy, C₆₋₁₄ aryl group, or C₆₋₁₄ aryl C₁₋₄ alkyl group. Multiple substitutions may be dependently or independently selected from the group consisting of: C₁₋₄ alkyl group, C₆₋₁₄ aryl group, C₁₋₄ alkoxy group, C₇₋₁₄ aralkyl group, C₁₋₄ alkyl, C₆₋₁₄ aryl group, C₁₋₄ alkoxy, C₆₋₁₄ aryl group, or C₆₋₁₄ aryl C₁₋₄ alkyl group.

In some embodiments R is selected from the groups consisting of aryl, heteroaryl, substituted aryl, substituted heteroaryl, nitro, halogen, cyano, silyl, substituted silyl, sulfone, substituted sulfone (aryl substituted sulfone), fluorene, and substituted fluorene.

In some embodiments R is selected from the group consisting of aryl, heteroaryl, substituted aryl and substituted heteroaryl.

In some embodiments R is aryl, such as phenyl.

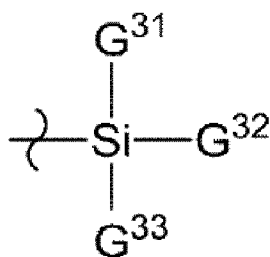
In some embodiments, when R is substituted aryl, R may be substituted with halide, such as iodide, fluoride, bromide or chloride, such as phenyl substituted with halide, such as iodide, fluoride, bromide or chloride.

In some embodiments R¹ is hydrogen. In some embodiments R¹ is C₁₋₃ alkyl, such as methyl, ethyl or propyl. In some embodiments R¹ is methyl.

In some embodiments, R is aryl, such as phenyl and R¹ is hydrogen.

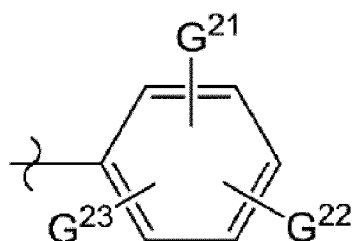
In some embodiments, R is aryl, such as phenyl, and R¹ is C₁₋₃ alkyl, such as methyl, ethyl or propyl.

In some embodiments R is



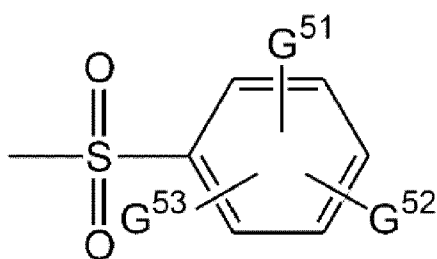
wherein G^{31} , G^{32} and G^{33} are independently selected from the groups consisting of C_{1-4} alkyl, C_{6-14} aryl, C_{1-4} alkoxy, C_{7-14} aralkyl, C_{1-4} alkyl, C_{6-14} aryl, C_{1-4} alkoxy, C_{6-14} aryl, and C_{6-14} aryl, C_{1-4} alkyl.

In some embodiments R is



wherein G^{21} , G^{22} and G^{23} are independently hydrogen, nitro, halogen, cyano or C_{1-3} alkyl.

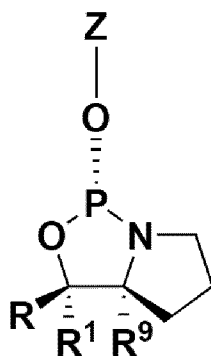
In some embodiments R is



wherein G^{51} , G^{52} and G^{53} are independently hydrogen, nitro, halogen, cyano or C_{1-3} alkyl or C_{1-3} alkoxy group.

In some embodiments R^5 and R^6 together form a heterocyclic ring (with the cyclic nitrogen shown in Formula 1). The heterocyclic ring may comprise, for example 3-16 carbon atoms, such as 4 carbons atoms.

In some embodiments R^5 and R^6 together form a heterocyclic ring (with the cyclic nitrogen shown in Formula 1) which comprises 4 carbon atoms, making a total of five atoms in the heterocyclic ring (4 carbon and the nitrogen shown in Formula 1). For example, the compound of the invention may be of formula 2:

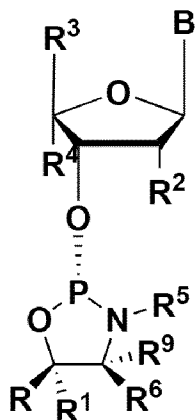


Formula 2

Wherein R, R^1 , R^9 and Z are as according to the compound of the invention.

In some embodiments R^5 and R^6 together form a heterocyclic ring (with the cyclic nitrogen shown in Formula 1) which comprises 4 carbon atoms, making a total of five atoms in the heterocyclic ring (4 carbon and the nitrogen shown in Formula 1), and R is aryl, such as phenyl, R^1 is hydrogen or methyl. R^9 is hydrogen.

The Z group above is a nucleoside where the 3' oxygen of the nucleoside is the exocyclic oxygen shown in formula 1. In some embodiments the Z group is a LNA nucleoside moiety. In some embodiment the compound of the invention may therefore be represented as the compound of formula 3:

**Formula 3**

wherein, R, R¹, R⁵, R⁶ and R⁹ are as per the compound of the invention;

B is the guanine nucleobase group comprising an acyl protecting group on the guanine exocyclic nitrogen group;

R³ = is selected from the group consisting of CH₂ODMTTr, CH₂-Alkyl-O-DMTr, CH-Me-O-DMTr, CH₂OMMTTr, CH₂-Alkyl-O-MMTTr, CH(Me)-O-MMTTr, CH-R^a-O-DMTrR^b, and CH-R^a-O-MMTTrR^b;

R² is selected from the groups consisting of halo, such as -F, amino, azido, -SH, -CN, -OCN, -CF₃, -OCF₃, -O(R^m)-alkyl, -S(R^m)-alkyl, -N(R^m)-alkyl, -O(R^m)-alkenyl, -S(R^m)-alkenyl, -N(R^m)-alkenyl; -O(R^m)-alkynyl, -S(R^m)-alkynyl or -N(R^m)-alkynyl; O-alkylenyl-O-alkyl, alkynyl, alkaryl, aralkyl, O-alkaryl, O- aralkyl, O(CH₂)₂SCH₃, O-(CH₂)₂-O-N(R^m)(Rⁿ) or O-CH₂C(=O)-N(R^m)(Rⁿ), -O-(CH₂)₂OCH₃, and -O-CH₃, where each R^m and Rⁿ are independently, H, an amino protecting group or substituted or unsubstituted C₁₋₁₀ alkyl;

R⁴ = is selected from the group consisting of alkyl, cyclo-alkyl, cyclo-heteroalkyl, O-alkyl, S-alkyl, NH-alkyl, and hydrogen;

or R² and R⁴ together designate a bivalent bridge, such as consisting of 1, 2, 3 groups/atoms selected from the group consisting of -C(R^aR^b)-, -C(R^a)=C(R^b), -C(R^a)=N, O, -Si(R^a)₂-, S-, -SO₂-, -N(R^a)-, and >C=Z;

wherein R^a and, when present R^b, each is independently selected from hydrogen, optionally substituted C₁₋₆-alkyl, optionally substituted C₂₋₆-alkenyl, optionally

substituted C₂₋₆-alkynyl, hydroxy, optionally substituted C₁₋₆-alkoxy, C₂₋₆-alkoxyalkyl, C₂₋₆-alkenyloxy, carboxy, C₁₋₆-alkoxycarbonyl, C₁₋₆-alkylcarbonyl, formyl, aryl, aryl-oxy-carbonyl, aryloxy, arylcarbonyl, heteroaryl, hetero-aryloxy-carbonyl, heteroaryloxy, heteroarylcarbonyl, amino, mono- and di(C₁₋₆-alkyl)amino, carbamoyl, mono- and di(C₁₋₆-alkyl)-amino-carbonyl, amino- C₁₋₆-alkyl-aminocarbonyl, mono- and di(C₁₋₆-alkyl)amino- C₁₋₆-alkyl-aminocarbonyl, C₁₋₆-alkyl-carbonylamino, carbamido, C₁₋₆-alkanoyloxy, sulphonyl, C₁₋₆-alkylsulphonyloxy, nitro, azido, sulphonyl, C₁₋₆-alkylthio, halogen, where aryl and heteroaryl may be optionally substituted and where two geminal substituents R^a and R^b together may designate optionally substituted methylene (=CH₂), wherein for all chiral centers, asymmetric groups may be found in either R or S orientation.

In some embodiments, when incorporated into an oligonucleotide, the nucleoside (Z) confers a higher binding affinity to a complementary RNA target than an equivalent DNA nucleoside. Such nucleosides are referred to as high affinity nucleosides. Examples of high affinity nucleosides include 2'-O-MOE, 2'-fluoro, 2'-O-methyl, and LNA nucleosides. In the embodiments, where the nucleoside is a high affinity nucleoside R³ may, for example be CH₂-O-DMTr or CH₂-O-MMTTr.

In some embodiments, R² is selected from the group consisting of fluoro (-F), -O-(CH₂)₂OCH₃, and -O-C₁₋₃ alkyl, such as -O-CH₃. In such embodiments, optionally R⁴ is hydrogen.

In some embodiments, the nucleoside is a LNA nucleoside (also known as a bicyclic nucleoside) comprising a 2' – 4' bridge (biradicle).

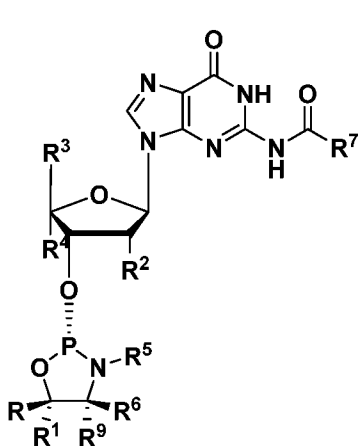
In some embodiments, R² and R⁴ together designate a bivalent bridge selected from the group consisting of bridge -C(R^aR^b)-O-, -C(R^aR^b) C(R^aR^b)-O-, -CH₂-O-, -CH₂ CH₂-O-, -CH(CH₃)-O-. In some embodiments, R² and R⁴ designate the bivalent bridge -CH₂-O- (methylene-oxy also known as oxy-LNA) or -CH(CH₃)-O- (methyl-methylene-oxy). The -CH(CH₃)-O- bridge introduces a chiral center at the carbon atom within the bridge, in some embodiments this is in the S position (for example a nucleoside known in the art as (S)cET – see EP1984381)). In some embodiments, R² and R⁴ designate the bivalent bridge -CH₂-O- wherein the bridge is in the beta-D position (beta-D-oxy LNA). In some embodiments, R² and R⁴ designate the bivalent bridge -CH₂-O-

wherein the bridge is in the alpha-L position (alpha-L-D-oxy LNA). In some embodiments, R^2 and R^4 designate the bivalent bridge $-\text{CH}_2\text{-S}-$ (thio LNA), or $-\text{CH}_2\text{-NH}_2-$ (amino LNA). In the embodiments where R^2 and R^4 together designate a bivalent bridge, R^3 may, for example be $\text{CH}_2\text{-O-DMTr}$ or $\text{CH}_2\text{-O-MMTr}$.

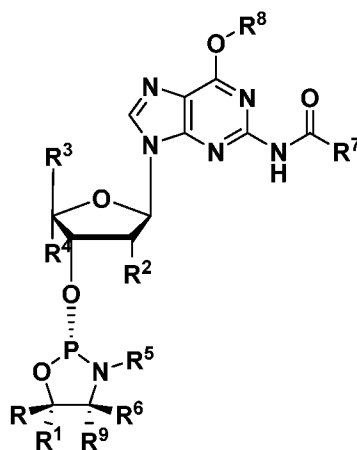
In some embodiments where the nucleoside (Z) is a bicyclic nucleotides (LNA) such as beta-D-oxy LNA, R is aryl, such as phenyl, and R^1 is hydrogen or C_{1-3} alkyl. In such an embodiment, R^5 and R^6 may together form a heterocyclic ring, such as a five membered heterocyclic ring, as described herein (e.g. see formula 2).

The compound of the invention comprises an acyl protected guanine nucleoside (Z).

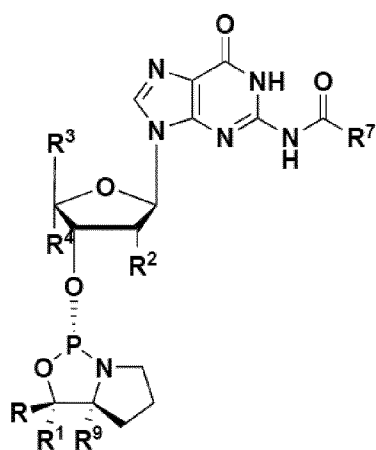
The compound of the invention may, in some embodiments, be represented by a compound of formula 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 24, or 25:



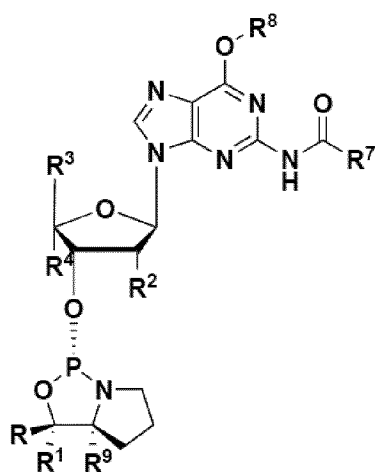
Formula 10



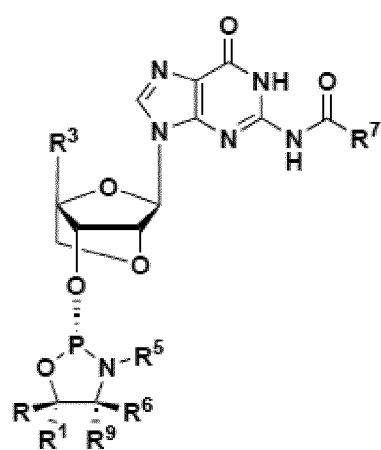
Formula 11



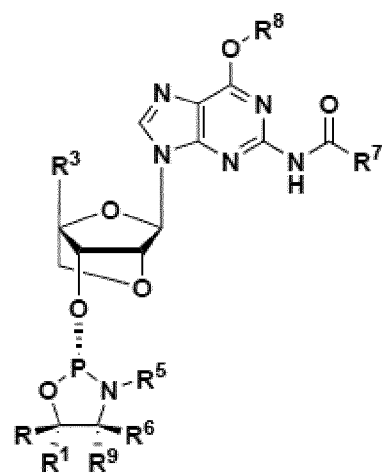
Formula 12



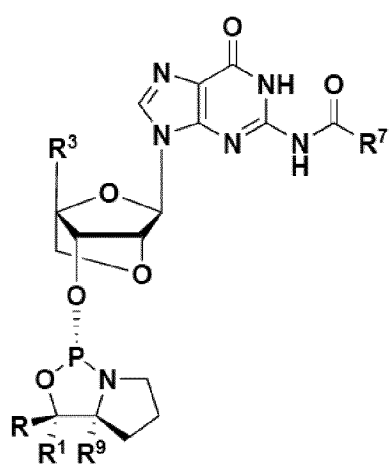
Formula 13



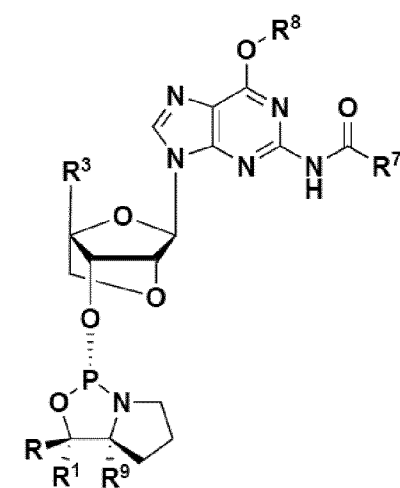
Formula 14



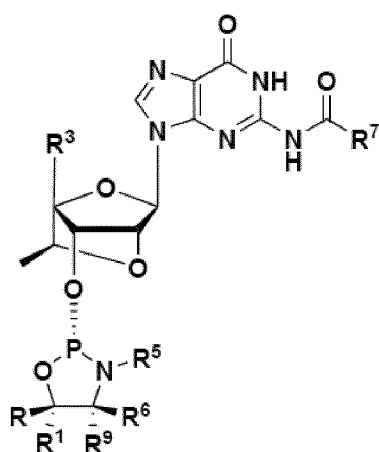
Formula 15



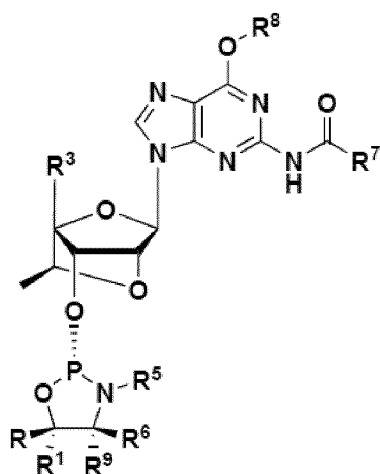
Formula 16



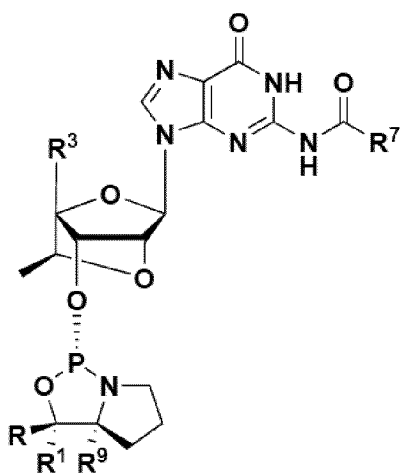
Formula 17



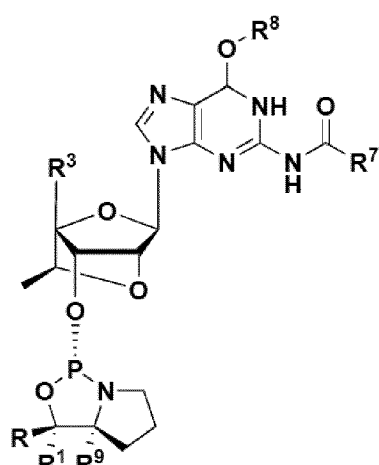
Formula 18



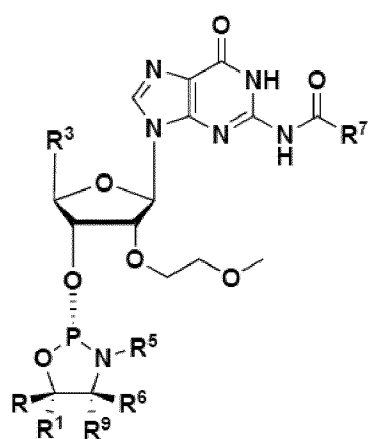
Formula 19



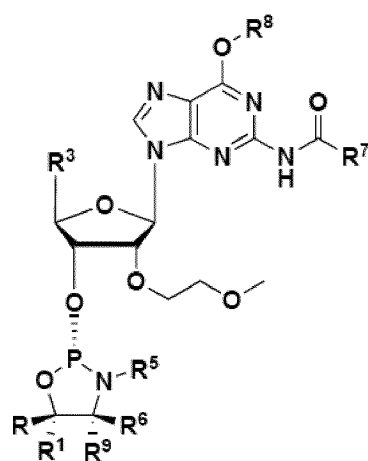
Formula 20



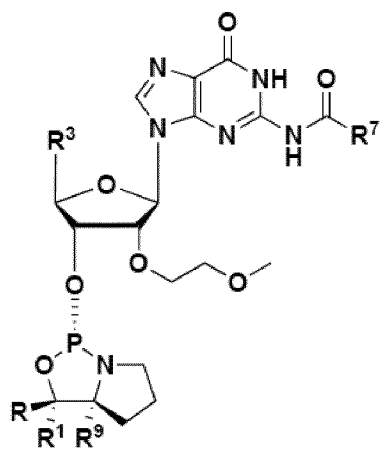
Formula 21



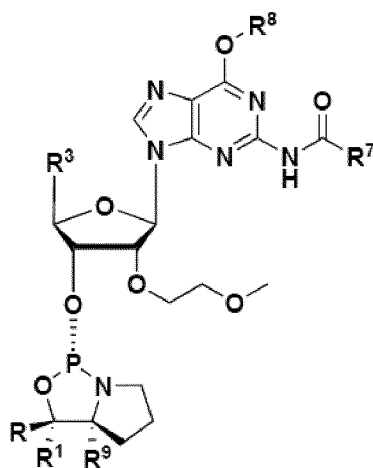
Formula 22



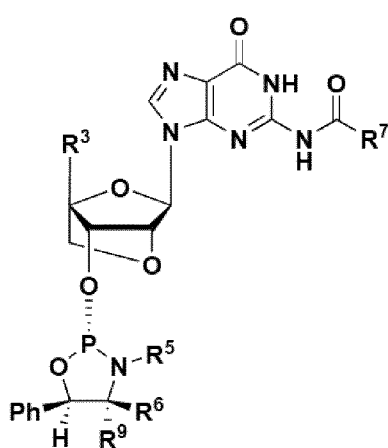
Formula 23



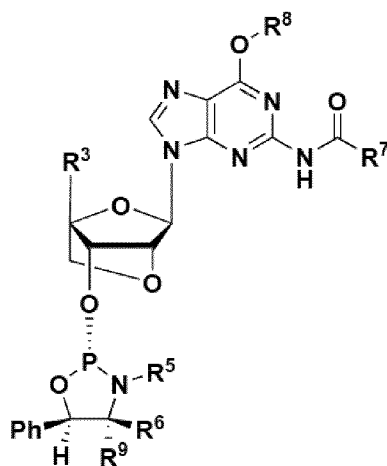
Formula 24



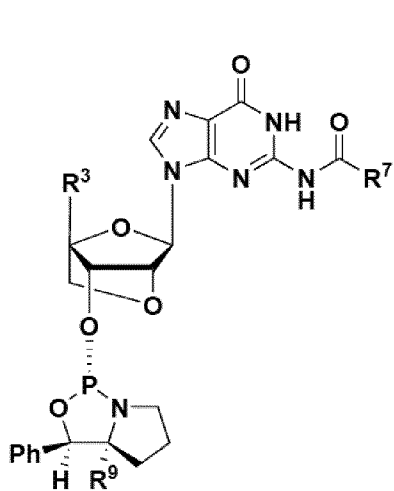
Formula 25



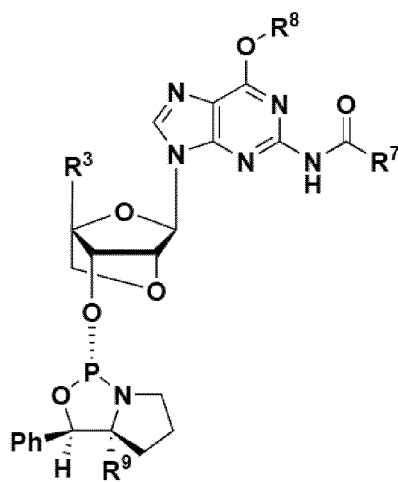
Formula 26



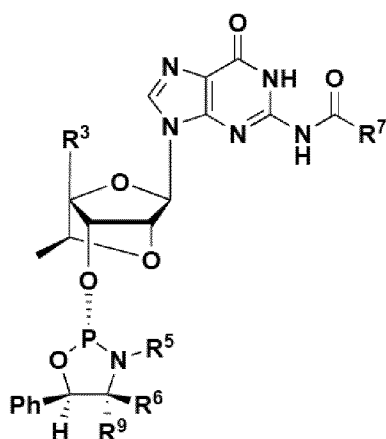
Formula 27



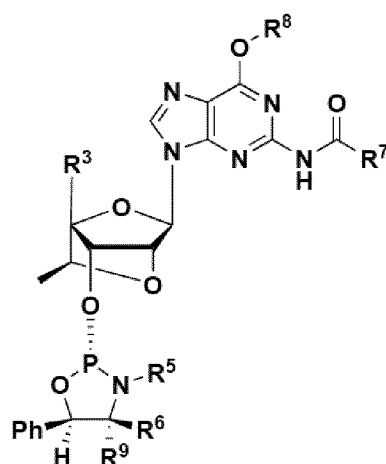
Formula 28



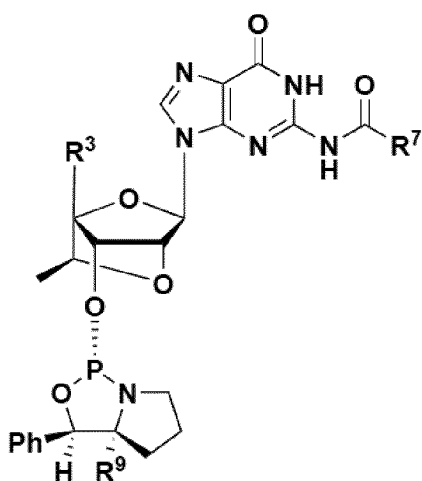
Formula 29



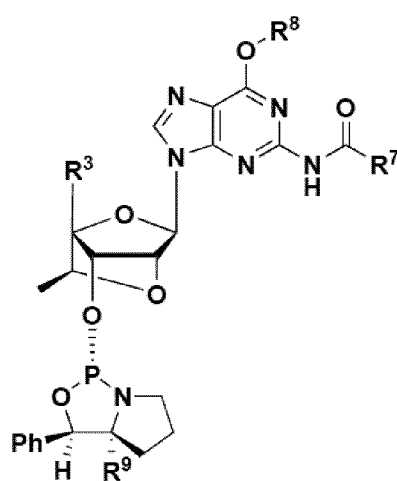
Formula 30



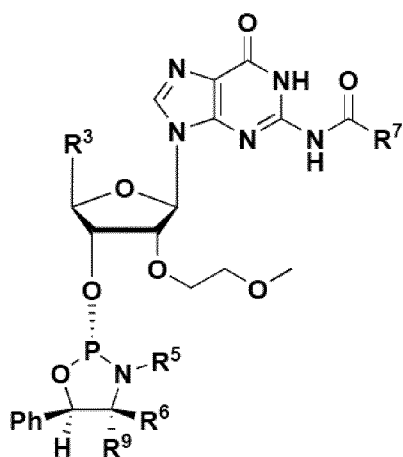
Formula 31



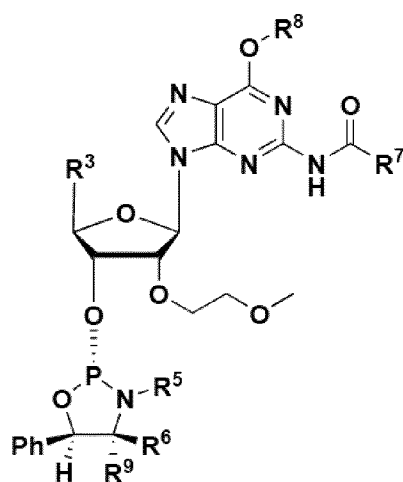
Formula 32



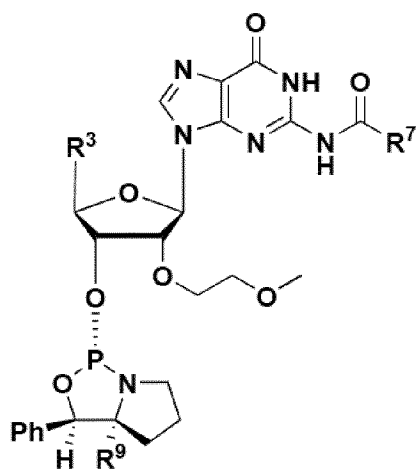
Formula 33



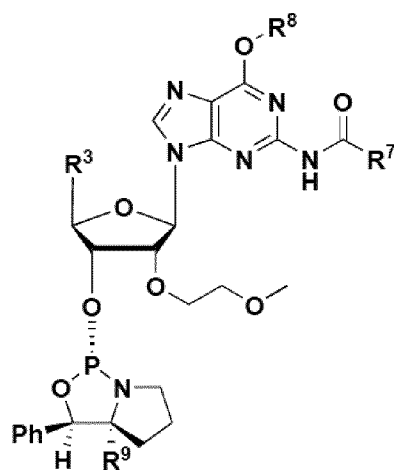
Formula 34



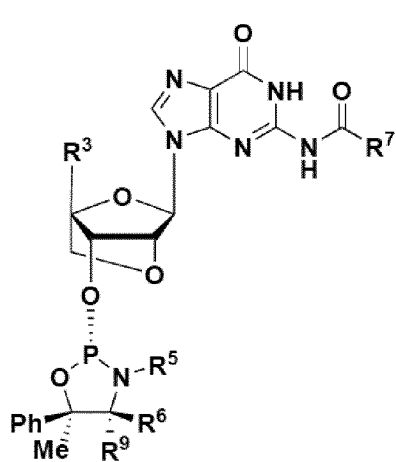
Formula 35



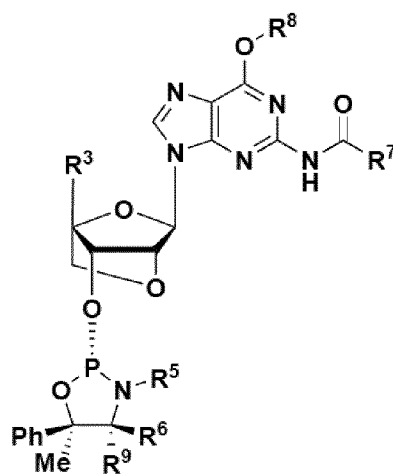
Formula 36



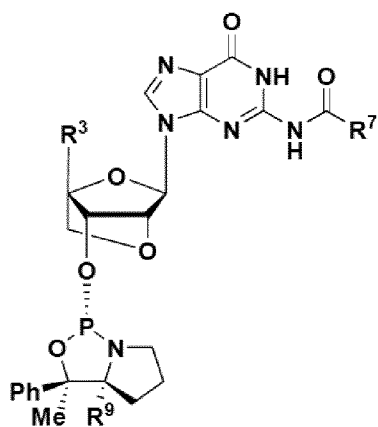
Formula 37



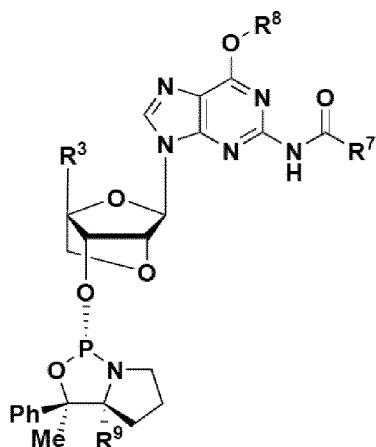
Formula 38



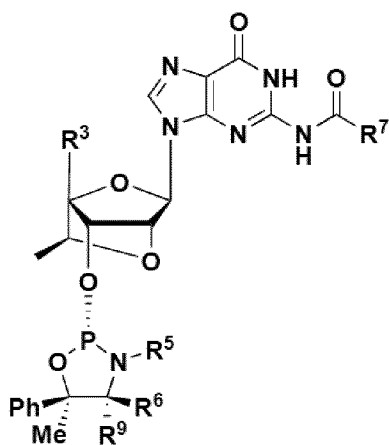
Formula 39



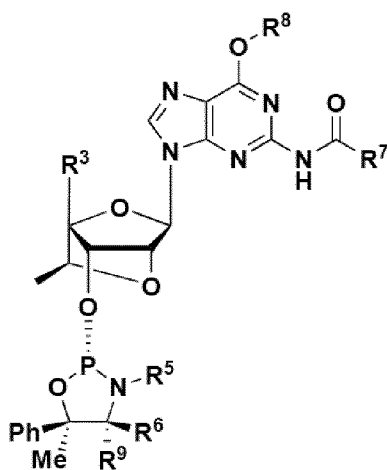
Formula 40



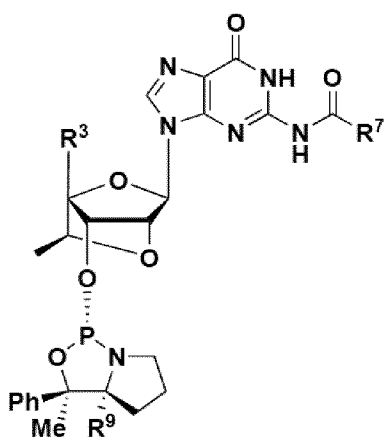
Formula 41



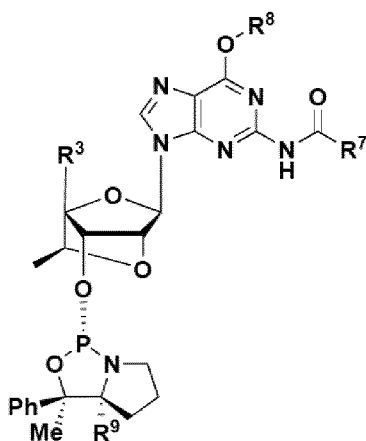
Formula 42



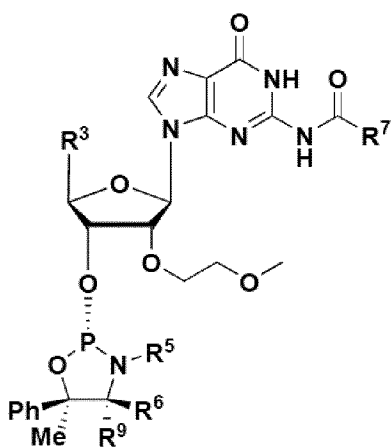
Formula 43



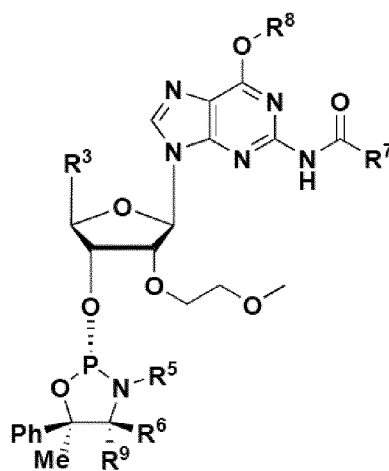
Formula 44



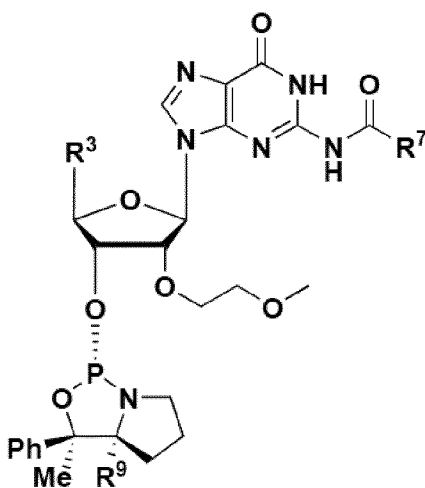
Formula 45



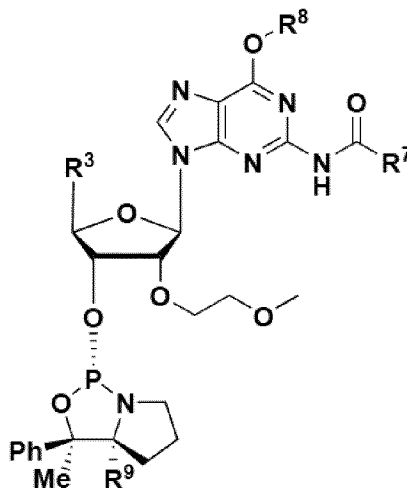
Formula 46



Formula 47



Formula 48



Formula 49

wherein, R, R¹, R², R³, R⁴, R⁵, R⁹ and R⁶ are as per the compound of the invention, and -C(=O)-R⁷ is the acyl protecting group on the exocyclic nitrogen of the guanine base, and R⁸ when present is a protecting group on the guanine exocyclic oxygen. In some embodiments R⁸ is cyanoethyl. In some embodiments, R⁹ is hydrogen.

In some embodiments of the compound of the invention, R⁷ is selected from the group consisting of optionally substituted alkyl-, alkenyl-, alkynyl-, cycloalkyl- or aryl-group, preferably from an optionally substituted C₁₋₆-alkyl-, C₂₋₆-alkenyl-, C₂₋₆-alkynyl-, C₃₋₇-cycloalkyl- or phenyl-group; wherein when substituted, the substituent group may be mono or poly substituted, e.g. with one or more substituents selected from the group consisting of halogen, C₁₋₆-alkyl, C₂₋₆-alkenyl, C₂₋₆-alkynyl, C₁₋₆-alkoxy, optionally

substituted aryloxy or optionally substituted aryl. In some embodiments alkyl is branched alkyl, such as C₃₋₁₀ or C₃₋₆ branched alkyl.

In some embodiments R⁷ is a branched alkyl, such as a substituted or unsubstituted branched alkyl, such as, iso-propyl, iso-butyl, sec-butyl, and tert-butyl. In some embodiments R⁷ is iso-propyl.

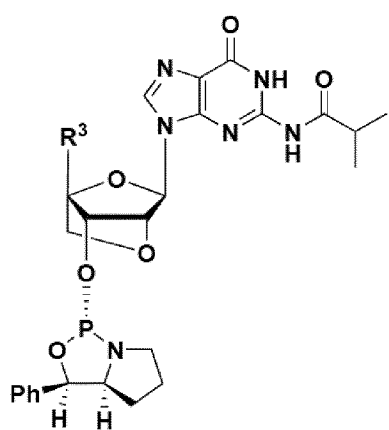
In some embodiments, the acyl protecting group (e.g. -C(=O)-R⁷) on the guanine exocyclic nitrogen group, is selected from the group consisting of isobutyryl (iBu), Acetyl (Ac), Phenoxyacetyl (PAC), p-Isopropylphenoxyacetyl (iPrPAC), phenylacetyl, Isopropoxyacetyl, methoxyacetyl, benzoyl, p-methoxyphenylacetyl, diphenylacetyl, cyclohexylcarbonyl, 1,1-dimethylpropanoyl, and p-tert-Butyl-phenoxyacetyl.

In some embodiments, the acyl protecting group on the guanine exocyclic nitrogen group is selected from the group consisting of isobutyryl (iBu), Acetyl (Ac), phenoxyacetyl (PAC), and p-Isopropylphenoxyacetyl (iPrPAC).

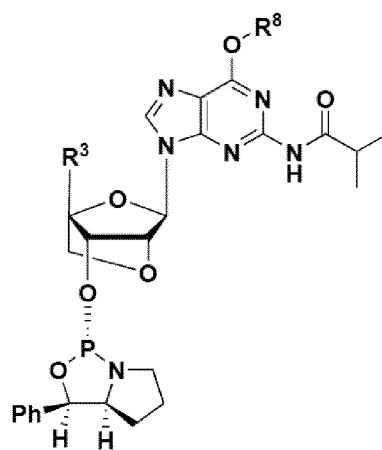
In some embodiments the acyl protecting group on the guanine exocyclic nitrogen group is an isobutyryl (iBu) terminal group

In the embodiments where R² and R⁴ together designate a bivalent bridge, R³ may be CH₂-O-DMTr or CH₂-O-MMTTr, and the acyl protecting group (e.g. -C(=O)-R⁷) on the guanine exocyclic nitrogen group is isobutyryl (iBu), R may be phenyl, and R¹ may be either hydrogen or methyl, and R⁵ and R⁶ together form a five membered heterocycle, such as that shown in formula 2.

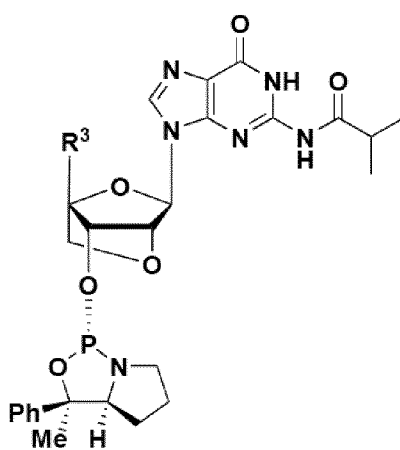
The compound of the invention may, in some embodiments, be represented by a compound of formula 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60 or 61:



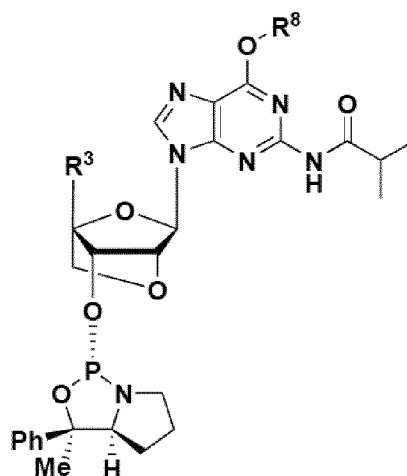
Formula 50



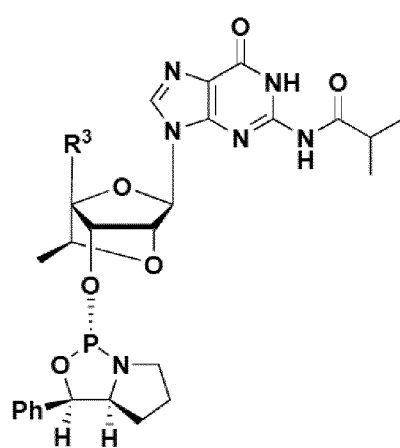
Formula 51



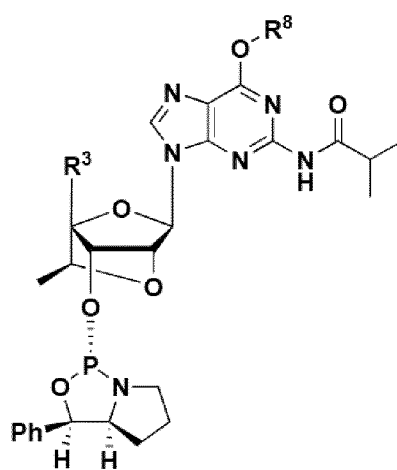
Formula 52



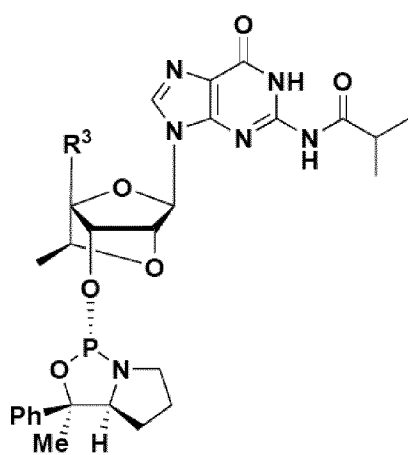
Formula 53



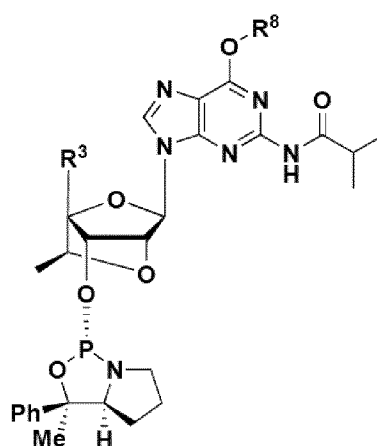
Formula 54



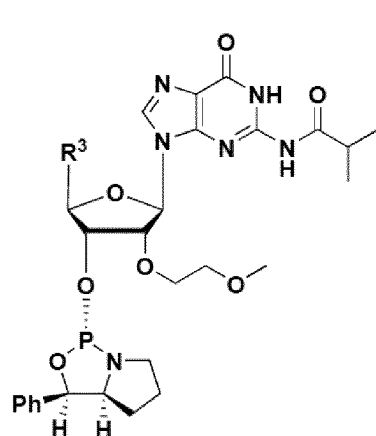
Formula 55



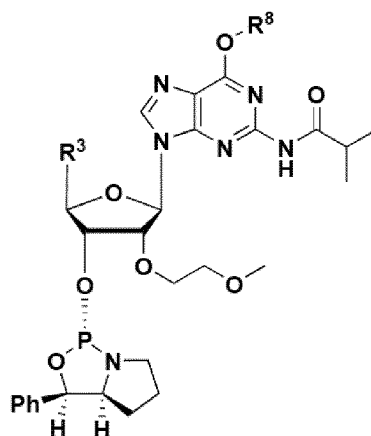
Formula 56



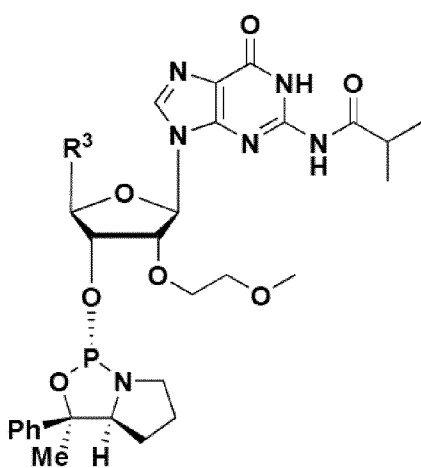
Formula 57



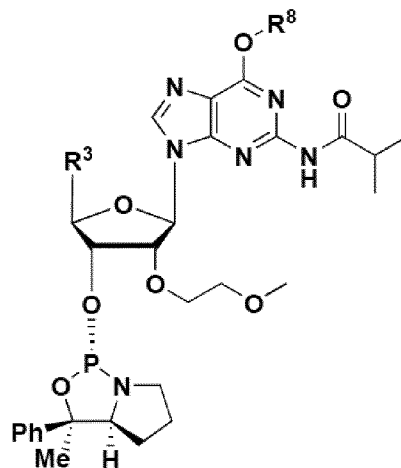
Formula 58



Formula 59



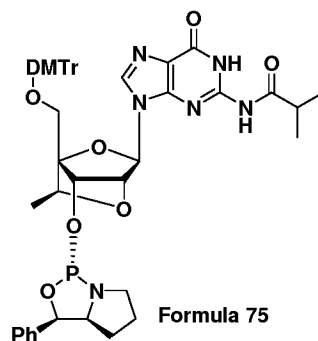
Formula 60



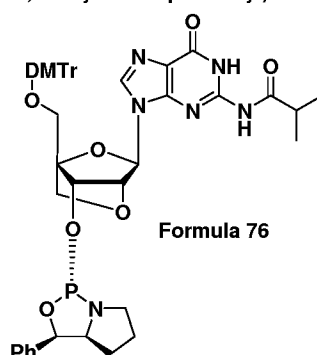
Formula 61

wherein R^3 and R^8 (when present) are as per the compound of the invention. In some embodiments, R^3 is selected from the group consisting of CH_2ODMTr , $CH_2-Alkyl-O-DMTr$, $CH-Me-O-DMTr$, CH_2OMMTr , $CH_2-Alkyl-O-MMTr$, $CH(Me)-O-MMTr$, $CH-R^a-O-DMTrR^b$, and $CH-R^a-O-MMTrR^b$, and R^8 (when present) may be cyanoethyl; wherein R_a and R_b are as per the compound of the invention.

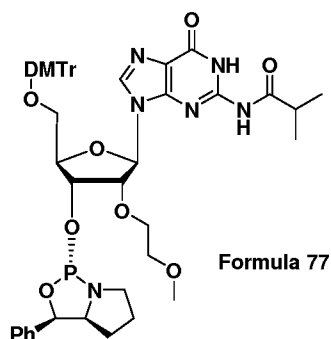
In some embodiments, the invention provides a compound according to any one of formulas 75, 76 and 77:



N-(9-((1*S*,3*R*,4*R*,6*S*,7*S*)-1-((bis(4-methoxyphenyl)(phenyl)methoxy)methyl)-6-methyl-7-(((1*R*,3*R*,3*aS*)-3-phenyltetrahydro-1*H*,3*H*-pyrrolo[1,2-*c*][1,3,2]oxazaphosphol-1-yl)oxy)-2,5-dioxabicyclo[2.2.1]heptan-3-yl)-6-oxo-6,9-dihydro-1*H*-purin-2-yl)isobutyramide



N-(9-((1*R*,3*R*,4*R*,7*S*)-1-((bis(4-methoxyphenyl)(phenyl)methoxy)methyl)-7-(((1*R*,3*R*,3*aS*)-3-phenyltetrahydro-1*H*,3*H*-pyrrolo[1,2-*c*][1,3,2]oxazaphosphol-1-yl)oxy)-2,5-dioxabicyclo[2.2.1]heptan-3-yl)-6-oxo-6,9-dihydro-1*H*-purin-2-yl)isobutyramide



N-(9-((2*R*,3*R*,4*R*,5*R*)-5-((bis(4-methoxyphenyl)(phenyl)methoxy)methyl)-3-(2-methoxyethoxy)-4-(((1*R*,3*R*,3*aS*)-3-phenyltetrahydro-1*H*,3*H*-pyrrolo[1,2-*c*][1,3,2]oxazaphosphol-1-yl)oxy)tetrahydrofuran-2-yl)-6-oxo-6,9-dihydro-1*H*-purin-2-yl)isobutyramide

It will be recognised that in some embodiments the compounds of formula 75, 76 and 77 may have R¹ group which is methyl (rather than hydrogen).

Solvent Compositions

The invention provides for a solvent composition comprising the compound of the invention and a solvent, such as a polar aprotic solvent. Suitably the compound of the

invention is soluble in the solvent. The invention therefore provides for a solution comprising the compound of the invention. The solution may be a stable solution. A stable solution, *i.e.* the compound of the invention is soluble in the solvent and is stable for at least 24 hours at room temperature (e.g. 20°C). The examples provide methods for determining the solubility and stability of solution compositions comprising the compounds of the invention.

In some embodiments, the stability of the compound of the invention in the solution (e.g. solution composition), is at least about 20%, such as at least about 30%, such as at least about 40%, such as at least about 50%, such as at least about 60%, such as at least about 70%, such as at least about 75%, as measured after 24 hours using the Stability Determination Assay provided in Example 6 (typically performed at room temperature, such as 20 - 25°C). Such solutions comprising the compound of the invention dissolved in solution which show stability after 24 hours (*i.e.* the amount of remaining compound after 24 hours as measured using the stability determination assay of example 6 is at least about 20%, such as at least about 30%, such as at least about 40%, such as at least about 50%, such as at least about 60%, such as at least about 70%, such as at least about 75%), are referred to as stable solutions herein. In some embodiments the invention provides a stable solution comprising the compound of the invention and a solvent, such as those referred to herein.

In some embodiments the solvent is a polar solvent. In some embodiments the solvent is an aprotic solvent.

In some embodiments, the solvent is or comprises a solvent selected from the group consisting of acetonitrile, DMF, DMSO, dioxane, tetrahydrofuran, dichloromethane, and dichloroethane.

In some embodiments, the solvent is or comprises acetonitrile or dioxane.

In some embodiments, the solvent comprises acetonitrile and acetone, for example in about 1:1 ratio.

In some embodiments, the solvent is or comprises DMSO or DMF.

In some embodiments, the solvent is or comprises tetrahydrofuran.

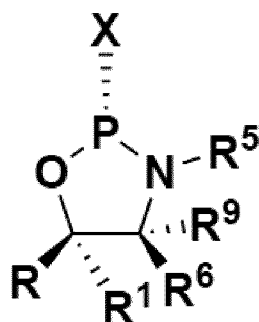
In some embodiments, the solvent is or comprises dichloromethane, or dichloroethane.

In some embodiments the solvent is other than toluene. In some embodiments, the solvent does not comprise toluene.

In some embodiments the solvent is other than DMSO or DMF. In some embodiments, the solvent does not comprise DMSO or DMF.

Method of Synthesis of Compounds of the Invention

The invention provides for a method of synthesis of the compound of the invention said method comprising the step of reacting a guanine nucleoside (Z) comprising a 3' -OH group; with a compound of formula 4:

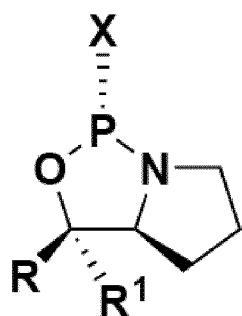


Formula 4

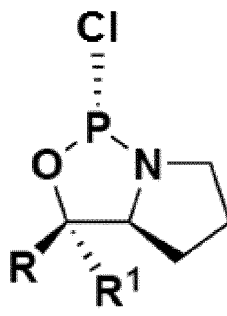
wherein X is halo, such as bromide, chloride or iodide, and wherein R, R¹, R⁵, R⁶ and R⁹ are as according to the compound of the invention;

and wherein the guanine nucleobase group on the guanine nucleoside comprises an acyl protecting group on the guanine exocyclic nitrogen group, such as the acyl protecting group -C(=O)-R⁷.

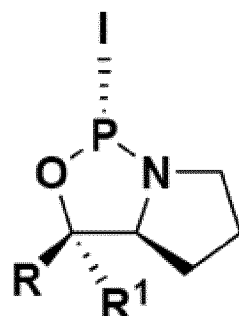
In some embodiments, the compound for formula 4 is selected from the group consisting of formula 5, 6, 7 and 8:



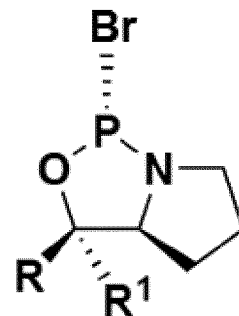
Formula 5



Formula 6



Formula 7



Formula 8

Wherein X is halo, such as chloride, bromide or iodide

In some embodiments X of formula 4 or 5 is chloride. The following may optionally apply to compounds of formula 4, 5, 6, 7 and 8:

In some embodiments R is selected from the groups consisting of aryl, heteroaryl, substituted aryl, substituted heteroaryl, nitro, halogen, cyano, silyl, substituted silyl, sulfone, substituted sulfone (aryl substituted sulfone), fluorene, and substituted fluorene.

In some embodiments R is selected from the group consisting of aryl, heteroaryl, substituted aryl and substituted heteroaryl.

In some embodiments R is aryl, such as phenyl.

In some embodiments, when R is substituted aryl, R may be substituted with halide, such as iodide, fluoride, bromide or chloride, such as phenyl substituted with halide, such as iodide, fluoride, bromide or chloride.

In some embodiments R^1 is hydrogen. In some embodiments R^1 is C_{1-3} alkyl, such as methyl, ethyl or propyl. In some embodiments R^1 is methyl.

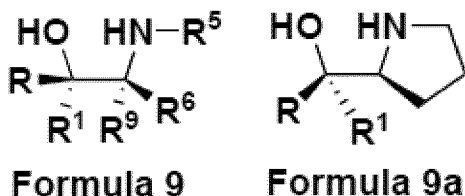
In some embodiments, R is aryl, such as phenyl and R^1 is hydrogen.

In some embodiments, R is aryl, such as phenyl, and R^1 is C_{1-3} alkyl, such as methyl, ethyl or propyl.

In some embodiments, R is phenyl, R^1 is hydrogen, X is bromine, and R^5 and R^6 together form a five membered heterocycle. In some embodiments, R is phenyl, R^1 is methyl, X is bromine, and R^5 and R^6 together form a five membered heterocycle. In some embodiments, R is phenyl, R^1 is hydrogen, X is chlorine, and R^5 and R^6 together form a five membered heterocycle. In some embodiments, R is phenyl, R^1 is methyl, X is chlorine, and R^5 and R^6 together form a five membered heterocycle.

The compound of formula 4 or Formula 5, 6, 7 or 8, is an intermediate compound which may be used in the method of synthesis of the compound of the invention, and the invention therefore provides for the compound of formula 4, 5, 6, 7 or 8, and its use in the synthesis of nucleoside monomers, such as acyl protected L-XNA-G, such as acyl protected L-LNA-G monomers.

The intermediate compound for formula 4 (such as compounds of formula 5, 6, 7, and 8) may be made in a prestep (**Step A**) by reacting the compound of formula 9 or formula 9a, with phosphorus trihalide, such as PCl_3 , PBr_3 or PI_3 , such as PCl_3 ,



wherein R, R¹, R⁵, R⁹ and R⁶ are as according to the compound of the invention.

The reaction between the compound of formula 9 or 9a and the phosphorus trihalide is typically performed in the presence of a tertiary non nucleophilic base, such as N-methylmorpholine (NMM), triethylamine, pyridine, N-Methylimidazole, or 1,4-Diazabicyclo[2.2.2]octane and may be performed in a solvent, such as toluene, THF, dioxane, diethylether or benzene, such as THF or toluene. In some embodiments, the tertiary non nucleophilic amine is NMM and the solvent is either toluene or THF.

In some embodiments of formula 9 or 9a, R is phenyl and R¹ is hydrogen. In some embodiments R is phenyl and R¹ is methyl.

The invention provides for a method for the synthesis of the compound of formula 4, 5, 6, 7, or 8 (which may be referred to in some embodiments described herein as **step A**) Said method comprising the step of reacting a compound for formula 9 or 9a with a solvent (e.g. toluene) solution of phosphorous trihalide (to make the compound of formula 4 and 5*), such as phosphorus trichloride (to make the compound of formula 6*), phosphorous triiodide (to make the compound of formula 7*), or phosphorous tribromide (to make the compound of formula 8*), at a temperature below 0°C, to produce the compound of formula 4, 5, 6, 7, 8 or 9. The solvent, may for example be selected from the group consisting of toluene, THF, dioxane, diethylether or benzene, such as THF or toluene. It will be recognised that precursor 9a may be used to make intermediates of formula 5, 6, 7, 8 or 9, depending upon which phosphorous trihalide is used(as indicated by the * in relation to formula 5, 6, 7, and 8). Therefore, the reaction of the phosphorus trihalide and the compound of formula 9 or 9a forms the intermediate compound of formula 4, 5, 6, 7 or 8.

In some embodiments the reaction of compound 9 (or 9a) and the phosphorous trihalide is performed at a temperature of about minus 45°C – about minus 65°C, such

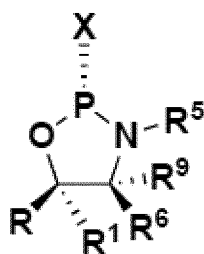
as between about 50°C – about minus 60°C, such as about minus 55°C. The term about includes the specific integer value indicated.

In some embodiments, phosphorus trihalide, such as PCl_3 , is used at a molar concentration no greater than that of the compound for formula 9 or 9a. In some embodiments, a molar excess of the compound of formula 9 or 9a is used in step A, as compared to the molar quantity of phosphorous trihalide. In some embodiments the molar ratio of precursor compound of formula 9 or 9a to phosphorus trihalide in step 1 is, greater than about 1, such as 1.05 of above. In some embodiments the molar ratio of precursor compound of formula 9 or 9a to phosphorus trihalide in step 1 is no greater than 1.5.

Subsequent to synthesis, the compound for formula 4, 5, 6, 7 or 8 may be dried, such as in a vacuum, and optionally redissolved in solvent such as , such as toluene, THF, dioxane, diethylether or benzene, such as THF or toluene, for use in the subsequent synthesis step, which may be referred to herein as **step B**.

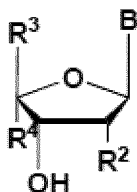
The invention provides for a method for the synthesis of the compound of formula 3 (which may be referred to in some embodiments described herein as **step B**)

Said method comprising the step of reacting a compound for formula 4,



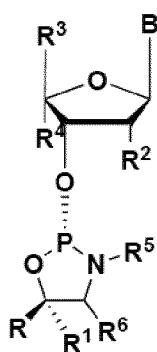
Formula 4

wherein X is halo, such as bromide, iodine or chloride (such as the compound for formula 5, 6, 7 or 8), and wherein R, R^1 , R^5 , R^9 and R^6 are as according to the compound of the invention, comprising the step of reacting the compound of formula 4 with a nucleoside of formula X



Formula X

wherein, R², R³ and R⁴ are as per the compound of the invention;
in a solvent, such as , such as toluene, THF, dioxane, diethylether or benzene, such
as THF or toluene; at a temperature below 0°C, to produce the compound of formula 3



Formula 3

In some embodiments, the reaction of step is performed in the presence of an organic base, such as a tertiary non-nucleophilic amine base, such as n-methylmorpholine, and triethylamine.

In some embodiments the reaction of compound of formula 4 (or of formula 5, 6, 7 or 8) and nucleoside X is performed at a temperature of about minus 60°C – about minus 80°C, such as between about 65°C – about minus 75°C, such as about minus 77°C.

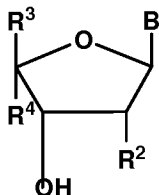
The term about includes the specific integer value indicated.

In some embodiments the molar concentration ratio of the compound of formula 4 (or of formula 5, 6, 7 or 8) and nucleoside X used in step B is at least 2, such as about 2 and about 4, such as about 2 and about 3. In some embodiments, the compound of formula 4 (or of formula 5, 6, 7 or 8) is used in a molar excess as compared to the compound of formula X.

In some embodiments, a solution of nucleoside X is added to a solution the compound of formula 4 (or of formula 5, 6, 7 or 8) gradually, *i.e.* not in a single addition step, such as over a time period of at least 15 seconds, such as at least 30 seconds, such as

over a period of at least 1 minute, such as at least 90 seconds, such as at least two minutes, such as between 5 and 30 minutes, such as between 10 and 20 minutes, such as about 15 minutes.

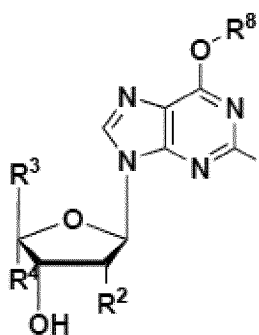
In some embodiments, the nucleoside has the formula



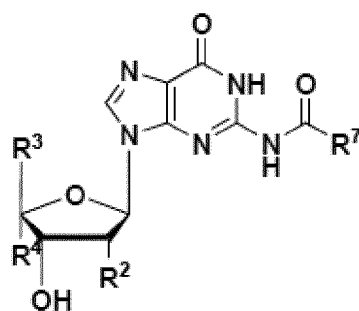
wherein, B, R², R³, R⁴, are as defined herein.

In some embodiments, the reaction in step B occurs in the presence of a base and a solvent. In some embodiments, the base is an organic base, such as a base selected from the group consisting of trimethylamine, triethylamine, and N-methylmorpholine. In some embodiments the solvent is or comprises toluene or tetrahydrofuran, optionally further comprising pyridine. In some embodiments, the solvent is or comprises a polar aprotic solvent. In some embodiments, the solvent is or comprises a solvent selected from the group consisting of acetonitrile, DMF, DMSO, dioxane, tetrahydrofuran, N-methyl-2-pyrrolidone, dichloromethane, and dichloroethane. In some embodiments, the solvent is or comprises tetrahydrofuran (THF) and the base is trimethylamine. In some embodiments, the reaction in step B occurs at a temperature below 0°C, such as below -10°C, such as below -20°C, such as below -30°C, such as below -40°C, such as below -50°C, such as below -60°C, such as below -70°C, such as between -75 and -80, such as about -77°C. About includes the exact integer mentioned.

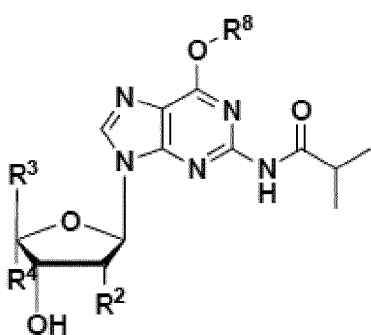
In some embodiments the compound of formula X is selected from the compounds of formula 62, 63, 64, 65, 66, 67, 68, 69, 70 and 71:



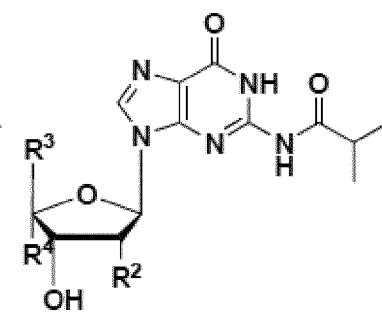
Formula 62



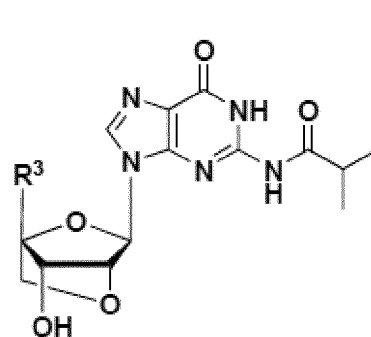
Formula 63



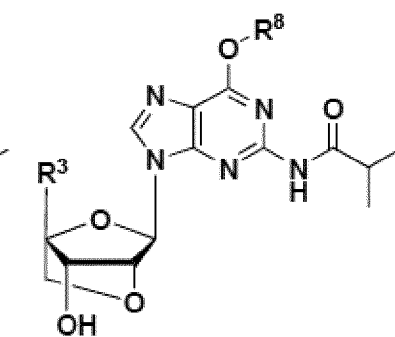
Formula 64



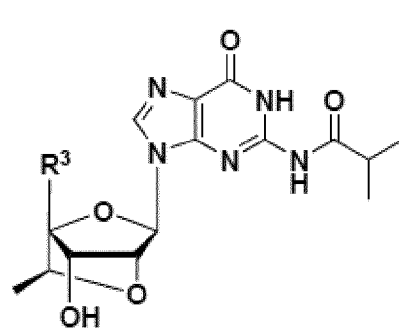
Formula 65



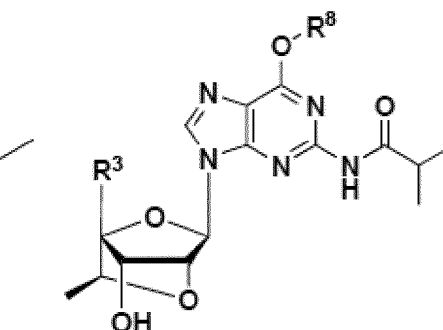
Formula 66



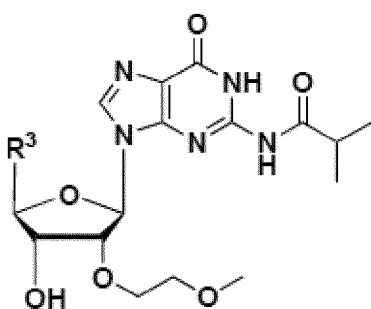
Formula 67



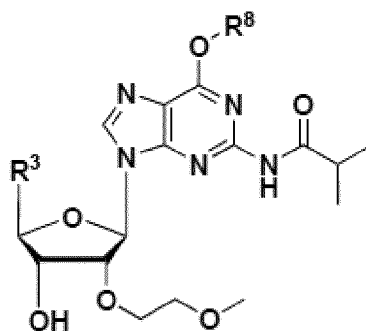
Formula 68



Formula 69



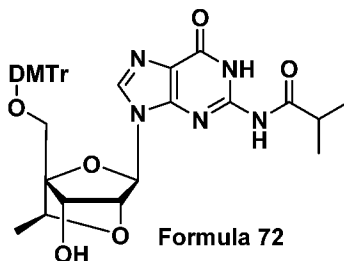
Formula 70



Formula 71

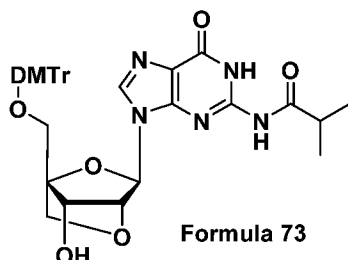
Where in R², R³, R⁴, R⁷ and R⁸ are as per the compound of the invention.

In some embodiments, the compound of formula X may be a compound of formula 72, 73 or 74:



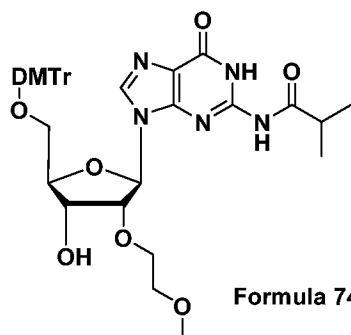
Formula 72

N-(9-((1*R*,3*R*,4*R*,6*S*,7*S*)-1-((bis(4-methoxyphenyl)(phenyl)methoxy)methyl)-7-hydroxy-6-methyl-2,5-dioxabicyclo[2.2.1]heptan-3-yl)-6-oxo-6,9-dihydro-1 *H*-purin-2-yl)isobutyramide



Formula 73

N-(9-((1*R*,3*R*,4*R*,7*S*)-1-((bis(4-methoxyphenyl)(phenyl)methoxy)methyl)-7-hydroxy-2,5-dioxabicyclo[2.2.1]heptan-3-yl)-6-oxo-6,9-dihydro-1 *H*-purin-2-yl)isobutyramide

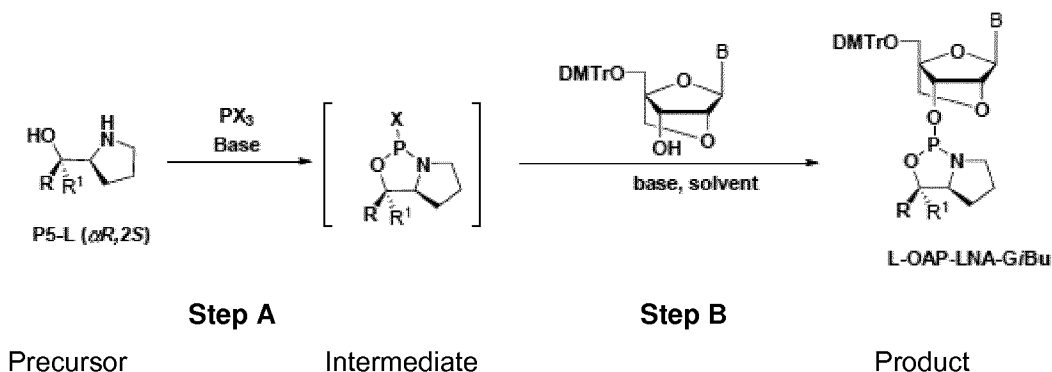


Formula 74

N-(9-((2*R*,3*R*,4*R*,5*R*)-5-((bis(4-methoxyphenyl)(phenyl)methoxy)methyl)-4-hydroxy-3-(2-methoxyethoxy)tetrahydrofuran-2-yl)-6-oxo-6,9-dihydro-1 *H*-purin-2-yl)isobutyramide

The invention provides a method for the synthesis of a compound of formula 1 (e.g. a compound of formula 3), comprising the subsequent steps A and B. An example of the methods step A and Step B are shown in the following reaction diagram, wherein R and R¹ are as per the compound of the invention, PX₃ is phosphorus halide, X is

halide, such as iodide, bromide or chloride, and B is the acyl protected guanine nucleobase of the invention.



Oligonucleotide Synthesis

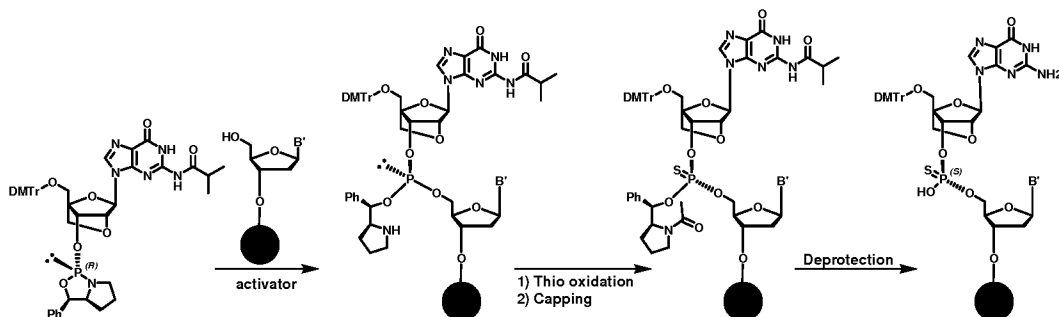
The invention provides for the use of the compound according to the invention, or the solvent composition comprising the compound of the invention, in the synthesis of an oligonucleotide.

The nucleoside monomer of the invention, when incorporated into an oligonucleotide via oligonucleotide synthesis, results in the creation of a *Sp* stereodefined phosphorothioate internucleoside linkage, 3' to the incorporated nucleoside.

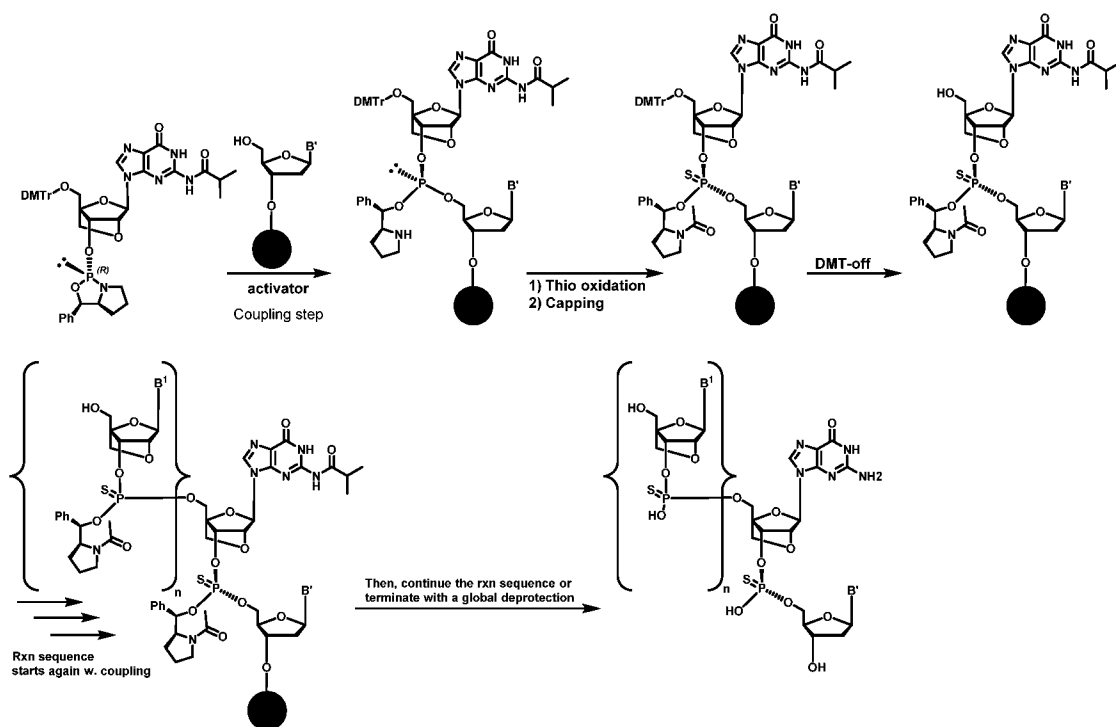
In some embodiments the oligonucleotide is a LNA oligonucleotide. The L-LNA-G monomer of the invention may be incorporated into the oligonucleotide via any suitable oligonucleotide synthesis method, such as phosphoramidite oligonucleotide synthesis. The L-LNA-G monomer of the invention is a phosphoramidite. In some embodiments the L-LNA-G monomer is incorporated into the oligonucleotide during phosphoramidite oligonucleotide synthesis.

In some embodiments, the LNA oligonucleotide made by the method of the invention may comprise at least 1 G monomers, such as at least 2 G monomers, such as at least 3 G monomers, such as at least 4 G monomers. Numerous designs of oligonucleotide are known, and the method of the invention may be used, for example to make LNA gapmers, mixmers, totalmers, and TINY LNAs.

The following figure shows a schematic representation of the reiterative cycles of oxidation, capping and de-protection which may be used in methods of phosphoramidite oligonucleotide synthesis, as exemplified below:



or



The method of preparing an oligonucleotide may utilise any suitable oligonucleotide synthesis method, such as phosphoramidite oligonucleotide synthesis. Oligonucleotide synthesis may be performed on a solid support, such as a linker support. Oligonucleotide synthesis may be performed by the sequential steps of

coupling, oxidation, capping and deprotection. Once the oligonucleotide has been synthesised it, any remaining protection (e.g. $-C(=O)-R^7$ and when present R^8) groups may be removed, and the oligonucleotide may be liberated from the solid support, for example using NH_4OH at $60^\circ C$.

Stereodefined phosphorothioate oligonucleotides

Typically, oligonucleotide phosphorothioates are synthesised as a random mixture of R_p and S_p phosphorothioate linkages (also referred to as a diastereomeric mixture). In the method of the present invention, phosphorothioate oligonucleotides are provided where at least one of the phosphorothioate linkages of the oligonucleotide is stereodefined, *i.e.* is either R_p or S_p in at least 75%, such as at least 80%, or at least 85%, or at least 90% or at least 95%, or at least 97%, such as at least 98%, such as at least 99%, or (essentially) all of the oligonucleotide molecules present in the oligonucleotide sample. Stereodefined oligonucleotides comprise at least one phosphorothioate linkage which is stereodefined. The term stereodefined, may be used to describe a defined chirality of one or more phosphorothioate internucleoside linkages as either R_p or S_p , or may be used to describe a oligonucleotide which comprises such a (or more) phosphorothioate internucleoside linkage. It is recognised that a stereodefined oligonucleotide may comprise a small amount of the alternative stereoisomer at any one position, for example Wan et al reports a 98% stereoselectivity for the gapmers reported in NAR, November 2014.

LNA Oligonucleotide

An LNA oligonucleotide is an oligonucleotide which comprises at least one LNA nucleoside. The LNA oligonucleotide may be an antisense oligonucleotide. The term oligonucleotide as used herein is defined as it is generally understood by the skilled person as a molecule comprising two or more covalently linked nucleosides. For use as an antisense oligonucleotide, oligonucleotides are typically synthesised as 7 – 30 nucleotides in length.

The term “antisense oligonucleotide” as used herein refers to oligonucleotides capable of modulating expression of a target gene by hybridizing to a target nucleic acid, in particular to a contiguous sequence on a target nucleic acid. An antisense oligonucleotide can also be defined by it's complementary to a target nucleic acid. Antisense oligonucleotides are single stranded. Antisense oligonucleotides are not

essentially double stranded and are not therefore siRNAs. An antisense oligonucleotide comprises a contiguous nucleotide which is complementary to a target nucleic acid. Antisense oligonucleotides typically comprise one or more modified internucleoside linkages, and may by way of a non-limiting example be in the form of a LNA gapmer or a mixed wing gapmer. In other embodiments the oligonucleotide may be an LNA mixmers (LNA and non-LNA nucleotides, e.g. LNA and DNA (see e.g. WO2007/112754 hereby incorporated by reference), or LNA and 2'-O-MOE nucleotides, or LNA, DNA and 2'-O-MOE nucleotides), or a LNA totalmers (only LNA nucleotides – see. E.g. WO2009/043353 hereby incorporated by reference).

The term “modified internucleoside linkage” is defined as generally understood by the skilled person as linkages other than phosphodiester (PO) linkages, that covalently couples two nucleosides together. Modified internucleoside linkages are particularly useful in stabilizing oligonucleotides for *in vivo* use, and may serve to protect against nuclease cleavage. A phosphorothioate internucleoside linkage is particularly useful due to nuclease resistance, beneficial pharmacokinetics and ease of manufacture. In some embodiments at least 70%, such as at least 80 or such as at least 90% of the internucleoside linkages in the oligonucleotide, or contiguous nucleotide sequence thereof, are phosphorothioate. In some embodiments all of the internucleoside linkages of the oligonucleotide, or contiguous nucleotide sequence thereof, are phosphorothioate, wherein at least one of the phosphorothioate internucleoside linkages is a stereodefined phosphorothioate internucleoside linkage (originating from the incorporation of the acyl protected L-XNA-G monomer of the invention into the oligonucleotide during oligonucleotide synthesis). Further internucleoside linkers are disclosed in WO2009/124238 (incorporated herein by reference).

The term nucleobase includes the purine (e.g. adenine and guanine) and pyrimidine (e.g. uracil, thymine and cytosine) moiety present in nucleosides and nucleotides which form hydrogen bonds in nucleic acid hybridization. In the context of the present invention the term nucleobase also encompasses modified nucleobases which may differ from naturally occurring nucleobases, but are functional during nucleic acid hybridization. In some embodiments the nucleobase moiety is modified by modifying or replacing the nucleobase. In this context “nucleobase” refers to both naturally occurring nucleobases such as adenine, guanine, cytosine, thymidine, uracil, xanthine and hypoxanthine, as well as non-naturally occurring variants. Such variants are for example described in Hirao et al (2012) Accounts of Chemical Research vol 45 page

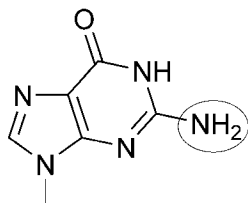
2055 and Bergstrom (2009) Current Protocols in Nucleic Acid Chemistry Suppl. 37 1.4.1.

Nucleotides are the building blocks of oligonucleotides and polynucleotides, and for the purposes of the present invention include both naturally occurring and non-naturally occurring nucleotides. In nature, nucleotides, such as DNA and RNA nucleotides comprise a ribose sugar moiety, a nucleobase moiety and one or more phosphate groups (which is absent in nucleosides). Modified nucleosides and nucleotides are modified as compared to the equivalent DNA or RNA nucleoside/tide by the introduction of a modification to the ribose sugar moiety, the nucleobase moiety, or in the case of modified nucleotides, the internucleoside linkage. Nucleosides and nucleotides may also interchangeably be referred to as “units” or “monomers”.

The term “modified nucleoside” or “nucleoside modification” as used herein refers to nucleosides modified as compared to the equivalent DNA or RNA nucleoside by the introduction of one or more modifications of the sugar moiety or the (nucleo)base moiety. The term modified nucleoside may also be used herein interchangeably with the term “nucleoside analogue” or modified “units” or modified “monomers”. Examples of modified nucleosides are described in the separate section “Oligomer modifications” and its sub-sections.

Acyl protected exocyclic nitrogen

The exocyclic nitrogen group of guanine is illustrated below (encircled). This group is protected by an acyl group in the compound of the invention. The oxygen group may optionally also be protected.



L-XNA-G Monomers

In some embodiments, the compound of the invention comprises a nucleoside moiety (Z) which is other than DNA or RNA, such monomers are referred to as L-XNA-G monomers. The “L” annotation in L-XNA-G (and L-LNA-G) refers to the

stereochemistry at the stereocenter R/R^1 (and the stereocenter at the R^9 position, such as R^6/R^9 position) as shown in formula 1, 2 and 3. The alternative stereoisomer, the D- form has the reverse stereochemistry at the R/R^1 and R^9 stereocenters.

Nucleosides other than DNA and RNA may be referred to as nucleoside analogues. The nucleosides may be high affinity nucleosides (high affinity nucleoside analogues). Such monomers include, but are not limited to LNA monomers (L-LNA-G monomers), as well as 2' substituted nucleosides, such as 2'O-MOE, 2'-fluoro or 2'OMethyl. Other 2' substitutions are known in the art and some are listed under the definition of R^2 herein.

The LNA G Monomer

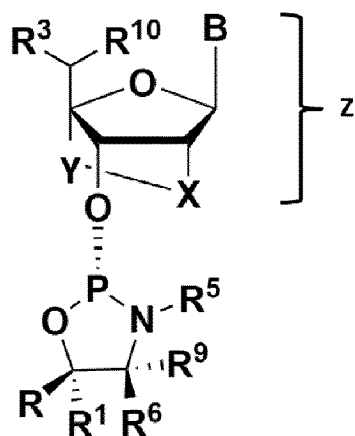
The term LNA-G refers to a nucleoside which comprises a 2'-4' biradical in the furanose ring and a guanine nucleobase. The invention provides L-LNA-G monomers, where the non cyclic nitrogen group is protected by use of an acyl protection group. Optionally the oxygen atom of the G residue is also protected.

Locked Nucleic Acid Nucleosides (LNA).

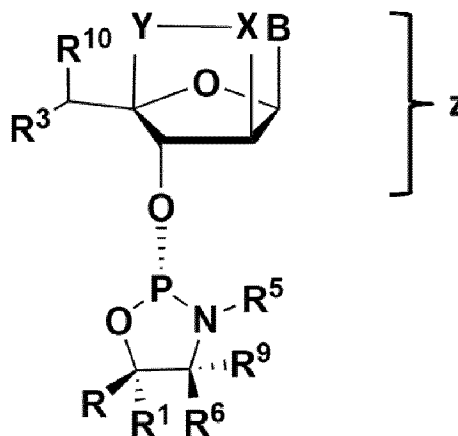
LNA nucleosides are modified nucleosides which comprise a linker group (referred to as a biradicle or a bridge) between C2' and C4' of the ribose sugar ring of a nucleotide (i.e. the embodiment where R^2 and R^4 together designate a bivalent bridge).

These nucleosides are also termed bridged nucleic acid or bicyclic nucleic acid (BNA) in the literature.

In some embodiments, the monomer of the invention is or comprises a LNA nucleoside, e.g. the compound of the invention may be of formula I or II:



Formula I



Formula II

The annotation Z represents the acyl protected guanine nucleoside (Z) of the compound of the invention – it is included for illustrative purposes.

B designates the acyl protected guanine nucleobase; R, R¹, R⁶, R³, R⁹, R⁵ are as according to the compound of the invention.

X designates a group selected from the list consisting of -C(R^aR^b)-, -C(R^a)=C(R^b)-, -C(R^a)=N-, -O-, -Si(R^a)₂-, -S-, -SO₂-, -N(R^a)-, and >C=Z

In some embodiments, X is selected from the group consisting of: -O-, -S-, NH-, NR^aR^b-, -CH₂-, CR^aR^b-, -C(=CH₂)-, and -C(=CR^aR^b)-

In some embodiments, X is -O-

Y designates a group selected from the group consisting of -C(R^aR^b)-, -C(R^a)=C(R^b)-, -C(R^a)=N-, -O-, -Si(R^a)₂-, -S-, -SO₂-, -N(R^a)-, and >C=Z

In some embodiments, Y is selected from the group consisting of: -CH₂-, -C(R^aR^b)-, -CH₂CH₂-, -C(R^aR^b)-C(R^aR^b)-, -CH₂CH₂CH₂-, -C(R^aR^b)C(R^aR^b)C(R^aR^b)-, -C(R^a)=C(R^b)-, and -C(R^a)=N-

In some embodiments, Y is selected from the group consisting of: -CH₂-, -CHR^a-, -CHCH₃-, CR^aR^b-

or -X-Y- together designate a bivalent linker group (also referred to as a radicle)

together designate a bivalent linker group consisting of 1, 2, or 3 groups/atoms selected from the group consisting of -C(R^aR^b)-, -C(R^a)=C(R^b)-, -C(R^a)=N-, -O-, -Si(R^a)₂-, -S-, -SO₂-, -N(R^a)-, and >C=Z,

In some embodiments, -X-Y- designates a biradicle selected from the groups consisting of: -X-CH₂-, -X-CR^aR^b-, -X-CHR^a-, -X-C(HCH₃)-, -O-Y-, -O-CH₂-, -S-

CH₂-, -NH-CH₂-, -O-CHCH₃-, -CH₂-O-CH₂-, -O-CH(CH₃CH₃)-, -O-CH₂-CH₂-,
OCH₂-CH₂-CH₂-, -O-CH₂OCH₂-, -O-NCH₂-, -C(=CH₂)-CH₂-, -NR^a-CH₂-, N-O-
CH₂-, -S-CR^aR^b- and -S-CHR^a-.

In some embodiments -X-Y- designates -O-CH₂- or -O-CH(CH₃)-.

and R^a and, when present R^b, each is independently selected from hydrogen, optionally substituted C₁₋₆-alkyl, optionally substituted C₂₋₆-alkenyl, optionally substituted C₂₋₆-alkynyl, hydroxy, optionally substituted C₁₋₆-alkoxy, C₂₋₆-alkoxyalkyl, C₂₋₆-alkenyloxy, carboxy, C₁₋₆-alkoxycarbonyl, C₁₋₆-alkylcarbonyl, formyl, aryl, aryloxy-carbonyl, aryloxy, arylcarbonyl, heteroaryl, heteroaryloxy-carbonyl, heteroaryloxy, heteroarylcarbonyl, amino, mono- and di(C₁₋₆-alkyl)amino, carbamoyl, mono- and di(C₁₋₆-alkyl)-amino-carbonyl, amino-C₁₋₆-alkyl-aminocarbonyl, mono- and di(C₁₋₆-alkyl)amino-C₁₋₆-alkyl-aminocarbonyl, C₁₋₆-alkyl-carbonylamino, carbamido, C₁₋₆-alkanoyloxy, sulphono, C₁₋₆-alkylsulphonyloxy, nitro, azido, sulphanyl, C₁₋₆-alkylthio, halogen, where aryl and heteroaryl may be optionally substituted and where two geminal substituents R^a and R^b together may designate optionally substituted methylene (=CH₂), wherein for all chiral centers, asymmetric groups may be found in either *R* or *S* orientation.

R¹⁰ may be hydrogen or in some embodiments may be selected from the group consisting of: optionally substituted C₁₋₆-alkyl, optionally substituted C₂₋₆-alkenyl, optionally substituted C₂₋₆-alkynyl, hydroxy, C₁₋₆-alkoxy, C₂₋₆-alkoxyalkyl, C₂₋₆-alkenyloxy, carboxy, C₁₋₆-alkoxycarbonyl, C₁₋₆-alkylcarbonyl, formyl, aryl, aryloxy-carbonyl, aryloxy, arylcarbonyl, heteroaryl, heteroaryloxy-carbonyl, heteroaryloxy, heteroarylcarbonyl, amino, mono- and di(C₁₋₆-alkyl)amino, carbamoyl, mono- and di(C₁₋₆-alkyl)-amino-carbonyl, amino-C₁₋₆-alkyl-aminocarbonyl, mono- and di(C₁₋₆-alkyl)amino-C₁₋₆-alkyl-aminocarbonyl, C₁₋₆-alkyl-carbonylamino, carbamido, C₁₋₆-alkanoyloxy, sulphono, C₁₋₆-alkylsulphonyloxy, nitro, azido, sulphanyl, C₁₋₆-alkylthio, halogen, where aryl and heteroaryl may be optionally substituted, and where two geminal substituents together may designate oxo, thioxo, imino, or optionally substituted methylene.

In some embodiments R¹⁰ is selected from C₁₋₆ alkyl, such as methyl, and hydrogen.

In some embodiments R¹⁰ is hydrogen.

In some embodiments, R^a is either hydrogen or methyl. In some embodiments, when present, R^b is either hydrogen or methyl.

In some embodiments, one or both of R^a and R^b is hydrogen

In some embodiments, one of R^a and R^b is hydrogen and the other is other than hydrogen

In some embodiments, one of R^a and R^b is methyl and the other is hydrogen

In some embodiments, both of R^a and R^b are methyl.

In some embodiments, the biradicle $-X-Y-$ is $-O-CH_2-$, and R^{10} is hydrogen. In some embodiments, the biradicle $-X-Y-$ is $-S-CH_2-$, and R^{10} is hydrogen.

In some embodiments, the biradicle $-X-Y-$ is $-NH-CH_2-$, and R^{10} is hydrogen.

In some embodiments, the biradicle $-X-Y-$ is $-O-CH_2-CH_2-$ or $-O-CH_2-CH_2-CH_2-$, and R^{10} is hydrogen.

In some embodiments, the biradicle $-X-Y-$ is $-O-CH_2-$, and R^{10} is C_{1-6} alkyl, such as methyl.

In some embodiments, the biradicle $-X-Y-$ is $-O-CR^aR^b-$, wherein one or both of R^a and R^b are other than hydrogen, such as methyl, and R^{10} is C_{1-6} alkyl, such as methyl.

In some embodiments, the biradicle $-X-Y-$ designate the bivalent linker group $-O-CH(CH_2OCH_3)-$ (2' O-methoxyethyl bicyclic nucleic acid - Seth at al., 2010, J. Org. Chem., 2010, 75 (5), pp 1569–1581). In some embodiments, the biradicle $-X-Y-$ designate the bivalent linker group $-O-CH(CH_2CH_3)-$ (2' O-ethyl bicyclic nucleic acid - Seth at al., 2010, J. Org. Chem). In some embodiments, the biradicle $-X-Y-$ is $-O-CHR^a-$, and R^{10} is hydrogen.

In some embodiments, the biradicle $-X-Y-$ is $-O-CH(CH_2OCH_3)-$, and R^{10} is hydrogen. Such LNA nucleosides are also known as cyclic MOEs in the art (cMOE) and are disclosed in WO07090071.

In some embodiments, the biradicle $-X-Y-$ designate the bivalent linker group $-O-CH(CH_3)-$ in either the R- or S- configuration. In some embodiments, the biradicle $-X-Y-$ together designate the bivalent linker group $-O-CH_2-O-CH_2-$ (Seth at al., 2010, J. Org. Chem). In some embodiments, the biradicle $-X-Y-$ is $-O-CH(CH_3)-$, and R^{10} is hydrogen. Such 6' methyl LNA nucleosides are also known as cET nucleosides in the art, and may be either (S)cET or (R)cET stereoisomers, as disclosed in WO07090071 (beta-D) and WO2010/036698 (alpha-L).

In some embodiments, the biradicle $-X-Y-$ is $-O-CR^aR^b-$, wherein in neither R^a or R^b is hydrogen, and R^{10} is hydrogen. In some embodiments, R^a and R^b are both methyl.

In some embodiments, the biradicle $-X-Y-$ is $-S-CHR^a-$, and R^{10} is hydrogen.

In some embodiments, the biradicle $-X-Y-$ is $-C(=CH_2)-C(R^aR^b)-$, such as $-C(=CH_2)-CH_2-$, or $-C(=CH_2)-CH(CH_3)-$, and R^{10} is hydrogen.

In some embodiments the biradicle $-X-Y-$ is $-N(-OR^a)-$, and R^{10} is hydrogen. In some embodiments R^a is C_{1-6} alkyl such as methyl. In some embodiments, the biradicle $-X-Y-$ together designate the bivalent linker group $-O-NR^a-CH_3-$ (Seth et al., 2010, J. Org. Chem). In some embodiments the biradicle $-X-Y-$ is $-N(R^a)-$, and R^{10} is hydrogen. In some embodiments R^a is C_{1-6} alkyl such as methyl.

In some embodiments, and R^{10} is C_{1-6} alkyl such as methyl. In such an embodiment, the biradicle $-X-Y-$ may be selected from $-O-CH_2-$ or $-O-C(HCR^a)-$, such as $-O-C(HCH_3)-$.

In some embodiments, the biradicle is $-CR^aR^b-O-CR^aR^b-$, such as CH_2-O-CH_2- , and R^{10} is hydrogen. In some embodiments R^a is C_{1-6} alkyl such as methyl.

In some embodiments, the biradicle is $-O-CR^aR^b-O-CR^aR^b-$, such as $O-CH_2-O-CH_2-$, and R^{10} is hydrogen. In some embodiments R^a is C_{1-6} alkyl such as methyl.

It will be recognized that, unless specified, the LNA nucleosides may be in the beta-D or alpha-L stereoisomer.

As illustrated in the examples, in some embodiments of the invention the LNA nucleosides are or comprise beta-D-oxy-LNA nucleosides, such as where the 2' – 4' bridge is as per formula I, and where X is oxygen, Y is CH_2 , and R^{10} is hydrogen.

Gapmer

The term gapmer as used herein refers to an antisense oligonucleotide which comprises a region of RNase H recruiting oligonucleotides (gap) which is flanked 5' and 3' by one or more affinity enhancing modified nucleosides (flanks). Various gapmer designs are described herein. Headmers and tailmers are oligonucleotides capable of recruiting RNase H where one of the flanks are missing, i.e. only one of the ends of the oligonucleotide comprises affinity enhancing modified nucleosides. For headmers the 3' flank is missing (i.e. the 5' flank comprises affinity enhancing modified nucleosides) and for tailmers the 5' flank is missing (i.e. the 3' flank comprises affinity enhancing modified nucleosides).

LNA Gapmer

The term LNA gapmer is a gapmer oligonucleotide wherein at least one of the affinity enhancing modified nucleosides is an LNA nucleoside.

Mixed Wing Gapmer

The term mixed wing gapmer refers to a LNA gapmer wherein the flank regions comprise at least one LNA nucleoside and at least one non-LNA modified nucleoside, such as at least one 2' substituted modified nucleoside, such as, for example, 2'-O-alkyl-RNA, 2'-O-methyl-RNA, 2'-alkoxy-RNA, 2'-O-methoxyethyl-RNA (MOE), 2'-amino-DNA, 2'-Fluoro-DNA, arabino nucleic acid (ANA), 2'-fluoro-ANA and 2'-F-ANA nucleoside(s). In some embodiments the mixed wing gapmer has one flank which comprises LNA nucleosides (e.g. 5' or 3') and the other flank (3' or 5' respectively) comprises 2' substituted modified nucleoside(s).

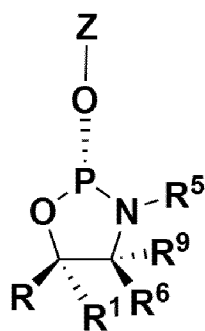
Length

When referring to the length of a nucleotide molecule as referred to herein, the length corresponds to the number of monomer units, i.e. nucleotides, irrespective as to whether those monomer units are nucleotides or nucleotide analogues. With respect to nucleotides, the terms monomer and unit are used interchangeably herein.

The process of the present invention is particularly suitable for the purification of short oligonucleotides, for example, consisting of 7 to 30 nucleotides, such as 7 – 10, such as 7, 8, 9, 10 or 10 to 20 nucleotides, such as 12 to 18 nucleotides, for example, 12, 13, 14, 15, 16, 17 or 18 nucleotides.

FURTHER EMBODIMENTS OF THE INVENTION

1. A compound of formula 1



Formula 1

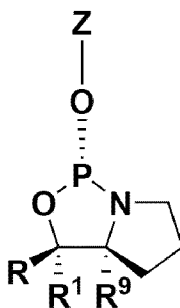
wherein

Z is a guanine nucleoside wherein the guanine nucleobase group comprises an acyl protection group on the guanine exocyclic nitrogen group, wherein the exocyclic oxygen of Formula I is covalently attached to the 3' carbon of the nucleoside Z;

R^5 and R^6 are independently selected from the group consisting of hydrogen, alkyl, cyclo-alkyl, aryl, heteroaryl, substituted alkyl, substituted cyclo-alkyl, substituted aryl, and substituted heteroaryl, or R^5 and R^6 together form a heterocyclic ring comprising 3 – 16 carbon atoms, together with the N atom of formula (I);

R^1 is selected from the groups consisting of hydrogen and C_{1-3} alkyl; R^9 is hydrogen; and R is selected from the groups consisting of aryl, heteroaryl, substituted aryl, substituted heteroaryl, nitro, halogen, cyano, silyl, substituted silyl, sulfone, substituted sulfone (aryl substituted sulfone), fluorene, and substituted fluorene.

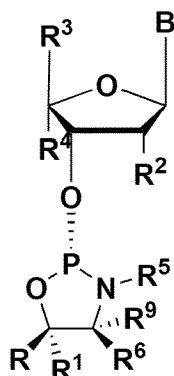
2. The compound according to embodiment 1, wherein R is selected from the group consisting of aryl, heteroaryl, substituted aryl and substituted heteroaryl.
3. The compound according to embodiment 1, wherein R is aryl, such as phenyl.
4. The compound according to any one of embodiments 1 – 3, wherein R^1 is hydrogen.
5. The compound according to any one of embodiments 1 – 3, wherein R^1 is C_{1-3} alkyl, such as methyl.
6. The compound according to any one of embodiments 1 – 5, wherein R^5 and R^6 together form a heterocyclic ring comprising 3 – 16 (e.g. 4) carbon atoms, together with the N atom of formula (I)
7. The compound according to any one of embodiments 1 – 5, wherein R^5 and R^6 together form a heterocyclic ring comprising 4 carbon atoms, together with the N atom of formula (I).
8. The compound according to embodiment 6 or 7 wherein, the compound is of formula 2



Formula 2

wherein Z, R, and R^1 are as according to any one of embodiments 1 – 7.

9. The compound according to any one of embodiments 1 – 8, wherein the compound is of formula 3

**Formula 3**

wherein,

R, R¹, R⁵, R⁶ and R⁹ are as according to any one of embodiments 1 – 8;

B is the guanine nucleobase group comprising an acyl protecting group on the guanine exocyclic nitrogen group;

R³ = is selected from the group consisting of CH₂ODMT_r, CH₂-Alkyl-O-DMT_r, CH-Me-O-DMT_r, CH₂OMMT_r, CH₂-Alkyl-O-MMT_r, CH(Me)-O-MMT_r, CH-R^a-O-DMT_rR^b, and CH-R^a-O-MMT_rR^b;

R² is selected from the groups consisting of halo, such as -F, amino, azido, -SH, -CN, -OCN, -CF₃, -OCF₃, -O(R_m)-alkyl, -S(R_m)-alkyl, -N(R_m)-alkyl, -O(R_m)-alkenyl, -S(R_m)-alkenyl, -N(R_m)-alkenyl; -O(R_m)-alkynyl, -S(R_m)-alkynyl or -N(R_m)-alkynyl; O-alkylenyl-O-alkyl, alkynyl, alkaryl, aralkyl, O-alkaryl, O- aralkyl, O(CH₂)₂SCH₃, O-(CH₂)₂-O-N(R_m)(R_n) or O-CH₂C(=O)-N(R_m)(R_n), -O-(CH₂)₂OCH₃, and -O-CH₃, where each R_m and R_n are independently, H, an amino protecting group or substituted or unsubstituted C₁₋₁₀ alkyl;

R⁴ = is selected from the group consisting of alkyl, cyclo-alkyl, cyclo-heteroalkyl, O-alkyl, S-alkyl, NH-alkyl, and hydrogen;

or R² and R⁴ together designate a bivalent bridge consisting of 1, 2, 3 groups/atoms selected from the group consisting of -C(R^aR^b)-, -C(R^a)=C(R^b), -C(R^a)=N, O, -Si(R^a)₂-, S-, -SO₂-, -N(R^a)-, and >C=Z;

wherein R^a and, when present R^b, each is independently selected from hydrogen, optionally substituted C₁₋₆-alkyl, optionally substituted C₂₋₆-alkenyl, optionally substituted C₂₋₆-alkynyl, hydroxy, optionally substituted C₁₋₆-alkoxy, C₂₋₆-alkoxyalkyl, C₂₋₆-alkenyloxy, carboxy, C₁₋₆-alkoxycarbonyl, C₁₋₆-alkylcarbonyl, formyl, aryl, aryl-oxy-carbonyl, aryloxy, arylcarbonyl, heteroaryl, hetero-aryloxy-carbonyl, heteroaryloxy, heteroarylcarbonyl, amino, mono- and di(C₁₋₆-alkyl)amino, carbamoyl, mono- and di(C₁₋₆-alkyl)-amino-carbonyl, amino- C₁₋₆-alkyl-aminocarbonyl, mono- and di(C₁₋₆-

alkyl)amino- C₁₋₆-alkyl-aminocarbonyl, C₁₋₆-alkyl-carbonylamino, carbamido, C₁₋₆-alkanoyloxy, sulphonyl, C₁₋₆-alkylsulphonyloxy, nitro, azido, sulphonyl, C₁₋₆-alkylthio, halogen, where aryl and heteroaryl may be optionally substituted and where two geminal substituents Ra and Rb together may designate optionally substituted methylene (=CH₂), wherein for all chiral centers, asymmetric groups may be found in either R or S orientation.

10. The compound according to any one of embodiments 1 - 9, wherein the acyl protecting group on the guanine exocyclic nitrogen group is -C(=O)-R⁷, wherein R⁷ is selected from the group consisting of optionally substituted alkyl-, alkenyl-, alkynyl-, cycloalkyl- or aryl-group, preferably from an optionally substituted C₁₋₆-alkyl-, C₂₋₆-alkenyl-, C₂₋₆-alkynyl-, C₃₋₇-cycloalkyl- or phenyl-group; wherein when substituted, the substituent group may be mono or poly substituted, e.g. with one or more substituents selected from the group consisting of halogen, C₁₋₆-alkyl, C₂₋₆-alkenyl, C₂₋₆-alkynyl, C₁₋₆-alkoxy, optionally substituted aryloxy or optionally substituted aryl.

11. The compound according to any one of embodiments 1 - 9 wherein the acyl protecting group on the guanine exocyclic nitrogen group is selected from the group consisting of isobutyryl (iBu), Acetyl (Ac), Phenoxyacetyl (PAC), p-Isopropylphenoxyacetyl (iPrPAC), phenylacetyl, Isopropoxyacetyl, methoxyacetyl, benzoyl, p-methoxyphenylacetyl, diphenylacetyl, cyclohexylcarbonyl, 1,1-dimethylpropanoyl, and p-tert-Butyl-phenoxyacetyl.

12. The compound according to any one of embodiments 1 - 9 wherein the acyl protecting group on the guanine exocyclic nitrogen group is selected from the group consisting of isobutyryl (iBu), Acetyl (Ac), phenoxyacetyl (PAC), and p-Isopropylphenoxyacetyl (iPrPAC).

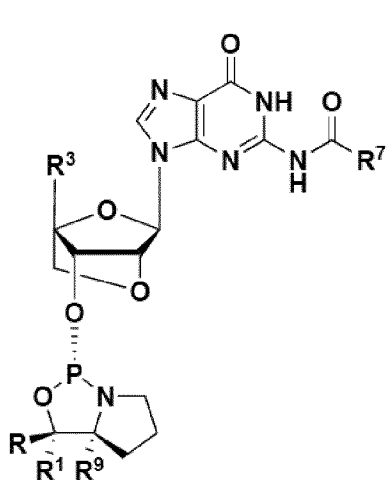
13. The compound according to any one of embodiments 1 - 9, wherein the acyl protecting group on the guanine exocyclic nitrogen group is isobutyryl (iBu).

14. The compound according to any one of embodiments 9-13, of formula III, wherein R² and R⁴ together designate a bivalent bridge selected from the group consisting of bridge -C(R_aR_b)-O-, -C(R_aR_b) C(R_aR_b)-O-, -CH₂-O-, -CH₂ CH₂-O-, and -CH(CH₃)-O-.

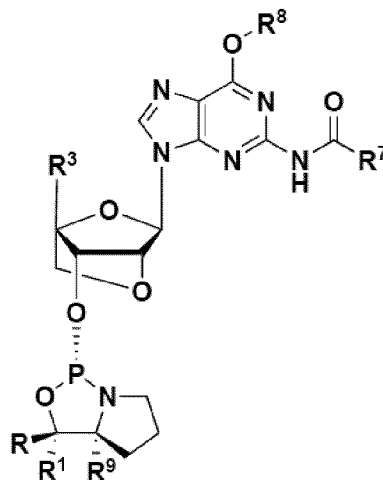
15. The compound according to any one of embodiments 9-13, wherein R² and R⁴ designate the bivalent bridge -CH₂-O- (methylene-oxy) or -CH(CH₃)-O- (methyl-methylene-oxy).

16. The compound according to any one of embodiments 1 - 15, wherein R³ is CH₂-O-DMTr or CH₂-O-MMTr.

17. The compound according to any one of embodiments 1 – 16, wherein the compound is of formula 16 or 17:



Formula 16



Formula 17

wherein R, R¹, R⁹, R³, R⁷ and R⁸ are as according to any one of embodiments 1 – 16.

18. The compound according to embodiment 17, wherein R is phenyl and R¹ is hydrogen or methyl.

19. The compound according to embodiment 17, wherein R is phenyl and R¹ is hydrogen.

20. The compound according to embodiment 17, wherein R is phenyl and R¹ is methyl.

21. The compound according to any one of embodiments 17 – 20, wherein the acyl protection group (-C(=O)-R⁷) is isobutyl.

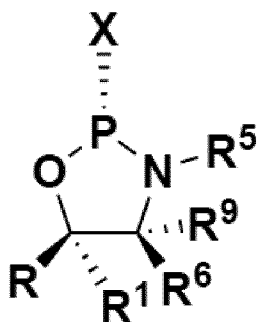
22. A solution comprising the compound of anyone of embodiments 1 – 21 and a solvent.

23. The solution according to embodiment 22, wherein the solvent is or comprises a polar aprotic solvent.

24. The solution according to embodiment 22 or 23, wherein the solvent is selected from the group consisting of acetonitrile, DMF, DMSO, dioxane, tetrahydrofuran, N-methyl-2-pyrrolidone, dichloromethane, and dichloroethane.

25. The use of the compound according to any one of embodiments 1 – 21, or the solution according to embodiments 22 – 24 in the synthesis of an oligonucleotide.

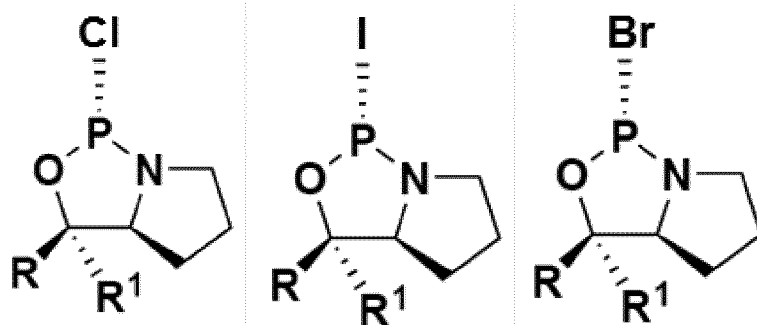
26. A method for the synthesis of a compound according to any one of embodiments 1 – 21, said method comprising the step of reacting a guanine nucleoside comprising a 3' -OH group; with a compound of formula 4

**Formula 4**

wherein X is halide, such as iodide, bromide or chloride, and wherein R, R¹, R⁵, R⁹ and R⁶ are as according to any one of the preceding embodiments, and wherein the guanine nucleobase group on the guanine nucleoside comprises an acyl protecting group on the guanine exocyclic nitrogen group, such as the acyl protecting group of any one of embodiments 10 – 13.

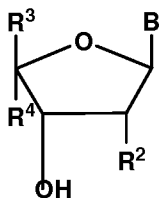
27. The method according to embodiment 26, wherein the compound of formula 4 wherein X is chloride.

28. The method according to embodiment 26 or 27, wherein the compound of formula 4 is selected from the group consisting of



29. The method according to any one of embodiments 26 – 28, wherein R, R¹, R⁵, R⁶ and R⁹ are as defined in any one of embodiments 1 – 25.

30. The method according to any one of embodiments 26 – 29, wherein the nucleoside has the formula



wherein, B, R², R³, R⁴, are as defined in any one of embodiments 9 – 25.

31. The method according to any one of embodiments 26 -30, wherein the reaction step occurs in the presence of a base and a solvent.
32. The method according to embodiment 32 wherein the base is an organic base, such as a tertiary non-nucleophilic organic base, such as a base selected from the group consisting of trimethylamine, triethylamine, and N-methylmorpholine.
33. The method according to embodiment 31 or 32, wherein the solvent is selected from the group consisting of those defined in any one of embodiments 22 – 24.
34. The method according to any one of embodiments 26 – 33, wherein the solvent is or comprises tetrahydrofuran (THF) or toluene, wherein optionally the solvent may further comprise pyridine.
35. The method according to any one of embodiments 26 – 34, wherein the reaction occurs at a temperature below 0°C, such as below -50°C.

EXAMPLES

Example 1 - General Synthesis Method:

To a solution of N-methylmorpholine in toluene (50 mL) PCl_3 (2.93 mL 33.4 mmol) was added at -70 °C over a time course of 10 min. Hereafter, proline (P5-D or P5-L) auxiliary (6.24 g 35.2 mmol) in toluene (50 mL) was added over 30 min (see *J. Am. Chem. Soc.*, **2008**, *130*, 16031–16037 for synthesis of P5-D and P5-L). The resulting mixture was stirred at room temperature for 1.5 h after which solvent and volatiles were removed in vacuo (40 °C and 15 mbar). Then, the remaining residue was dissolved in THF (50 mL) and hereafter cooled to -70 °C followed by the addition of first NEt_3 (17.8 mL 128 mmol) and then, over 30 min, 5'-ODMT-DNA-Nucleoside (16 mmol) as a solution in THF (50 mL). The reaction mixture was stirred at -77 °C for 30 min and then for 2 h at room temperature. Hereafter, cold EtOAc (200 mL) was added and mixture was washed with cold NaHCO_3 (150 mL), brine (150 mL), dried (Na_2SO_4), filtered, and evaporated to dryness. The crude product was purified by flash column chromatography under argon with 7% NEt_3 included in the eluent to avoid degradation on silica.

The product was obtained as a solid potentially containing small amounts of residual solvents from e.g. EtOAc, THF, and NEt_3 .

Using the above procedure, the following monomers were synthesized:

D-DNA A: ^{31}P NMR (160 MHz, DMSO- d_6): δ 150.3
L-DNA A: ^{31}P NMR (160 MHz, DMSO- d_6): δ 148.5
D-DNA T: ^{31}P NMR (160 MHz, DMSO- d_6): δ 151.0
L-DNA T: ^{31}P NMR (160 MHz, DMSO- d_6): δ 149.1
D-DNA C: ^{31}P NMR (160 MHz, DMSO- d_6): δ 151.7
L-DNA C: ^{31}P NMR (160 MHz, DMSO- d_6): δ 149.8
D-DNA G-i-Bu: ^{31}P NMR (160 MHz, DMSO- d_6): δ 151.7
L-DNA G-DMF: ^{31}P NMR (160 MHz, DMSO- d_6): δ 150.3

Example 2

Synthesis of D-LNA-G-DMF

5'-ODMT-LNA-G (3.51 g 5.00 mmol) was co-evaporated with pyridine and then with toluene to remove any residual water or other solvents. Then the residue was dissolved in pyridine (10 mL) and THF (10 mL). This solution was added to solution of D-oxazaphospholidine (3.51 g 5.00 mmol), PCl_3 (0.88 mL 10.0 mmol), and NEt_3 (3.50 mL 25.0 mmol) at -77°C . The resulting reaction mixture was then stirred at -77°C for 15 min and then at 1.5 h at room temperature. Hereafter, EtOAc (150 mL) was added and mixture was washed with cold NaHCO_3 (100 mL) and brine (100 mL), dried using Na_2SO_4 , filtered, and finally evaporated together with toluene.

The resulting residue was purified by column chromatography (eluent THF in EtOAc from 10% to 30% + 7% NEt_3) giving D-LNA-G-DMF (3.91 g, estimated yield 84%).

^1H NMR (400 MHz, DMSO- d_6): δ 11.42 (1H, s), 8.56 (1H, s), 7.95 (1H, s), 7.49-7.16 (14H, m), 6.90-6.83 (4H, m), 5.96 (1H, s), 5.58 (1H, d, $J = 6.7$ Hz), 3.87 (1H, d, $J = 8.1$ Hz), 3.72 (6H, s), 3.62-3.54 (1H, m), 3.45 (2H, s), 3.40-3.33 (1H, m), 3.08 (3H, s), 2.99 (3H, s), 2.93-2.84 (1H, m), 1.53-1.39 (2H, m), 1.06-0.97 (1H, m), 0.79-0.63 (1H, m).

^{31}P NMR (160 MHz, DMSO- d_6): δ 151.6

LRMS (ESI) m/z $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{46}\text{H}_{49}\text{N}_7\text{O}_8\text{P}$: 858.3. Found: 858.7.

Example 3

Synthesis of L-LNA-G-DMF

5'-ODMT-LNA-G (4.91 g 7.00 mmol) was co-evaporated with pyridine and then with toluene to remove any residual water or other solvents. Then the residue was dissolved in pyridine (10 mL) and THF (15 mL). This solution was added to solution of

L-oxazaphospholidine (2.48 g 14.0 mmol), PCl_3 (1.22 mL 14.0 mmol), and NEt_3 (4.90 mL 35.0 mmol) at -77°C . The resulting reaction mixture was then stirred at -77°C for 15 min and then at 1.5 h at room temperature. Hereafter, EtOAc (150 mL) was added and mixture was washed with cold NaHCO_3 (100 mL) and brine (100 mL), dried using Na_2SO_4 , filtered, and finally evaporated together with toluene.

The resulting residue was purified by column chromatography (eluent THF in EtOAc/DCM 1:1 using a gradient from 15% to 25% + 7% NEt_3) giving D-LNA-G-DMF (3.41 g, estimated yield 84%). The product was purified by column chromatography as described above.

^1H NMR (400 MHz, DMSO-d_6): δ 12.3-11.9 (1H, br s), 11.8-11.5 (1H, br s), 8.05 (1H, s), 7.45-7.40 (2H, m), 7.35-7.21 (10H, m), 7.02-6.97 (2H, m), 6.92-6.86 (4H, m), 5.94 (1H, s), 5.09 (1H, d, $J = 6.5$ Hz), 4.88 (1H, d, $J = 7.5$ Hz), 4.69 (1H, s), 3.89-3.81 (2H, m), 3.74 (3H, s), 3.73 (3H, s), 3.71-3.64 (1H, m), 3.48-3.38 (3H, m), 2.83-2.73 (1H, m), 2.71-2.64 (1H, m), 1.55-1.45 (2H, m), 1.14-1.05 (1H, m), 1.08 (3H, d, $J = 6.9$ Hz), 1.05 (3H, d, $J = 6.9$ Hz), 0.76-0.66 (1H, m).

^{31}P NMR (160 MHz, DMSO-d_6): δ 148.7

LRMS (ESI) m/z $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{47}\text{H}_{50}\text{N}_6\text{O}_9\text{P}$: 873.3. Found: 873.7.

Example 4

Synthesis of D-DNA G-DMF

To a solution of N-methylmorpholine in toluene (50 mL) was PCl_3 (2.93 mL 33.4 mmol) added at -70°C over a time course of 10 min. Hereafter P5-D (6.24 g 35.2 mmol) in toluene (50 mL) was added over 30 min. The resulting reaction mixture was stirred at room temperature for 1.5 h after which solvent and volatiles were removed in vacuo (40°C and 15 mbar). Then, the remaining residue was dissolved in THF (50 mL) and hereafter cooled to -70°C followed by the addition of first NEt_3 (17.8 mL 128 mmol) and then, over 30 min, 5'-ODMT-DNA-G (9.99 g 16.0 mmol) as a solution in THF (50 mL). The reaction mixture was stirred at -77°C for 30 min and then for 2 h at room temperature. Hereafter, cold EtOAc (200 mL) was added and mixture was washed with cold NaHCO_3 (150 mL), brine (150 mL), dried (Na_2SO_4), filtered, and evaporated to dryness. The crude product was purified by flash column chromatography under argon (eluent DCM/EtOAc=2/1 + 7% NEt_3). D-DNA-G-DMF was isolated as a white foam (10.6 g, 72%) with traces of solvent impurities (EtOAc, toluene, and NEt_3).

^1H NMR (400 MHz, DMSO- d_6): δ 11.36 (1H, s), 8.52 (1H, s), 7.96 (1H, s), 7.40-7.16 (14H, m), 6.83-6.77 (4H, m), 6.27 (1H, t, J = 6.4 Hz), 5.65 (1H, d, j = 6.5 Hz), 5.08-5.01 (1H, m), 4.02-3.98 (1H, m), 3.91-3.83 (1H, m), 3.71 (6H, s), 3.45-3.35 (1H, m), 3.27-3.18 (2H, m), 3.07 (3H, s), 3.00 (3H, s), 2.97-2.88 (2H, m), 2.49-2.40 (1H, m), 1.58-1.48 (1H, m), 1.47-1.38 (1H, m), 1.16-1.09 (1H, m), 0.86-0.76 (1H, m).

^{31}P NMR (160 MHz, DMSO- d_6): δ 151.7

LRMS (ESI) m/z $[\text{M} - \text{H}]^-$ calcd for $\text{C}_{45}\text{H}_{47}\text{N}_7\text{O}_7\text{P}$: 828.3. Found: 828.6.

Example 5

Synthesis of L-DNA G-DMF

To solution of N-methylmorpholine in toluene (25 mL) was PCl_3 (1.33 mL 15.2 mmol) during 5 minutes added at -55 °C followed with the addition of P5-L (2.84 g 16.00 mmol) in toluene (25 mL) during 15 min. The resulting reaction mixture was stirred at -55-45 °C for 10 min and then at 1.5 h at room temperature. Then, the solvent and other volatiles were removed in vacuo (40 °C and 6 mbar). The remaining residue was then dissolved in THF (25 mL) and cooled to -77 °C. Hereafter, NEt_3 (8.92 mL 64 mmol) was added followed by a solution of 5'-ODMT-DNA-G-DMF (4.5 g, 7.2 mmol) in THF (25 mL) during 15 min. The reaction mixture was stirred at -77 °C for 15 min and then at 3 h at room temperature. Hereafter, EtOAc (150 mL) was added and the mixture was extracted with cold NaHCO_3 (100 mL), brine (50 mL), dried (Na_2SO_4), filtered, and evaporated.

The product was isolated by flash column chromatography under argon (eluent EtOAc/DCM=1/2 + 7% NEt_3) as a white foam (3.77 g, 63%) together with traces of EtOAc.

^1H NMR (400 MHz, DMSO- d_6): δ 11.36 (1H, s), 8.51 (1H, s), 7.96 (1H, s), 7.39-7.11 (14H, m), 6.80-6.73 (4H, m), 6.28 (1H, t, J = 6.5 Hz), 5.72 (1H, d, j = 6.5 Hz), 5.06-4.96 (1H, m), 4.02-3.95 (1H, m), 3.84-3.76 (1H, m), 3.70 (3H, s), 3.69 (3H, s), 3.50-3.39 (1H, m), 3.27-3.18 (2H, m), 3.08 (3H, s), 3.02 (3H, s), 2.98-2.83 (2H, m), 2.48-2.39 (1H, m), 1.58-1.40 (2H, m), 1.12-1.02 (1H, m), 0.83-0.71 (1H, m).

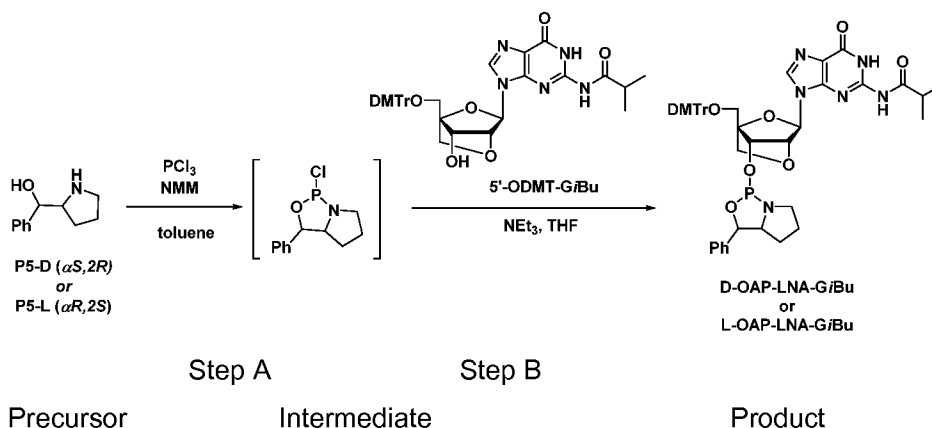
^{31}P NMR (160 MHz, DMSO- d_6): δ 150.3

LRMS (ESI) m/z $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{45}\text{H}_{49}\text{N}_7\text{O}_7\text{P}$: 830.3. Found: 830.6.

Example 6

Synthesis of L-LNA-G-Ibu monomers

Procedure for the synthesis of 5'-OAP-LNA-G-iBu derivatives



Step A: To a solution of N-methylmorpholine (1.76 mL 16.0 mmol) in toluene (15 mL) was added PCl_3 (0.66 mL 7.6 mmol) over 5 min at -55°C . Hereafter, a solution of (*S*)-phenyl-(*R*)-pyrolidin-2-yl)methanol (P5-D) (1.42 g 8.00 mmol) in toluene (12 mL) was added during the next 15 min. Then, the reaction mixture was stirred for 10 min between -55 to -45°C and then at room temperature for 1.5 h.

Solvents and other volatile compounds were removed *in vacuo* at 40°C and 6 mbar after which THF (13 mL) was added.

Step B: This was followed by a cooling of the reaction mixture to -77°C whereafter triethylamine (5.54 mL, 40 mmol) was added followed by a solution of 5'-ODMT-LNA-G-iBu (2.67 g, 4 mmol) in THF (13 mL) over 15 min. The resulting mixture was stirred for 15 min at -77°C and then at room temperature for 3 h. Hereafter, EtOAc (75 mL) was added and the mixture was washed with cold NaHCO_3 (50 mL) and brine (50 mL), dried using Na_2SO_4 , filtered, and evaporated *in vacuo*. The crude product was purified by flash column chromatography under Ar (EtOAc:hexane, 1:4 + 7% NEt_3).

The product was obtained as a white foam (1.95 g, estimated yield of 55%).

^{31}P -NMR in DMSO 148.8 ppm +1% at 28.8 ppm.

Additional optimization of the synthesis for both D-LNA G-iBu and L-LNA G-iBu

No.	St. m.	molar ratio P5 : PCl_3 : 5'-ODMT-LNA-G-iBu	5'-ODMT-LNA-G-iBu, mmol	Estimated yield, ^a %
1	P5-L	2 : 2 : 1	8.00	48
2	P5-L	2 : 1.9 : 1	4.00	55
3	P5-D	2.2 : 2.1 : 1	7.20	64
4	P5-L	2.4 : 2.4 : 1	8.00	64
5	P5-L	2.2 : 2.1 : 1	8.00	68

It was found that a slight excess of PCl_3 over the precursor (e.g. P5) causes formation of side products that significantly reduce the yield of the product (e.g. OAP-LNA-GiBu). It is therefore desirable to use at least molar equivalents of precursor & PCl_3 . In some embodiments the molar ratio of precursor to PCl_3 in step 1 is, greater than about 1, such as 1.05 or above. In some embodiments the molar ratio of precursor to PCl_3 in step 1 is no greater than 1.5.

It was found that the use of over two fold molar equivalents of the intermediate in step 2 gave the highest yield of product (see table, entries 3 and 5). In some embodiments the molar ratio of intermediate (e.g. 5'-ODMT-G/iBu) to the precursor and PCl_3 is greater than 2.

The purity of the products was determined from ^{31}P -NMR spectra.

Example 6

Determination of stability and solubility of products

To investigate the stability and solubility of L-LNA G-DMF and L-LNA G-i-Bu the following experimental procedure was followed:

To a 1.5 mL vial was added 0.013 mmol of amidite after which the solid material was dissolved in 0.13 mL of solvent. Hereafter, the vial was capped, vortexed, and finally left at room temperature for 24 hours. Then, the dissolved material was visually examined regarding the solubility (Figure 1). If the solution appeared cloudy or otherwise non-homogenous the solubility was set to "no". If the solution appeared completely homogenous the solubility was set to "yes" (examination repeated after 24 hours).

Stability Determination Method: To complete the analysis the stability of the amidite was investigated using an Agilent 1100 series HPLC-MS with from the following specifications:

Column: Waters XTerra, MS C-18, 5 μm , 2.1 x 100 mm
Temp.: 40°C
Flow: 0.3 mL/ min
Detection: UV at 254 nm
Run time: 12 min
Eluent: A: 0.1 % sat. NH_4OH (aq) in H_2O B: 20 % A in CH_3CN

Time (min): % B Eluent:
0.00 : 80
0.50 : 80
3.00 : 100

7.00 : 100
8.00 : 80
12.00 : 80

The mass and UV peak of the mother compound was identified at 0 hours and at 24 hours. Hereafter, the relative stability compared to other by-products was reported by integrating the UV chromatogram (254 nm) and normalizing the area to the chromatogram recorded at 0 hours (Figure 2).

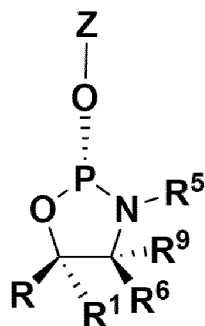
The solubility data at 0 hours and 24 hours after synthesis for the three monomers is illustrated in Figure 1. The stability data measured after 24 hours in various solvents is shown in Figure 2 and Figure 3a (L-LNA-G-*i*Bu) and 3b (L-LNA-G-DMF)..

The monomer L-LNA G-DMF is unsoluble in most solvents (MeCN, MeCN:DCE, MeCN:Tol, MeCN:acetone, Dioxane, and THF). The solvents where the monomer is soluble (MeCN:DCM, DMF, DMSO, NMP, DCM, DCE, and Toluene) shows a tremendous instability. The best solvent being DCM with 10% left of the amidite after 24 hours.

The monomer L-LNA G-*i*Bu is soluble in all solvents investigated (12 different) with the best performing being MeCN, MeCN:acetone, DCM, and DCE. All solvents investigated for the L-LNA G-*i*Bu monomer shows a significant improvement in solubility and stability.

CLAIMS

1. A compound of formula 1

**Formula 1**

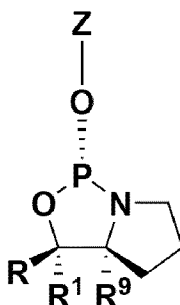
wherein

Z is a guanine nucleoside wherein the guanine nucleobase group comprises an acyl protection group on the guanine exocyclic nitrogen group, wherein the exocyclic oxygen of Formula I is covalently attached to the 3' carbon of the nucleoside Z;

R⁵ and R⁶ are independently selected from the group consisting of hydrogen, alkyl, cyclo-alkyl, aryl, heteroaryl, substituted alkyl, substituted cyclo-alkyl, substituted aryl, and substituted heteroaryl, or R⁵ and R⁶ together form a heterocyclic ring comprising 3 – 16 carbon atoms, together with the N atom of formula (I);

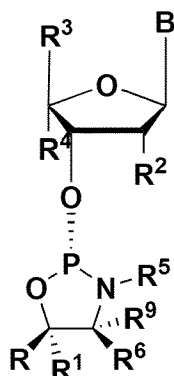
R¹ is selected from the groups consisting of hydrogen and C₁₋₃ alkyl; R⁹ is hydrogen; and R is selected from the groups consisting of aryl, heteroaryl, substituted aryl, substituted heteroaryl, nitro, halogen, cyano, silyl, substituted silyl, sulfone, substituted sulfone (aryl substituted sulfone), fluorene, and substituted fluorene.

2. The compound according to claim 1, wherein R is selected from the group consisting of aryl, heteroaryl, substituted aryl and substituted heteroaryl.
3. The compound according to claim 1, wherein R is aryl, such as phenyl.
4. The compound according to any one of claims 1 – 3, wherein R¹ is hydrogen.
5. The compound according to any one of claims 1 – 4, wherein R⁵ and R⁶ together form a heterocyclic ring comprising 4 carbon atoms, together with the N atom of formula (I).
6. The compound according to claim 5 wherein, the compound is of formula 2

**Formula 2**

wherein Z, R, and R¹ are as according to any one of claims 1 – 5.

7. The compound according to any one of claims 1 - 6, wherein the acyl protecting group on the guanine exocyclic nitrogen group is -C(=O)-R⁷, wherein R⁷ is selected from the group consisting of optionally substituted alkyl-, alkenyl-, alkynyl-, cycloalkyl- or aryl-group, preferably from an optionally substituted C₁₋₆-alkyl-, C₂₋₆-alkenyl-, C₂₋₆-alkynyl-, C₃₋₇-cycloalkyl- or phenyl-group; wherein when substituted, the substituent group may be mono or poly substituted, e.g. with one or more substituents selected from the group consisting of halogen, C₁₋₆-alkyl, C₂₋₆-alkenyl, C₂₋₆-alkynyl, C₁₋₆-alkoxy, optionally substituted aryloxy or optionally substituted aryl.
8. The compound according to any one of claims 1 - 6 wherein the acyl protecting group on the guanine exocyclic nitrogen group is selected from the group consisting of isobutyryl (iBu), Acetyl (Ac), Phenoxyacetyl (PAC), p-Isopropylphenoxyacetyl (iPrPAC), phenylacetyl, Isopropoxyacetyl, methoxyacetyl, benzoyl, p-methoxyphenylacetyl, diphenylacetyl, cyclohexylcarbonyl, 1,1-dimethylpropanoyl, and p-tert-Butyl-phenoxyacetyl.
9. The compound according to any one of claims 1 - 6 wherein the acyl protecting group on the guanine exocyclic nitrogen group is selected from the group consisting of isobutyryl (iBu), Acetyl (Ac), phenoxyacetyl (PAC), and p-Isopropylphenoxyacetyl (iPrPAC).
10. The compound according to any one of claims 1 – 6, wherein the acyl protecting group on the guanine exocyclic nitrogen group is isobutyryl (iBu).
11. The compound according to any one of claims 1-10, of formula 3,

**Formula 3**

wherein,

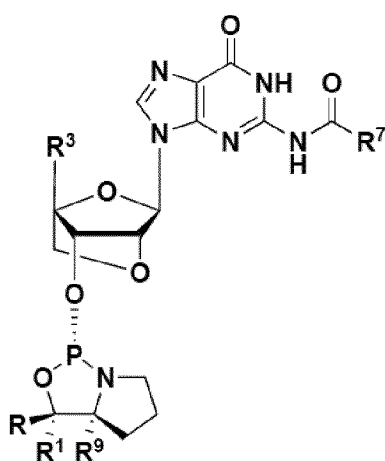
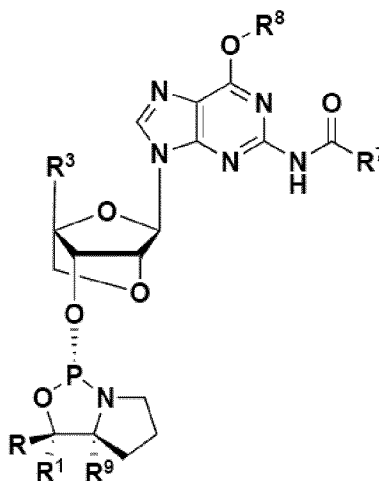
R, R¹, R⁵, R⁶ and R⁹ are as according to any one of claims 1 – 8;

B is the guanine nucleobase group comprising an acyl protecting group on the guanine exocyclic nitrogen group;

R³ = is selected from the group consisting of CH₂ODMT_r, CH₂-Alkyl-O-DMT_r, CH-Me-O-DMT_r, CH₂OMMT_r, CH₂-Alkyl-O-MMT_r, CH(Me)-O-MMT_r, CH-R^a-O-DMT_r^b, and CH-R^a-O-MMT_r^b; and R² and R⁴ together designate a bivalent bridge selected from the group consisting of bridge -C(R_aR_b)-O-, -C(R_aR_b) C(R_aR_b)-O-, -CH₂-O-, -CH₂ CH₂-O-, and -CH(CH₃)-O-.

12. The compound according to any one of claims 11, wherein R² and R⁴ designate the bivalent bridge -CH₂-O- (methylene-oxy) or -CH(CH₃)-O- (methyl-methylene-oxy).

13. The compound according to any one of claims 1 – 12, wherein the compound is of formula 16 or 17:

**Formula 16****Formula 17**

wherein R, R¹, R⁹, R³, R⁷ and R⁸ are as according to any one of claims 1 – 16.

14. The compound according to claim 13, wherein R is phenyl and R¹ is hydrogen or methyl.

15. The compound according to claims 13 or 14, wherein the acyl protection group (-C(=O)-R⁷) is isobutyryl.

FIGURES

Figure 1

Stability at 24 hours	MeCN	MeCN: DCM (1:1)	MeCN: DCE (1:1)	MeCN: Toluene (1:1)	MeCN: Acetone (1:1)	DMF	DMSO	Dioxane	THF	NMP	DCM	DCE	Toluene
D-LNA A-DMF	2	3	3	3	2	3	3	2	1	3	1	1	3
L-LNA A-DMF	3	3	3	3	2	3	3	1	1	3	1	1	3
D-LNA T-DMF	1	1	1	3	2	2	3	2	1	3	1	1	3
L-LNA T-DMF	1	1	1	3	2	1	2	1	1	2	1	1	3
D-LNA C-DMF	3	3	3	3	3	3	3	2	2	3	1	1	3
L-LNA C-DMF	2	2	2	3	3	3	3	1	1	3	2	2	3
D-LNA G-DMF	1	1	1	3	2	1	1	1	2	3	1	1	3
L-LNA G-DMF	Not soluble	3	Not soluble	Not soluble	Not soluble	3	3	Not soluble	Not soluble	3	3	3	Not soluble
L-LNA G- <i>t</i> Bu	2	2	2	3	2	3	3	1	2	n/a	2	2	3
D-DNA A-DMF	3	3	3	3	3	3	3	2	2	3	2	2	3
L-DNA A-DMF	3	3	3	3	3	3	3	2	2	3	2	2	3
D-DNA T-DMF	3	3	3	3	2	3	3	1	1	3	1	1	3
L-DNA T-DMF	3	3	3	3	3	3	3	1	2	3	1	1	3
D-DNA C-DMF	3	1	2	3	1	2	3	1	1	3	1	1	3
L-DNA C-DMF	2	2	2	3	2	3	3	1	1	3	1	1	3
D-DNA G-DMF	3	3	3	3	3	3	3	2	3	n/a	n/a	n/a	3
L-DNA G-DMF	2	3	3	3	3	3	3	2	3	n/a	n/a	n/a	3

Figure 2

Solubility 0 h

	MeCN:DCM (1:1)		MeCN:Tol. (1:1)		MeCN:DCE (1:1)		MeCN:Acetone (1:1)		DMF		DMSO		Dioxane		THF		NMP		DCM		DCE		Toluene	
	MeCN		MeCN		MeCN		MeCN		DMF		DMSO		Dioxane		THF		NMP		DCM		DCE		Toluene	
D-LNA G-DMF	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
L-LNA G-DMF	no	yes	no	no	no	no	no	no	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes	yes	no	no	no	no
L-LNA Gi-Bu	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	n/a	yes	yes	yes	yes	yes	yes	yes

Solubility 24 h

	MeCN:DCM (1:1)		MeCN:Tol. (1:1)		MeCN:DCE (1:1)		MeCN:Acetone (1:1)		DMF		DMSO		Dioxane		THF		NMP		DCM		DCE		Toluene	
	MeCN		MeCN		MeCN		MeCN		DMF		DMSO		Dioxane		THF		NMP		DCM		DCE		Toluene	
D-LNA G-DMF	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
L-LNA G-DMF	no	yes	no	no	yes	no	no	no	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes	yes	yes	no	no	no
L-LNA Gi-Bu	no	no	no	no	no	no	yes	yes	yes	yes	no	no	yes	yes	yes	n/a	yes	yes	yes	yes	yes	yes	yes	yes

3/3

Figure 3a

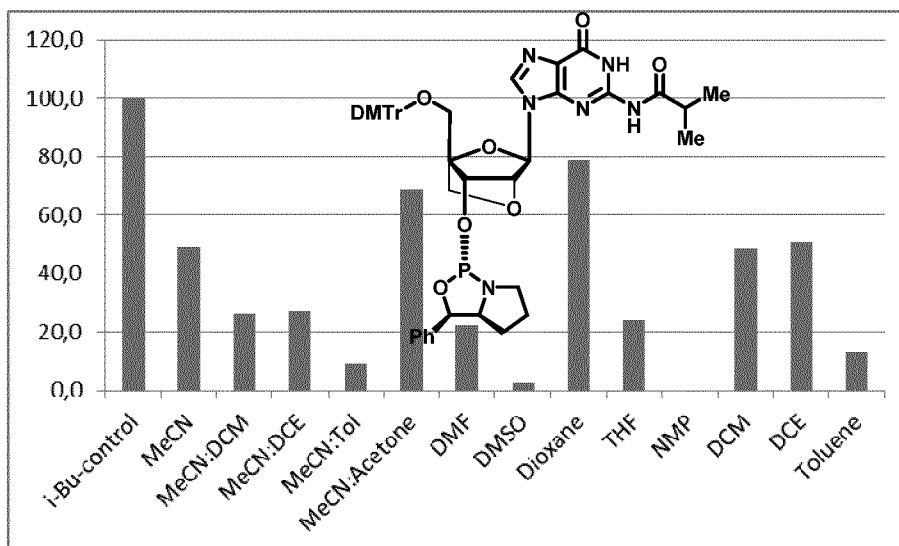
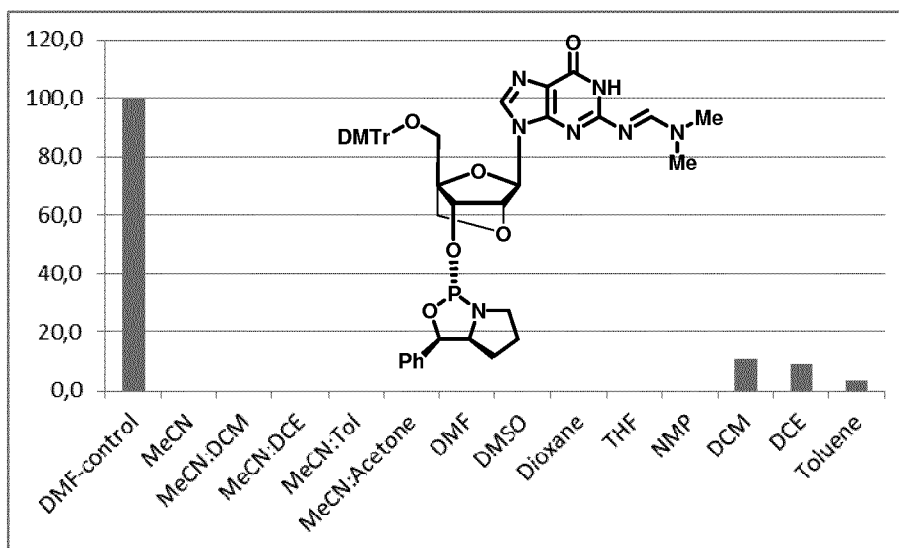


Figure 3b



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/054841

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07H19/06
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/010250 A1 (CHIRALGEN LTD [JP]) 16 January 2014 (2014-01-16) cited in the application abstract; claims page 17, paragraph [0139]-[0140] page 32; compound 3a page 41; compound 7a page 52; compound 15a page 57; compound 19a	1-15
X	WO 2014/012081 A2 (ONTORII INC [US]) 16 January 2014 (2014-01-16) abstract; claims pages 105, 130; compound 29a page 132; compound 33a page 233; compound 216 page 99, paragraph [0756] ----- -/-	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

18 May 2017

Date of mailing of the international search report

26/05/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Gohlke, Pascale

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/054841

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	YOHEI NUKAGA ET AL: "Stereocontrolled Solid-Phase Synthesis of Phosphorothioate Oligoribonucleotides Using 2'-O-(2-Cyanoethoxymethyl)-nucleoside 3'-O-Oxazaphospholidine Monomers", THE JOURNAL OF ORGANIC CHEMISTRY, vol. 77, no. 18, 21 September 2012 (2012-09-21), pages 7913-7922, XP055319868, ISSN: 0022-3263, DOI: 10.1021/jo301052v the whole document page 7914; table 1; compounds Rp-3d -----	1-14
A	NAOKI IWAMOTO ET AL: "Stereocontrolled synthesis of oligodeoxyribonucleoside boranophosphates by an oxazaphospholidine approach using acid-labile-protecting groups", TETRAHEDRON LETTERS, ELSEVIER, AMSTERDAM, NL, vol. 53, no. 33, 6 June 2012 (2012-06-06), pages 4361-4364, XP028427772, ISSN: 0040-4039, DOI: 10.1016/J.TETLET.2012.06.015 [retrieved on 2012-06-13] abstract page 4361, right-hand column, line 19 - page 4362, right-hand column, line 5 page 4362; table 1; compounds Rp-1d -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/054841

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014010250	A1	16-01-2014	
		AU 2013288048 A1	22-01-2015
		AU 2016204770 A1	28-07-2016
		CA 2879023 A1	16-01-2014
		CN 104684893 A	03-06-2015
		EP 2872485 A1	20-05-2015
		JP 2015523316 A	13-08-2015
		KR 20150039777 A	13-04-2015
		RU 2015100197 A	10-09-2016
		SG 11201500239V A	30-03-2015
		US 2015197540 A1	16-07-2015
		US 2017029445 A1	02-02-2017
		WO 2014010250 A1	16-01-2014

WO 2014012081	A2	16-01-2014	
		AU 2013289880 A1	05-02-2015
		CA 2878945 A1	16-01-2014
		CL 2015000092 A1	07-08-2015
		CN 104661664 A	27-05-2015
		EP 2872147 A2	20-05-2015
		HK 1210595 A1	29-04-2016
		JP 2015528002 A	24-09-2015
		KR 20150036642 A	07-04-2015
		SG 10201700283W A	30-03-2017
		SG 11201500232U A	29-04-2015
		US 2015211006 A1	30-07-2015
		WO 2014012081 A2	16-01-2014
