COMPOUNDS AND METHODS FOR REDUCING IFNAR1 EXPRESSION

Sequence Listing

The present application is being filed along with a Sequence Listing in electronic format. The Sequence Listing is provided as a file entitled BIOL0386WOSEQ_ST25.txt, created on June 13, 2022 which is 64 KB in size. The information in the electronic format of the sequence listing is incorporated herein by reference in its entirety.

Field

Provided are oligomeric compounds, methods, and pharmaceutical compositions for reducing the amount or activity of IFNAR1 RNA in a cell or animal, and in certain instances reducing the amount of IFNAR1 protein in a cell or animal. Such oligomeric compounds, methods, and pharmaceutical compositions are useful to treat neurological diseases or conditions associated with neuroinflammation, including Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia.

Background

Aicardi-Goutières Syndrome (AGS) is a progressive inflammatory encephalopathy associated with several neuropathological manifestations, including seizures, difficulty feeding, dystonia, spasticity, delayed motor development, delayed language development, and delayed social skill development. Imaging of AGS patients reveals white matter abnormalities, T cell infiltration, B cell infiltration, striatal necrosis, brain atrophy, basal ganglia calcification, and microencephaly; patients also have elevated levels of interferon alpha (IFNa) and lymphocytosis in cerebrospinal fluid. AGS has been associated with mutations in one of ten genes: TREX1 (DNA exonuclease), RNASEH2A, B or C (subunits of RNASEH2), SAMHD1 (dNTP hydrolase), ADAR1 (RNA editing enzyme), MDA5 (dsRNA sensor), USP18 (negative regulator of type I IFN signaling), LSM11 and RNU7-1 (components of the replication-dependent histone pre-mRNA–processing complex). Mutations in any one of these genes lead to aberrant activation of the antiviral response and high levels of IFNa (Adang, et al., 2020, J. Child Neurol., 35, 7016; Rodero, et al., 2016, J. Esp. Med., 213, 2527-2538).

Interferon Alpha and Beta Receptor Subunit 1 (IFNAR1) is one of two components of the interferon alpha receptor, involved in type I interferon signaling. Type I interferon signaling is elevated in AGS patients and is believed to be a key mediator of neuropathology. Elevated levels of type I interferon signaling are also associated with diseases or conditions such as neuroinflammation associated with stroke, brain injury, Alzheimer's disease, neuropsychiatric systemic lupus erythematosus, neuromyelitis optica, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, and ataxia telangectasia (Wlodarczyk, et al., 2021, Glia 69, 943-953; Santer, et al., 2009, J. Immunol. 182,1192-1201; Zeng, et al., 2019, Arthritis Res. Ther. 21, 205.017; Karageorgas, et al., 2011, J Biomed Biotechnol 2011, 273907; Roy, et al., 2020, J Clin Invest. 130, 1912–1930; Witcher, 2021, J. Neurosci. JN-RM-2469-2420; Blank, et al., 2016, Immunity 44, 901-912; Härtlova, et al., 2015, Immunity 44, 901-912; McDonugh, et al., 2017, J Neurosci. 37, 8292-8308). Over-expression of IFNa in transgenic mice leads to elevated levels of type I interferon signaling, resulting in neurodegenerative changes, T cell infiltration, B cell

infiltration, microglial cell activation, reactive astrocytosis, activation of endothelial cells, and calcification of the thalamus and cerebellum (Hofer, et al., 2013, *Cytokine & Growth Factor Reviews* 24, 257-267; Klok, et al., 2015, *Ann. Clin. Transl. Neurol.*, 2, 774-779). Type I interferon signaling induces expression of hundreds of genes, including Interferon Induced Protein with Tetratricopeptide Repeats 1 (Ifit1), Interferon Induced Protein with Tetratricopeptide Repeats 3 (Ifit 3), and Interferon Regulatory Factor 7 (Irf7) (Li, et al., 2018, *J. Biol. Chem.* 292, P5845-P5859). Crossing a mouse model of Alzheimer's disease with an IFNAR1 knockout mouse suppressed type I interferon signaling, resulted in a glial cell anti-inflammatory response, and reduced neuroinflammation (Minter, M.R., et al., 2016, *Acta Neuropathologica Commun.* 4:72).

Summary

Oligomeric compounds, methods, and pharmaceutical compositions of certain embodiments described herein are useful for reducing or inhibiting IFNAR1 expression in a cell or animal. In certain embodiments, IFNAR1 RNA or protein levels can be reduced in a cell or animal. In certain embodiments, the subject has Aicardi-Goutières Syndrome. In certain embodiments, the subject has a disease or disorder associated with a mutation in TREX1, RNASEH2A, RNASEH2B, RNASEH2C, SAMHD1, ADAR1, MDA5, USP18, LSM11, or RNU7-1.

Also provided are methods of treating a disease or disorder associated with elevated type I interferon signaling, in certain embodiments, the disease or disorder is AGS, stroke, epilepsy, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica or ataxia telangectasia.

Detailed Description

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive. Herein, the use of the singular includes the plural unless specifically stated otherwise. As used herein, the use of "or" means "and/or" unless stated otherwise. Furthermore, the use of the term "including" as well as other forms, such as "includes" and "included", is not limiting. Also, terms such as "element" or "component" encompass both elements and components comprising one unit and elements and components that comprise more than one subunit, unless specifically stated otherwise.

The section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described. All documents, or portions of documents, cited in this application, including, but not limited to, patents, patent applications, articles, books, and treatises, are hereby expressly incorporated-by-reference for the portions of the document discussed herein, as well as in their entirety.

DEFINITIONS

Unless specific definitions are provided, the nomenclature used in connection with, and the procedures and techniques of, analytical chemistry, synthetic organic chemistry, and medicinal and pharmaceutical chemistry described herein are those well-known and commonly used in the art. Where permitted, all patents, applications, published applications and other publications and other data referred to throughout in the disclosure are incorporated by reference herein in their entirety.

Unless otherwise indicated, the following terms have the following meanings:

As used herein, "2'-deoxynucleoside" means a nucleoside comprising a 2'-H(H) deoxyfuranosyl sugar moiety. In certain embodiments, a 2'-deoxynucleoside is a 2'-β-D-deoxynucleoside and comprises a 2'-β-D-deoxyribosyl sugar moiety, which has the β-D ribosyl configuration as found in naturally occurring deoxyribonucleic acids (DNA). In certain embodiments, a 2'-deoxynucleoside may comprise a modified nucleobase or may comprise an RNA nucleobase (uracil).

As used herein, "2'-MOE" means a 2'-$O(CH_2)_2OCH_3$ group in place of the 2'-OH group of a furanosyl sugar moiety. A "2'-MOE sugar moiety" or a "2'-O-methoxyethyl sugar moiety" means a sugar moiety with a 2'-$O(CH_2)_2OCH_3$ group in place of the 2'-OH group of a furanosyl sugar moiety. Unless otherwise indicated, a 2'-MOE sugar moiety is in the β-D-ribosyl configuration. "MOE" means O-methoxyethyl.

As used herein, "2'-MOE nucleoside" means a nucleoside comprising a 2'-MOE sugar moiety.

As used herein, "5-methylcytosine" means a cytosine modified with a methyl group attached to the 5 position. A 5-methylcytosine is a modified nucleobase.

As used herein, "ameliorate" in reference to a treatment means improvement in at least one symptom or hallmark relative to the same symptom or hallmark in the absence of the treatment. In certain embodiments, amelioration is the reduction in the severity or frequency of a symptom or hallmark or the delayed onset or slowing of progression in the severity or frequency of a symptom or hallmark. In certain embodiments, the symptom or hallmark is one or more of seizures, difficulty feeding, dystonia, spasticity, delayed motor development, delayed language development, delayed social skill development, white matter abnormalities, T cell infiltration, B cell infiltration, striatal necrosis, brain atrophy, basal ganglia calcification, and microencephaly. In certain embodiments, the hallmark is the level of IFNa or lymphocytosis in cerebrospinal fluid in the subject.

As used herein, "population" means a plurality of molecules of identical molecular formula.

As used herein, "chirally enriched" in reference to a population means a plurality of molecules of identical molecular formula, wherein the number or percentage of molecules within the population that contain a particular stereochemical configuration at a particular chiral center is greater than the number or percentage of molecules expected to contain the same particular stereochemical configuration at the same particular chiral center within the population if the particular chiral center were stereorandom as defined herein. Chirally enriched populations of molecules having multiple chiral centers within each molecule may contain one or more stereorandom chiral centers. In certain embodiments, the molecules are modified oligonucleotides. In certain embodiments, the molecules are oligomeric compounds comprising modified oligonucleotides. In certain embodiments, the chiral center is at the phosphorous atom of a phosphorothioate internucleoside linkage. In certain embodiments, the chiral center is at the phosphorous atom of a mesyl phosphoramidate internucleoside linkage.

As used herein, "chirally controlled" in reference to an internucleoside linkage means chirality at that linkage is enriched for a particular stereochemical configuration.

As used herein, "antisense agent" means an antisense compound and optionally one or more additional features, such as a sense compound. Although RNAis are not claimed, my thinking behind keeping it in was in the event we needed basis to distinguish our compounds from an siRNA sequence.

As used herein, "cerebrospinal fluid" or "CSF" means the fluid filling the space around the brain and spinal cord. "Artificial cerebrospinal fluid" or "aCSF" means a prepared or manufactured fluid that has certain properties (e.g., osmolarity, pH, and/or electrolytes) similar to cerebrospinal fluid and is biocompatible with CSF.

As used herein, "conjugate group" means a group of atoms that is directly attached to an oligonucleotide. Conjugate groups include a conjugate moiety and a conjugate linker that attaches the conjugate moiety to the oligonucleotide.

As used herein, "conjugate linker" means a single bond or a group of atoms comprising at least one bond that connects a conjugate moiety to an oligonucleotide.

As used herein, "conjugate moiety" means a covalently bound group of atoms that modifies one or more properties of a molecule compared to the identical molecule lacking the conjugate moiety, including but not limited to pharmacodynamics, pharmacokinetics, stability, binding, absorption, tissue distribution, cellular distribution, cellular uptake, charge, and clearance.

As used herein, "deoxy region" means a region of 5-12 contiguous nucleotides, wherein at least 70% of the nucleosides comprise a β-D-2`-deoxyribosyl sugar moiety. In certain embodiments, a deoxy region is the gap of a gapmer.

As used herein, "internucleoside linkage" is the covalent linkage between adjacent nucleosides in an oligonucleotide. As used herein "modified internucleoside linkage" means any internucleoside linkage other than a phosphodiester internucleoside linkage.

As used herein, "linked nucleosides" are nucleosides that are connected in a contiguous sequence (i.e., no additional nucleosides are presented between those that are linked).

As used herein, "motif" means the pattern of unmodified and/or modified sugar moieties, nucleobases, and/or internucleoside linkages, in an oligonucleotide.

As used herein, "modified nucleoside" means a nucleoside comprising a modified nucleobase and/or a modified sugar moiety.

As used herein, "non-bicyclic modified sugar moiety" means a modified sugar moiety that comprises a modification, such as a substituent, that does not form a bridge between two atoms of the sugar to form a second ring.

As used herein, "nucleobase" means an unmodified nucleobase or a modified nucleobase. A nucleobase is a heterocyclic moiety. As used herein an "unmodified nucleobase" is adenine (A), thymine (T), cytosine (C), uracil (U), or guanine (G). As used herein, a "modified nucleobase" is a group of atoms other than unmodified A, T, C, U, or G capable of pairing with at least one other nucleobase. A "5-methyl cytosine" is a modified nucleobase. A universal base is a modified nucleobase that can pair with any one of the five unmodified nucleobases.

As used herein, "nucleobase sequence" means the order of contiguous nucleobases in a nucleic acid or oligonucleotide independent of any sugar or internucleoside linkage modification.

As used herein, "nucleoside" means a compound or fragment of a compound comprising a nucleobase and a sugar moiety. The nucleobase and sugar moiety are each, independently, unmodified or modified.

As used herein, "oligomeric compound" means an oligonucleotide and optionally one or more additional features, such as a conjugate group or terminal group. An oligomeric compound may be paired with a second oligomeric compound that is complementary to the first oligomeric compound or may be unpaired. A "singled-stranded oligomeric compound" is an unpaired oligomeric compound.

As used herein, "oligonucleotide" means a strand of linked nucleosides connected via internucleoside linkages, wherein each nucleoside and internucleoside linkage may be modified or unmodified. Unless otherwise indicated, oligonucleotides consist of 8-50 linked nucleosides. As used herein, "modified oligonucleotide" means an oligonucleotide, wherein at least one nucleoside or internucleoside linkage is modified. As used herein, "unmodified oligonucleotide" means an oligonucleotide that does not comprise any nucleoside modifications or internucleoside modifications.

As used herein, "oligonucleotide" means a strand of linked nucleosides connected via internucleoside linkages, wherein each nucleoside and internucleoside linkage may be modified or unmodified. Unless otherwise indicated, oligonucleotides consist of 8-50 linked nucleosides. As used herein, "modified oligonucleotide" means an oligonucleotide, wherein at least one nucleoside or internucleoside linkage is modified. As used herein, "unmodified oligonucleotide" means an oligonucleotide that does not comprise any nucleoside modifications or internucleoside modifications.

As used herein, "pharmaceutically acceptable carrier or diluent" means any substance suitable for use in administering to an animal. Certain such carriers enable pharmaceutical compositions to be formulated as, for example, tablets, pills, dragees, capsules, liquids, gels, syrups, slurries, suspension and lozenges for the oral ingestion by a subject. In certain embodiments, a pharmaceutically acceptable carrier or diluent is sterile water, sterile saline, sterile buffer solution or sterile artificial cerebrospinal fluid.

As used herein "pharmaceutically acceptable salts" means physiologically and pharmaceutically acceptable salts of compounds. Pharmaceutically acceptable salts retain the desired biological activity of the parent compound and do not impart undesired toxicological effects thereto.

As used herein "pharmaceutical composition" means a mixture of substances suitable for administering to a subject. For example, a pharmaceutical composition may comprise an oligomeric compound and a sterile aqueous solution. In certain embodiments, a pharmaceutical composition shows activity in free uptake assay in certain cell lines.

As used herein, "stereorandom" or "stereorandom chiral center" in the context of a population of molecules of identical molecular formula means a chiral center that is not controlled during synthesis, or enriched following synthesis, for a particular absolute stereochemical configuration. The stereochemical configuration of a chiral center is random when it is the result of a synthetic method that is not designed to control the stereochemical configuration. For example, in a population of molecules comprising a stereorandom chiral center, the number of molecules having the (S) configuration of the stereorandom chiral center may be but is not necessarily the same as the number of molecules having the (R) configuration of the stereorandom chiral center. In certain embodiments, the stereorandom chiral center is not racemic because one absolute configuration predominates following synthesis, e.g., due to the action of non-chiral reagents near the enriched stereochemistry of an adjacent sugar moiety. In certain embodiments, the stereorandom chiral center is at the phosphorous atom of a stereorandom phosphorothioate or mesyl phosphoroamidate internucleoside linkage.

As used herein, "sugar moiety" means an unmodified sugar moiety or a modified sugar moiety. As used herein, "unmodified sugar moiety" means a 2'-OH(H) ribosyl moiety, as found in RNA (an "unmodified RNA sugar moiety"), or a 2'-H(H) deoxyribosyl sugar moiety, as found in DNA (an "unmodified DNA sugar moiety"). Unmodified sugar moieties have one hydrogen at each of the 1', 3', and 4' positions, an oxygen at the 3' position, and two hydrogens at the

5' position. As used herein, "modified sugar moiety" or "modified sugar" means a modified furanosyl sugar moiety or a sugar surrogate.

As used herein, "symptom or hallmark" means any physical feature or test result that indicates the existence or extent of a disease or disorder. In certain embodiments, a symptom is apparent to a subject or to a medical professional examining or testing said subject. In certain embodiments, a hallmark is apparent upon invasive diagnostic testing, including, but not limited to, post-mortem tests. In certain embodiments, a hallmark is apparent on a brain MRI scan.

As used herein, "target nucleic acid" and "target RNA" mean a nucleic acid that an oligomeric compound is designed to affect. Target RNA means an RNA transcript and includes pre-mRNA and mRNA unless otherwise specified.

As used herein, "target region" means a portion of a target nucleic acid to which an oligomeric compound is designed to hybridize.

As used herein, "terminal group" means a chemical group or group of atoms that is covalently linked to a terminus of an oligonucleotide.

As used herein, "antisense activity" means any detectable and/or measurable change attributable to the hybridization of an antisense compound to its target nucleic acid. In certain embodiments, antisense activity is a decrease in the amount or expression of a target nucleic acid or protein encoded by such target nucleic acid compared to target nucleic acid levels or target protein levels in the absence of the antisense compound.

As used herein, "gapmer" means a modified oligonucleotide comprising an internal region positioned between external regions having one or more nucleosides, wherein the nucleosides comprising the internal region are chemically distinct from the nucleoside or nucleosides comprising the external regions, and wherein the modified oligonucleotide supports RNAse H cleavage. The internal region may be referred to as the "gap" and the external regions may be referred to as the "wings." In certain embodiments, the internal region is a deoxy region. The positions of the internal region or gap refer to the order of the nucleosides of the internal region and are counted starting from the 5'-end of the internal region. Unless otherwise indicated, "gapmer" refers to a sugar motif. In certain embodiments, each nucleoside of the gap is a 2'-β-D-deoxynucleoside. As used herein, the term "MOE gapmer" indicates a gapmer having a gap comprising 2'-β-D-deoxynucleosides and wings comprising 2'-MOE nucleosides. Unless otherwise indicated, a gapmer may comprise one or more modified internucleoside linkages and/or modified nucleobases and such modifications do not necessarily follow the gapmer pattern of the sugar modifications.

As used herein, "hybridization" means the annealing of oligonucleotides and/or nucleic acids. While not limited to a particular mechanism, the most common mechanism of hybridization involves hydrogen bonding, which may be Watson-Crick, Hoogsteen or reversed Hoogsteen hydrogen bonding, between complementary nucleobases. In certain embodiments, complementary nucleic acid molecules include, but are not limited to, an antisense compound and a nucleic acid target. In certain embodiments, complementary nucleic acid molecules include, but are not limited to, an oligonucleotide and a nucleic acid target.

As used herein, "RNAi agent" means an antisense agent that acts, at least in part, through RISC or Ago2 to modulate a target nucleic acid and/or protein encoded by a target nucleic acid. RNAi agents include, but are not limited to double-stranded siRNA, single-stranded RNAi (ssRNAi), and microRNA, including microRNA mimics. RNAi agents may comprise conjugate groups and/or terminal groups. In certain embodiments, an RNAi agent modulates the amount and/or activity, of a target nucleic acid. The term RNAi agent excludes antisense agents that act through RNase H.

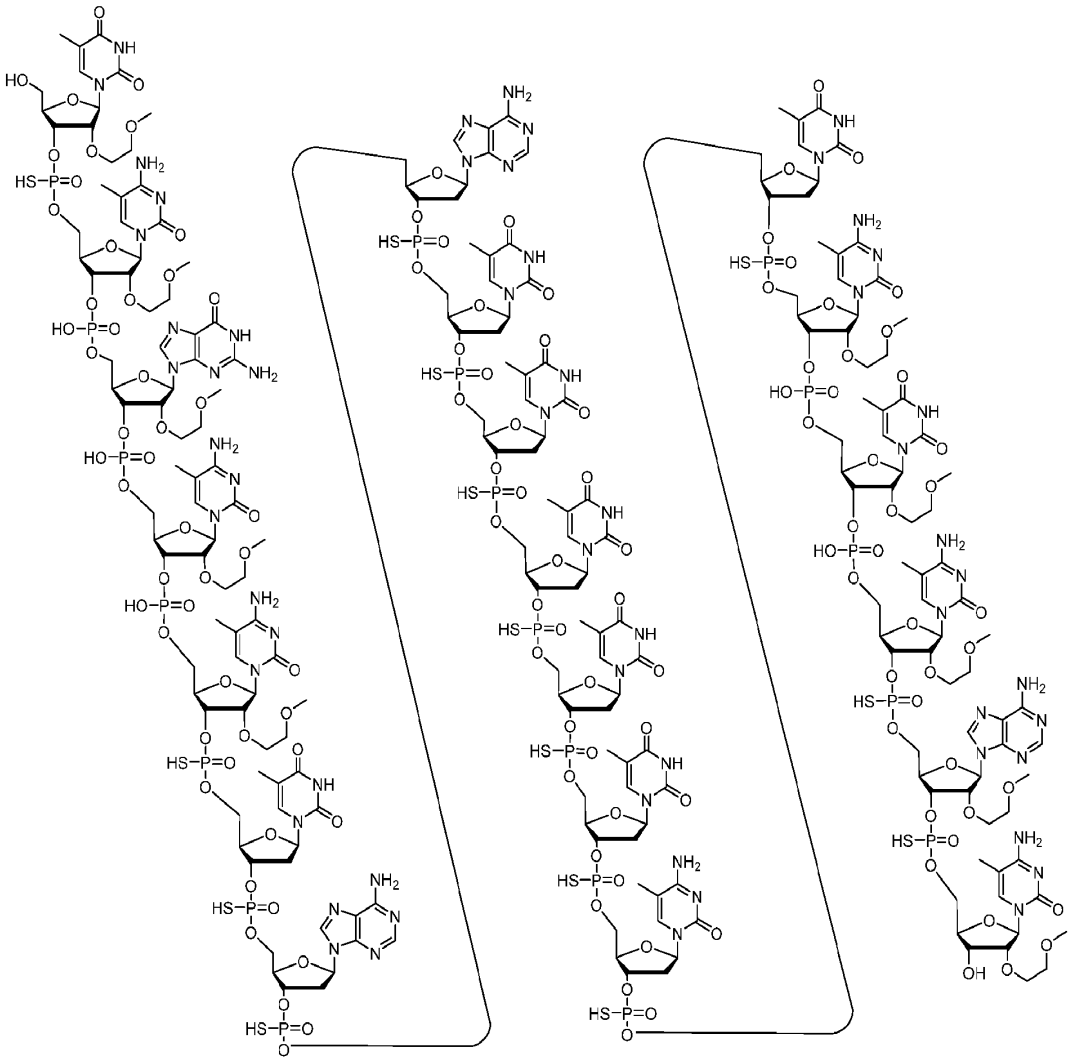
As used herein, "RNase H agent" means an antisense agent that acts through RNase H to modulate a target nucleic acid and/or protein encoded by a target nucleic acid. In certain embodiments, RNase H agents are single-stranded. In certain embodiments, RNase H agents are double-stranded. RNase H compounds may comprise conjugate groups and/or terminal groups. In certain embodiments, an RNase H agent modulates the amount and/or activity of a target nucleic acid. The term RNase H agent excludes antisense agents that act principally through RISC/Ago2.

As used herein, "treating" means improving a subject's disease or condition by administering an oligomeric compound described herein. In certain embodiments, treating a subject improves a symptom relative to the same symptom in the absence of the treatment. In certain embodiments, treatment reduces in the severity or frequency of a symptom, or delays the onset of a symptom, slows the progression of a symptom, or slows the severity or frequency of a symptom.

As used herein, "therapeutically effective amount" means an amount of a pharmaceutical agent or composition that provides a therapeutic benefit to an animal. For example, a therapeutically effective amount improves a symptom of a disease.

CERTAIN EMBODIMENTS

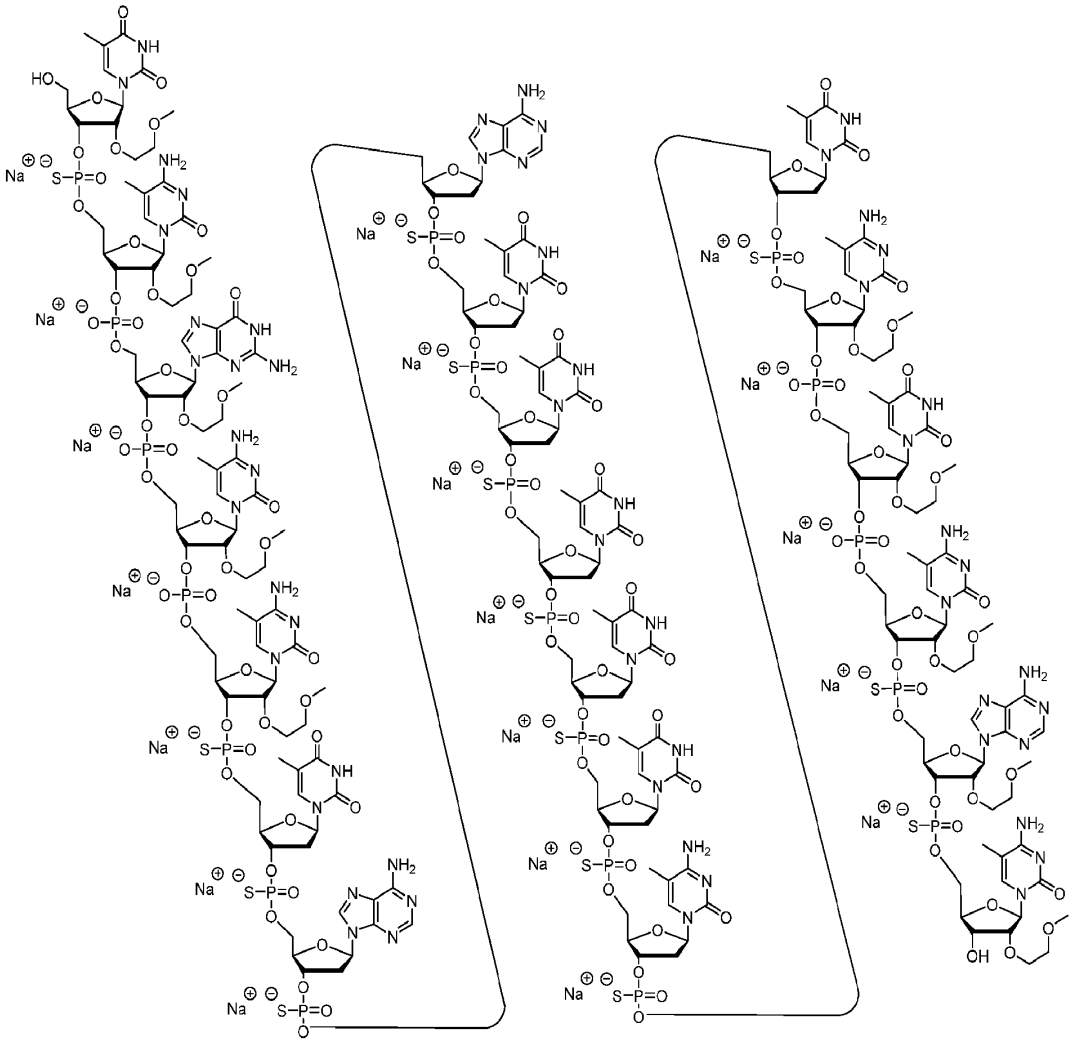
Embodiment 1. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 10), or a salt thereof.

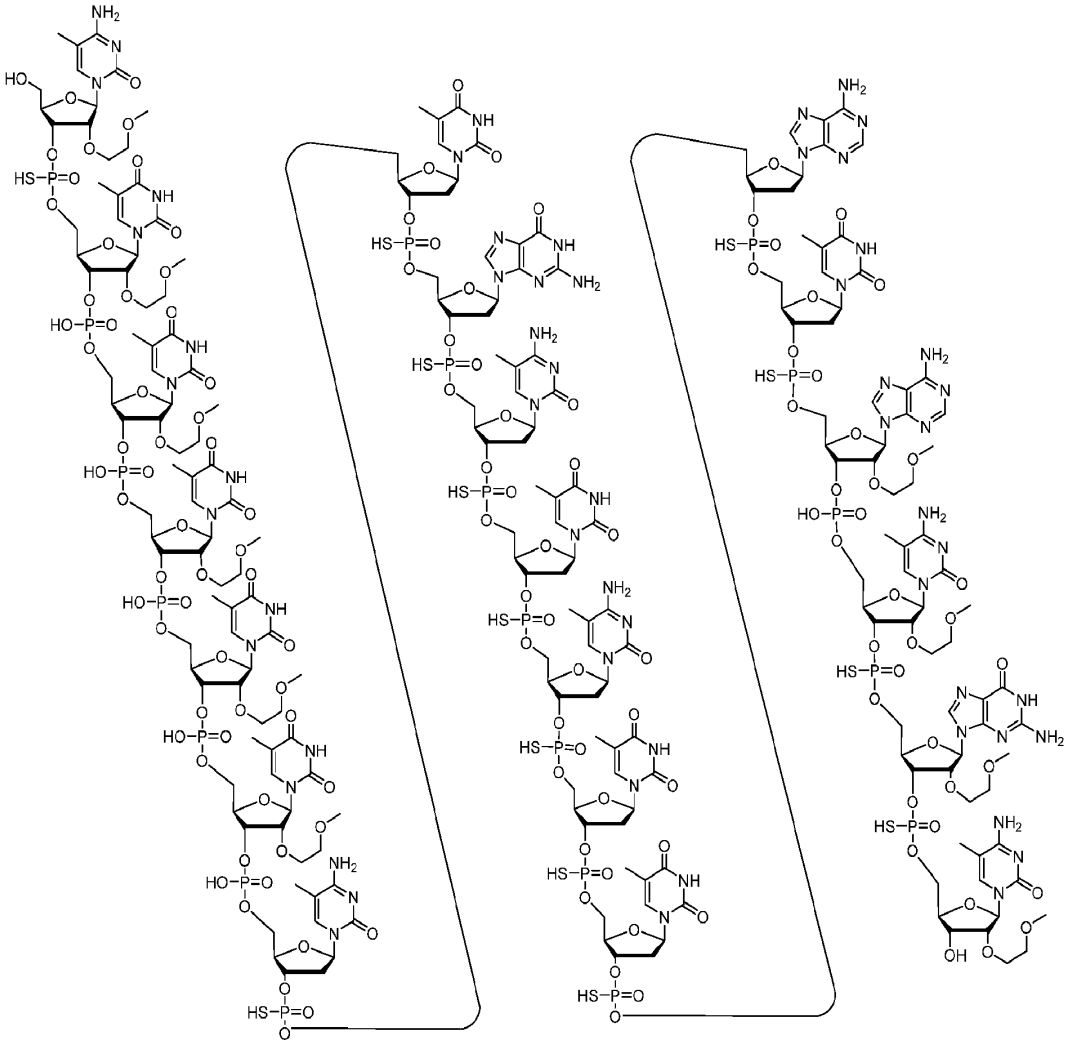
Embodiment 2. The modified oligonucleotide of embodiment 1, which is the sodium salt or the potassium salt.

Embodiment 3. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 10).

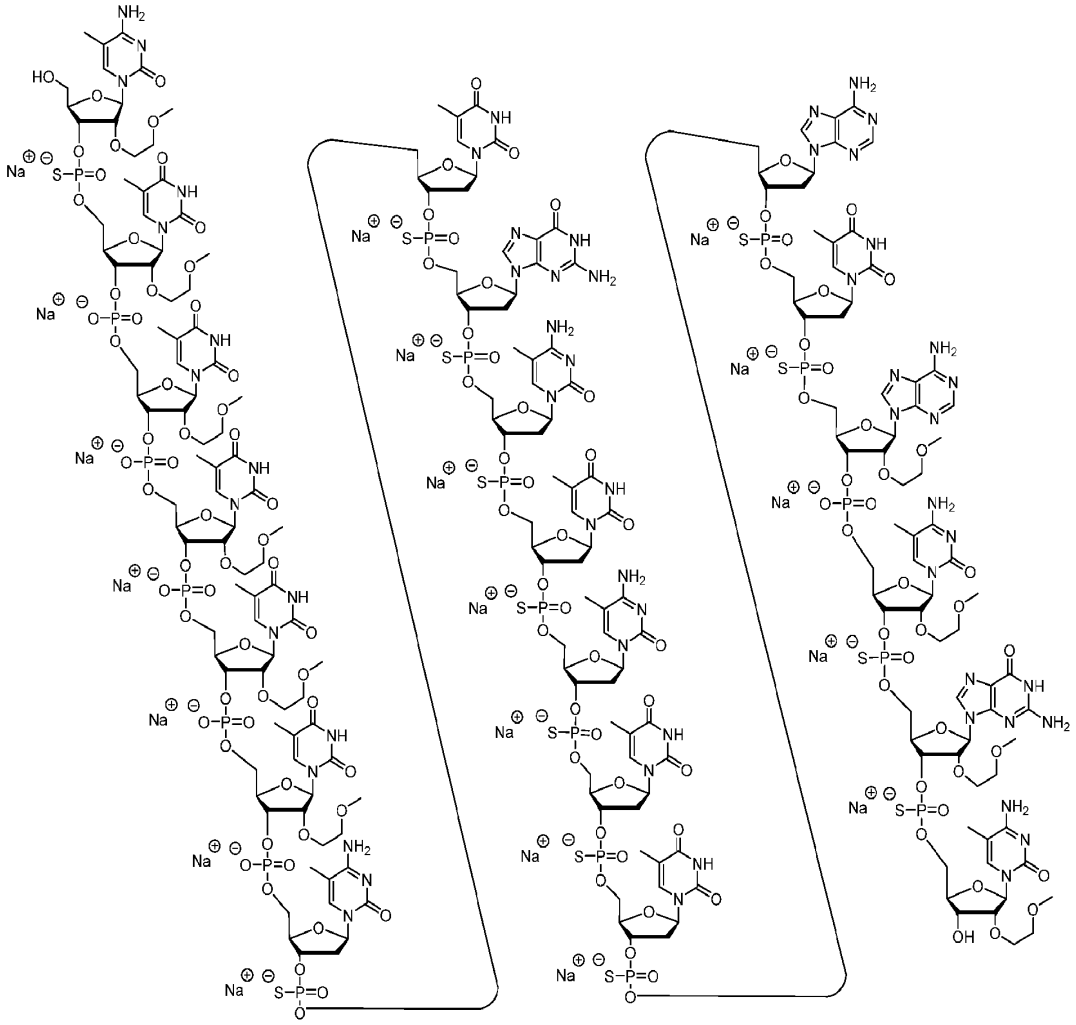
Embodiment 4. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 11), or a salt thereof.

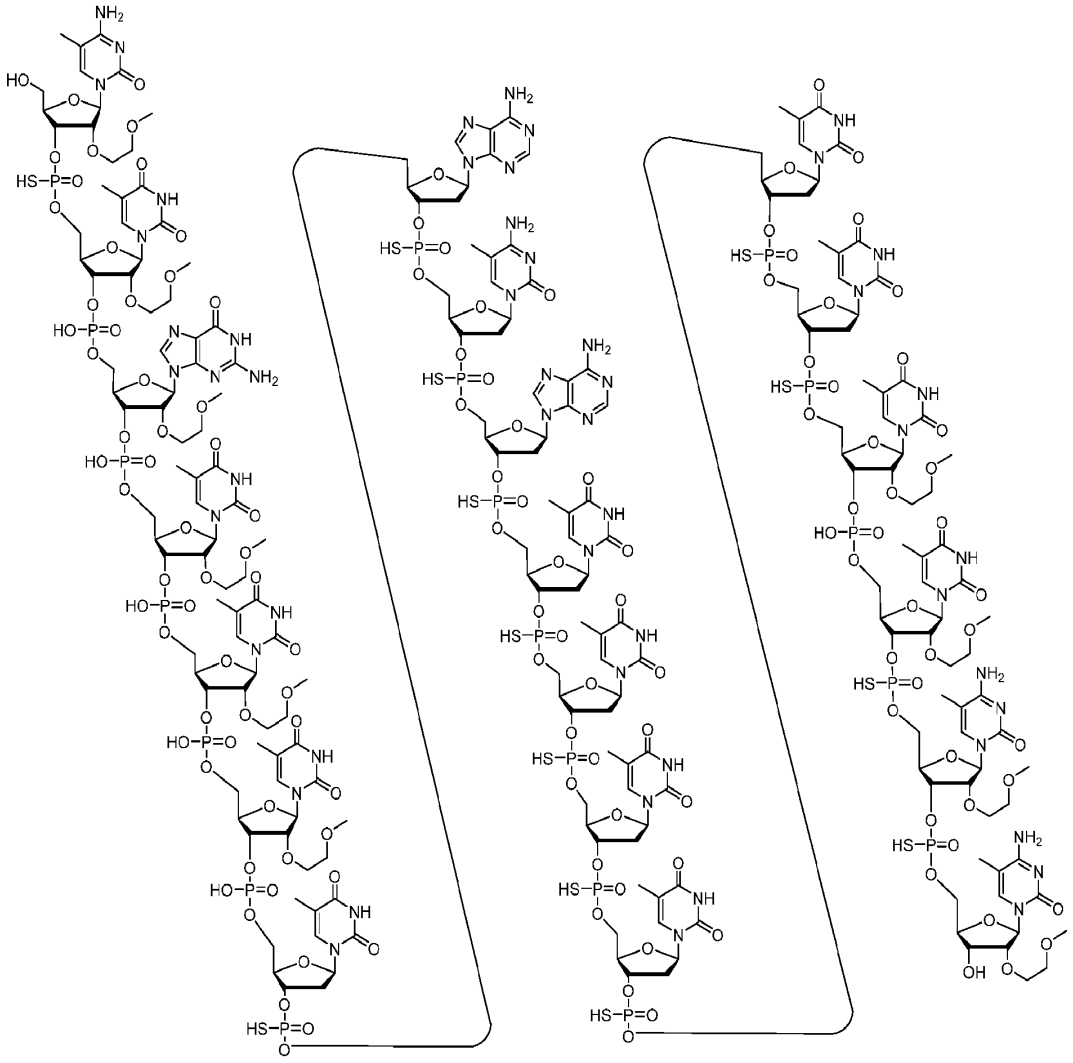
Embodiment 5. The modified oligonucleotide of embodiment 4, which is the sodium salt or the potassium salt.

Embodiment 6. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 11).

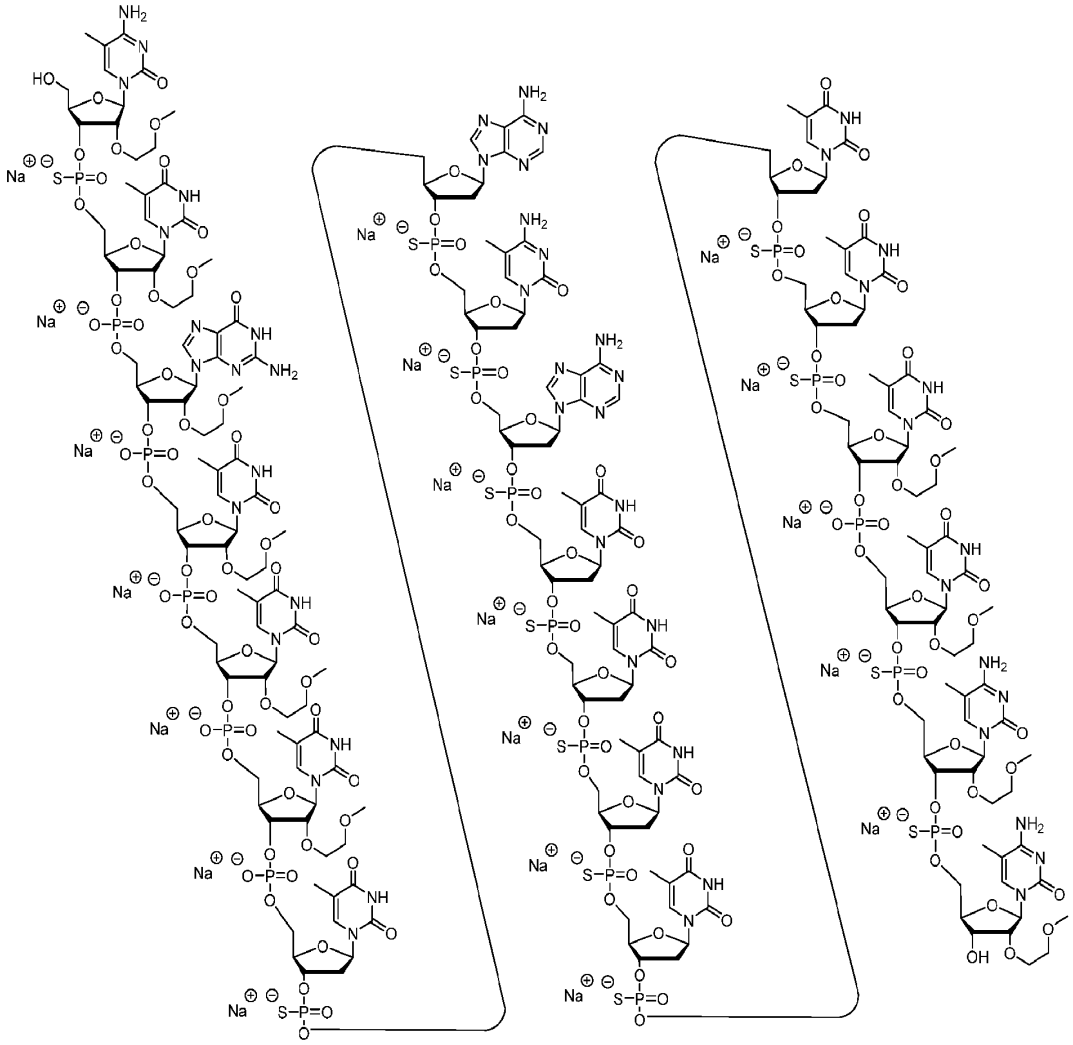
Embodiment 7. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 12), or a salt thereof.

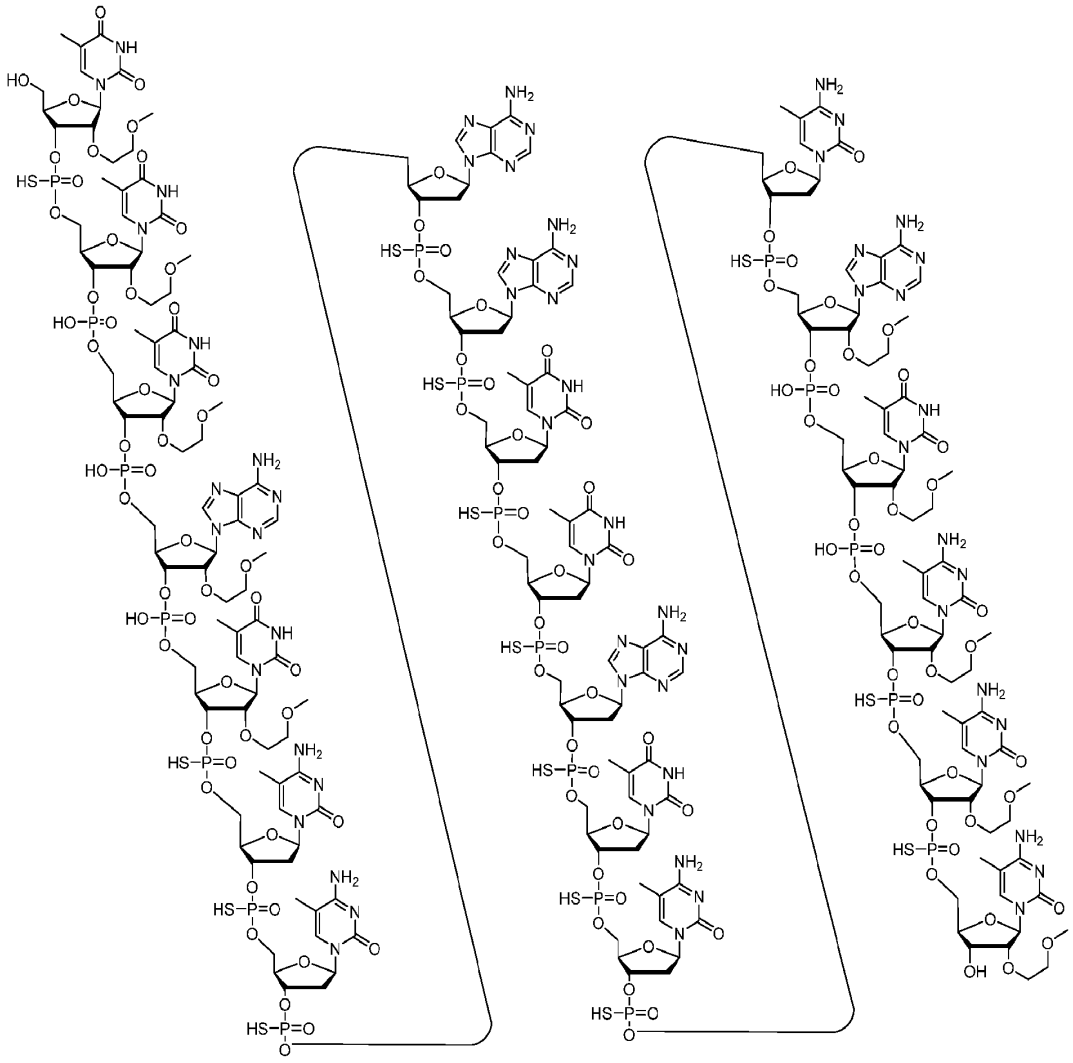
Embodiment 8. The modified oligonucleotide of embodiment 7, which is the sodium salt or the potassium salt.

Embodiment 9. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 12).

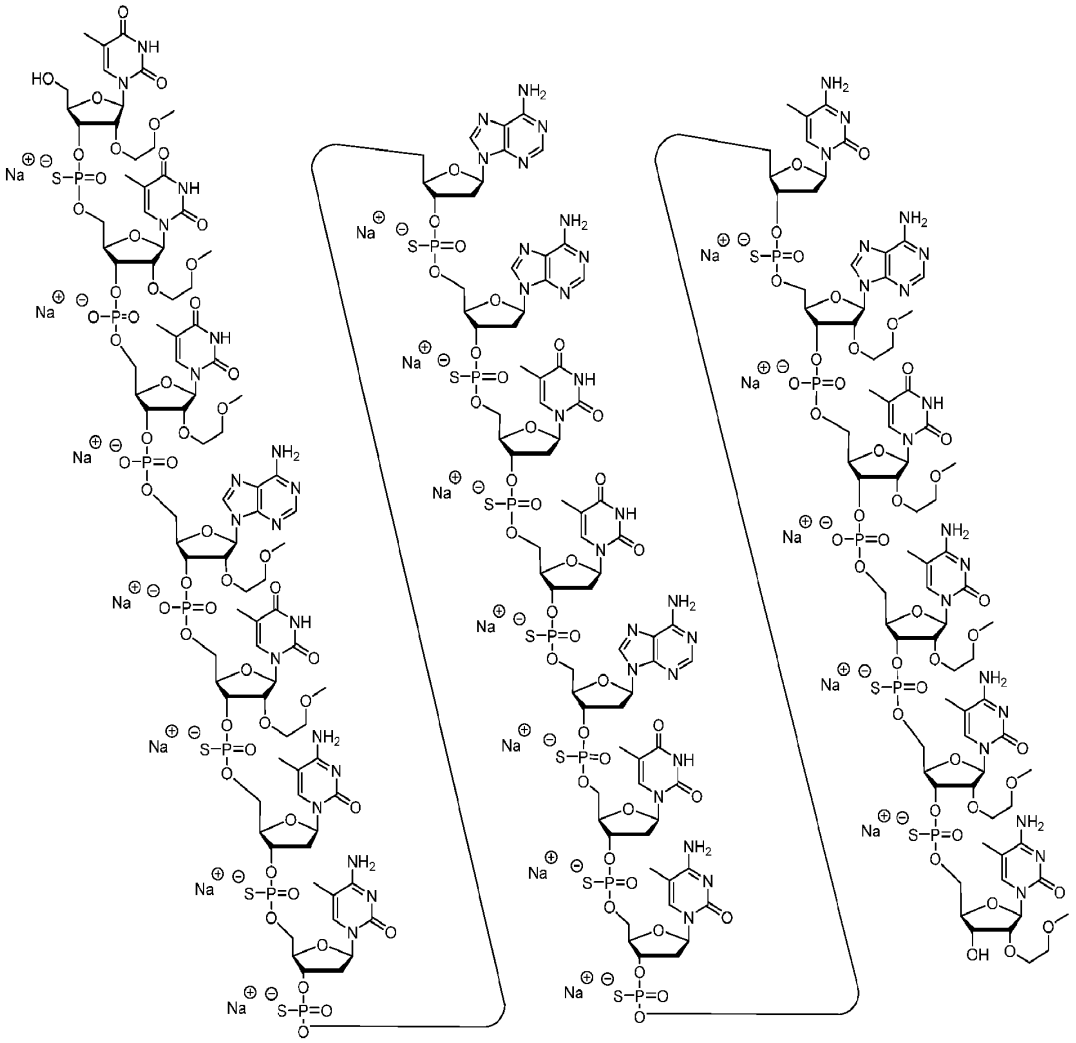
Embodiment 10. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 9), or a salt thereof.

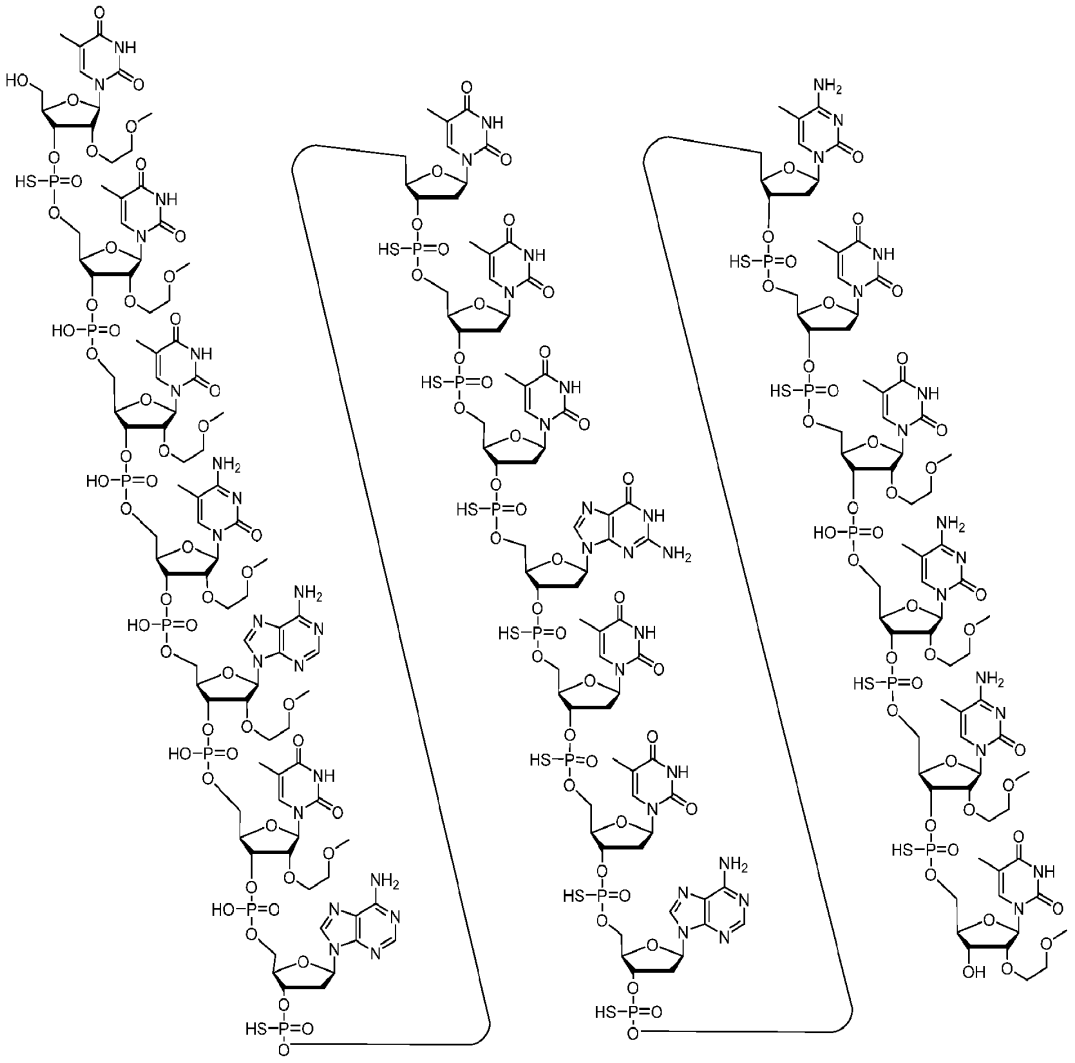
Embodiment 11. The modified oligonucleotide of embodiment 10, which is the sodium salt or the potassium salt.

Embodiment 12. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 9).

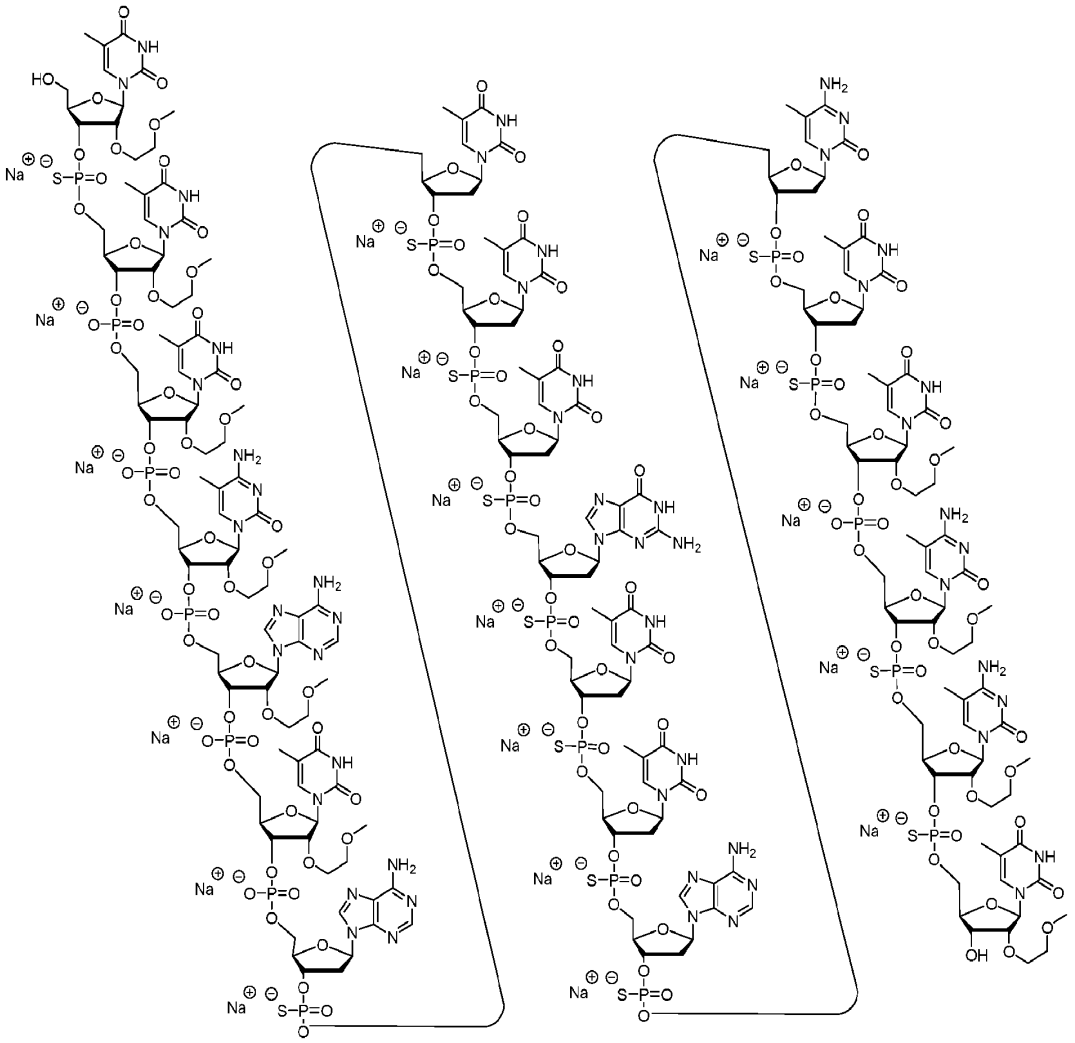
Embodiment 13. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 13), or a salt thereof.

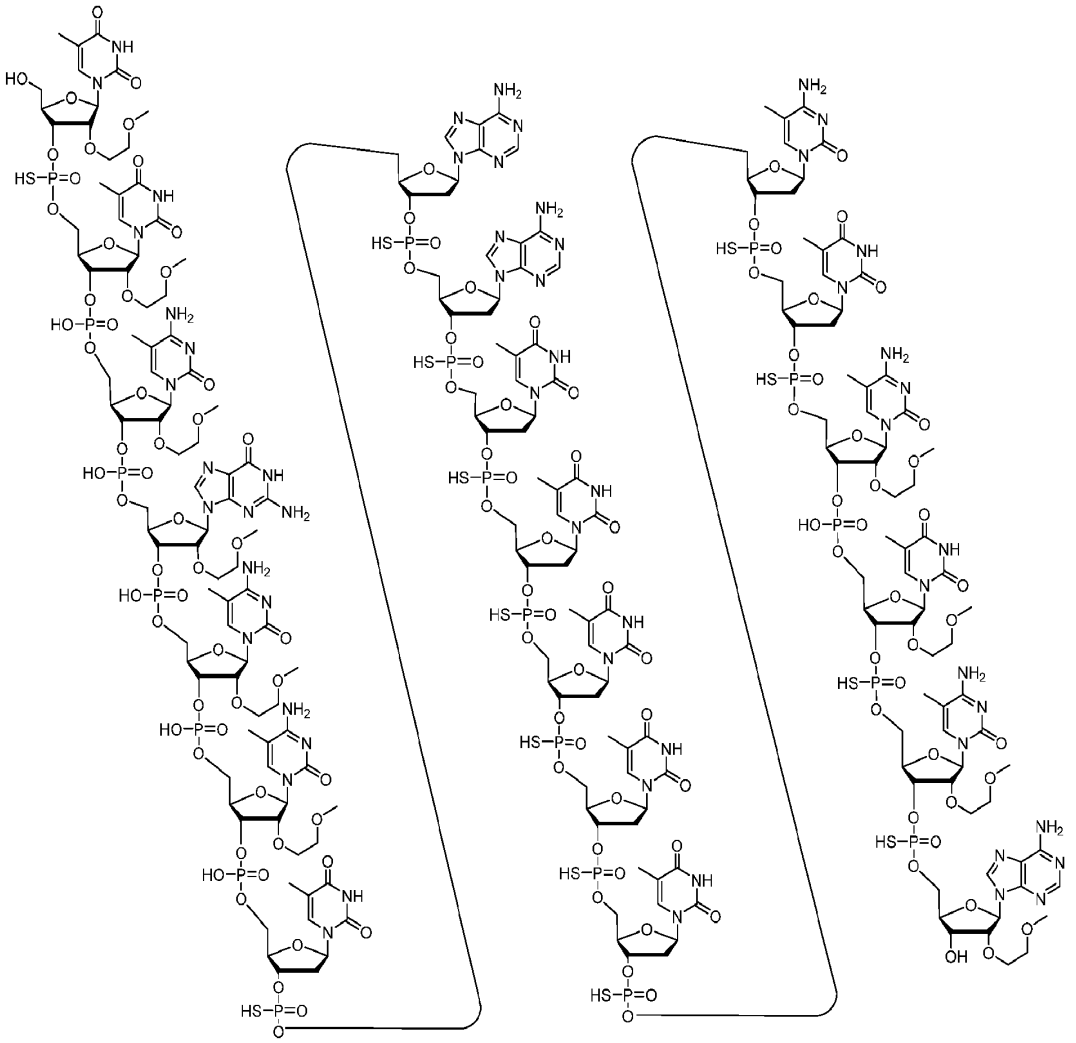
Embodiment 14. The modified oligonucleotide of embodiment 13, which is the sodium salt or the potassium salt.

Embodiment 15. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 13).

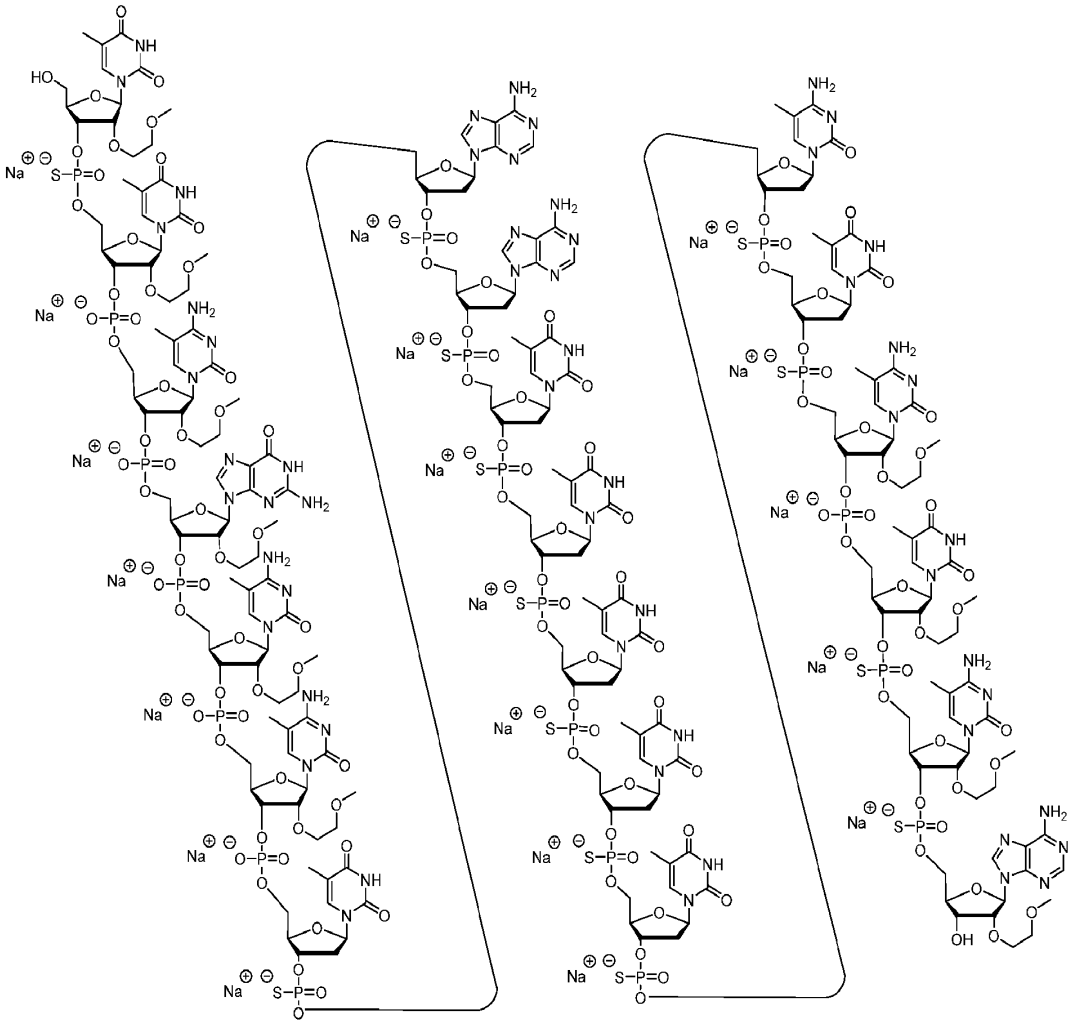
Embodiment 16. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 14), or a salt thereof.

Embodiment 17. The modified oligonucleotide of embodiment 16, which is the sodium salt or the potassium salt.

Embodiment 18. A modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 14).

Embodiment 19. An oligomeric compound comprising a modified oligonucleotide according to the following chemical notation: $T_{es}{}^{m}C_{eo}G_{eo}{}^{m}C_{eo}{}^{m}C_{es}T_{ds}A_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{eo}T_{eo}{}^{m}C_{es}A_{es}{}^{m}C_{e}$ (SEQ ID NO 10), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

Embodiment 20. An oligomeric compound comprising a modified oligonucleotide according to the following chemical notation: $^{m}C_{es}T_{eo}T_{eo}T_{eo}T_{eo}T_{eo}{}^{m}C_{ds}T_{ds}G_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{ds}T_{ds}T_{ds}A_{ds}T_{ds}A_{eo}{}^{m}C_{es}G_{es}{}^{m}C_{e}$ (SEQ ID NO 11), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

Embodiment 21. An oligomeric compound comprising a modified oligonucleotide according to the following chemical notation: $^{m}C_{es}T_{eo}G_{eo}T_{eo}T_{eo}T_{eo}T_{ds}A_{ds}{}^{m}C_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{eo}T_{es}{}^{m}C_{es}{}^{m}C_{e}$ (SEQ ID NO 12), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

Embodiment 22. An oligomeric compound comprising a modified oligonucleotide according to the following chemical notation: $T_{es}T_{eo}T_{eo}A_{eo}T_{es}{}^{m}C_{ds}{}^{m}C_{ds}A_{ds}A_{ds}T_{ds}T_{ds}A_{ds}T_{ds}{}^{m}C_{ds}{}^{m}C_{ds}A_{eo}T_{eo}{}^{m}C_{es}{}^{m}C_{es}{}^{m}C_{e}$ (SEQ ID NO 9), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

Embodiment 23. An oligomeric compound comprising a modified oligonucleotide according to the following chemical notation: $T_{es}T_{eo}T_{eo}{}^{m}C_{eo}A_{eo}T_{eo}A_{ds}T_{ds}T_{ds}T_{ds}G_{ds}T_{ds}T_{ds}A_{ds}{}^{m}C_{ds}T_{ds}T_{eo}{}^{m}C_{es}{}^{m}C_{es}T_{e}$ (SEQ ID NO 13), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

Embodiment 24. An oligomeric compound comprising a modified oligonucleotide according to the following chemical notation: $T_{es}T_{eo}{}^{m}C_{eo}G_{eo}{}^{m}C_{eo}{}^{m}C_{eo}T_{ds}A_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{eo}T_{es}{}^{m}C_{es}A_{e}$ (SEQ ID NO 14), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

Embodiment 25. A population of modified oligonucleotides of any of embodiments 1-18 or a population of oligomeric compounds of any of embodiments 19-24, wherein all of the phosphorothioate internucleoside linkages of the modified oligonucleotide are stereorandom.

Embodiment 26. A pharmaceutical composition comprising a modified oligonucleotide of any of embodiments 1-18, an oligomeric compound of any of embodiments 19-24, or a population of modified oligonucleotides or population of oligomeric compounds of embodiment 25, and a pharmaceutically acceptable diluent.

Embodiment 27. The pharmaceutical composition of embodiment 26, wherein the pharmaceutically acceptable diluent is artificial cerebrospinal fluid or phosphate-buffered saline.

Embodiment 28. The pharmaceutical composition of embodiment 27, wherein the pharmaceutical composition consists essentially of the modified oligonucleotide, the oligomeric compound, or the population, and artificial cerebrospinal fluid or phosphate-buffered saline.

Embodiment 29. A method comprising administering to a subject a modified oligonucleotide of any of embodiments 1-18, an oligomeric compound of any of embodiments 19-24, a population of modified oligonucleotides or population of oligomeric compounds of embodiment 25, or a pharmaceutical composition of any of embodiments 26-28.

Embodiment 30. A method of treating a disease associated with type I interferon signaling, comprising administering to a subject having a disease associated with type I interferon signaling a therapeutically effective amount of a modified oligonucleotide of any of embodiments 1-18, an oligomeric compound of any of embodiments 19-24, a population of modified oligonucleotides or population of oligomeric compounds of embodiment 25, or a pharmaceutical composition of any of embodiments 26-28; thereby treating the disease associated with type I interferon signaling.

Embodiment 31. The method of embodiment 30, wherein the disease associated with type I interferon signaling is Aicardi-Goutières Syndrome, stroke, Neuropsychiatric Systemic Lupus Erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, or ataxia telangiectasia.

Embodiment 32. The method of embodiment 30 or embodiment 31, wherein the disease is associated with an elevated level of interferon-alpha.

Embodiment 33. The method of any of embodiments 30-32, wherein administering the modified oligonucleotide, the oligomeric compound, the population of modified oligonucleotides or population of oligomeric compounds, or the pharmaceutical composition of reduces seizures, dystonia, spasticity, white matter abnormalities, T

cell infiltration, B cell infiltration, striatal necrosis, brain atrophy, basal ganglia calcification, or microencephaly in the subject; improves feeding, motor development, language development, or social skill development in the subject; or reduces interferon alpha or lymphocytosis in the cerebrospinal fluid of the subject.

Embodiment 34. A method of reducing expression of IFNAR1 in a cell, comprising contacting the cell with a modified oligonucleotide of any of embodiments 1-18, an oligomeric compound of any of embodiments 19-24, a population of modified oligonucleotides or population of oligomeric compounds of embodiment 25, or a pharmaceutical composition of any of embodiments 26-28.

Embodiment 35. The method of embodiment 34, wherein the cell is a neuron or a glial cell, optionally wherein the cell is an astrocyte or microglial cell.

Embodiment 36. The method of any of embodiments 29-33, wherein the subject is human.

Embodiment 37. The method of embodiment 34 or embodiment 35, wherein the cell is a human cell.

Embodiment 38. Use of a modified oligonucleotide of any of embodiments 1-18, an oligomeric compound of any of embodiments 19-24, a population of modified oligonucleotides or population of oligomeric compounds of embodiment 25, or a pharmaceutical composition of any of embodiments 26-28 for treating a disease associated with type I interferon signaling.

Embodiment 39. Use of a modified oligonucleotide of any of embodiments 1-18, an oligomeric compound of any of embodiments 19-24, a population of modified oligonucleotides or population of oligomeric compounds of embodiment 25, or a pharmaceutical composition of any of embodiments 26-28 in the manufacture of a medicament for treating a disease associated with type I interferon signaling.

Embodiment 40. The use of embodiment 38 or embodiment 39, wherein the disease is associated with an elevated level of interferon alpha.

Embodiment 41. The use of any of embodiments 38-40, wherein the disease associated with type I interferon signaling is Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, or ataxia telangiectasia.

1. Compound No. 1489477

In certain embodiments, Compound No. 1489477 is characterized as a 6-10-4 MOE gapmer having a sequence (from 5' to 3') of CTTTTTCTGCTCTTATACGC (SEQ ID NO 11), wherein each of nucleosides 1-6 and 17-20 (from 5' to 3') are 2'-MOE nucleosides and each of nucleosides 7-16 are 2'-β-D-deoxynucleosides, wherein the internucleoside linkages between nucleosides 2 to 3, 3 to 4, 4 to 5, 5 to 6, 6 to 7, and 17 to 18 are phosphodiester internucleoside linkages, the internucleoside linkages between nucleosides 1 to 2, 7 to 8, 8 to 9, 9 to 10, 10 to 11, 11 to 12, 12 to 13, 13 to 14, 14 to 15, 15 to 16, 16 to 17, 18 to 19, and 19 to 20 are phosphorothioate internucleoside linkages, and wherein each cytosine is a 5-methyl cytosine.

In certain embodiments, Compound No. 1489477 is represented by the following chemical notation: $^{m}C_{es}T_{eo}T_{eo}T_{eo}T_{eo}T_{eo}{}^{m}C_{ds}T_{ds}G_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{ds}T_{ds}T_{ds}A_{ds}T_{ds}A_{eo}{}^{m}C_{es}G_{es}{}^{m}C_{e}$ (SEQ ID NO 11), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

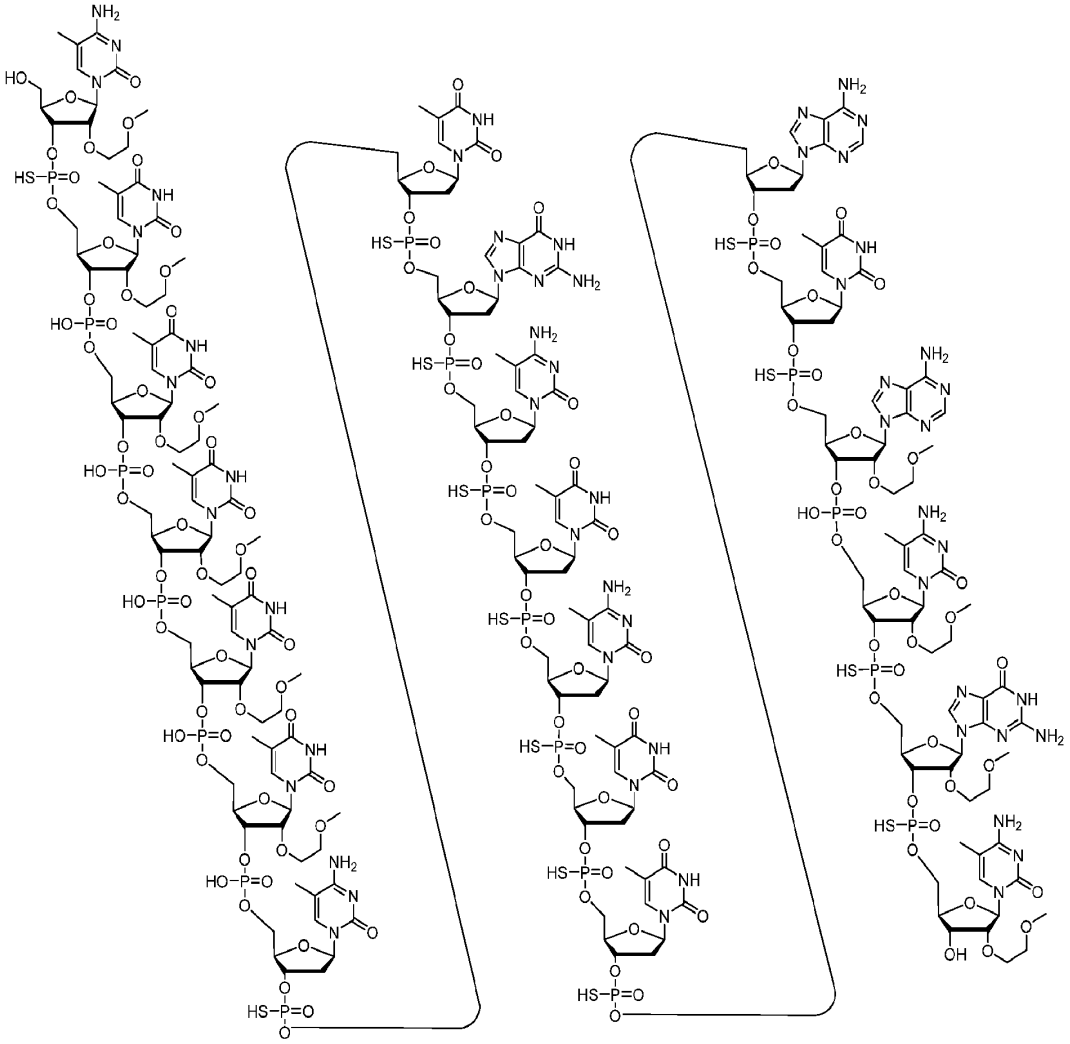
e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

In certain embodiments Compound No. 1489477 is represented by the following chemical structure:

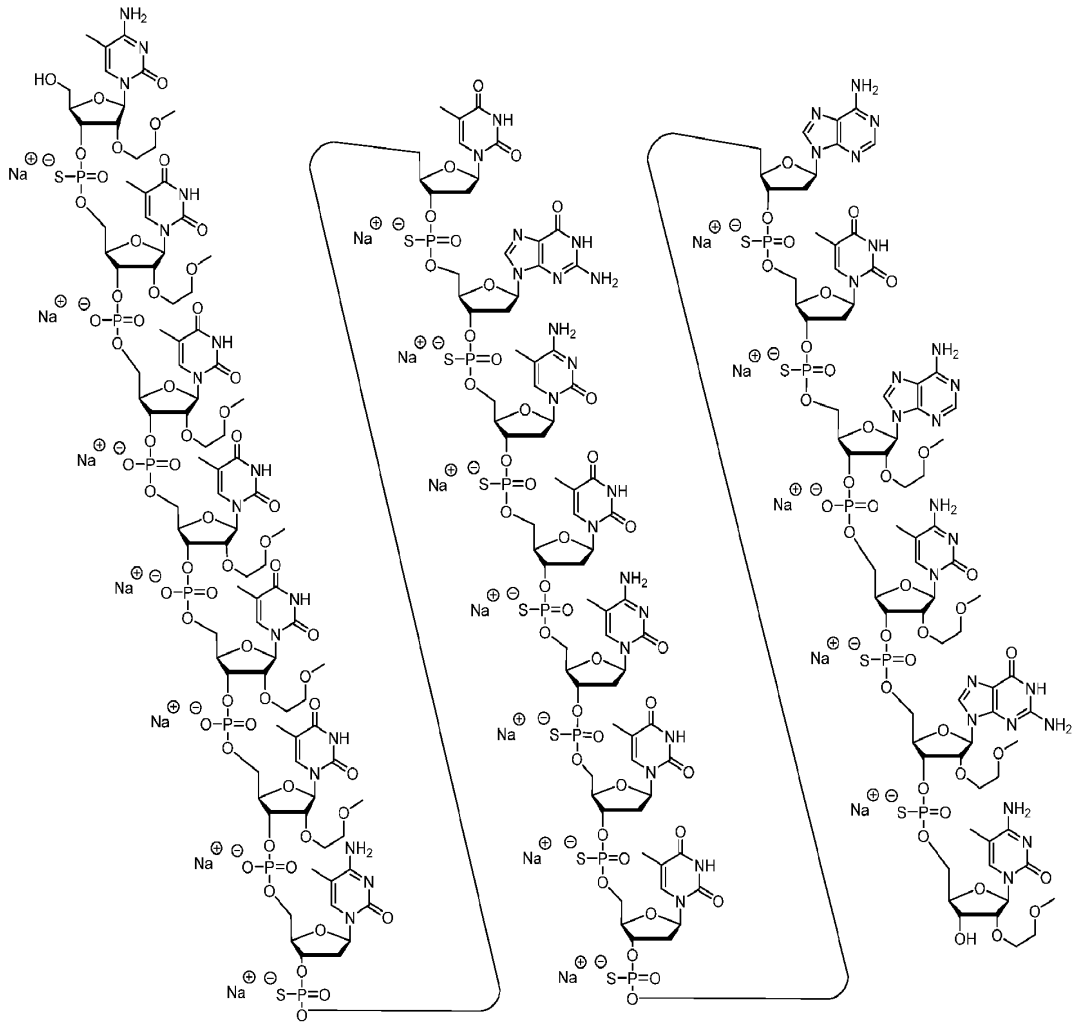


(SEQ ID NO 11).

Structure 1. Compound No. 1489477

In certain embodiments, an oligomeric compound comprises the sodium salt or the potassium salt of the modified oligonucleotide represented by Structure 1.

In certain embodiments the sodium salt of Compound No. 1489477 is represented by the following chemical structure:



(SEQ ID NO 11).

Structure 2. The sodium salt of Compound No. 1489477

2. Compound No. 1489494

In certain embodiments, Compound No. 1489494 is characterized as a 6-10-4 MOE gapmer having a sequence (from 5' to 3') of CTGTTTTACATTTTTTTTCC (SEQ ID NO 12), wherein each of nucleosides 1-6 and 17-20 (from 5' to 3') are 2'-MOE nucleosides and each of nucleosides 7-16 are 2'-β-D-deoxynucleosides, wherein the internucleoside linkages between nucleosides 2 to 3, 3 to 4, 4 to 5, 5 to 6, 6 to 7, and 17 to 18 are phosphodiester internucleoside linkages, the internucleoside linkages between nucleosides 1 to 2, 7 to 8, 8 to 9, 9 to 10, 10 to 11, 11 to 12, 12 to 13, 13 to 14, 14 to 15, 15 to 16, 16 to 17, 18 to 19, and 19 to 20 are phosphorothioate internucleoside linkages, and wherein each cytosine is a 5-methyl cytosine.

In certain embodiments, Compound No. 1489494 is represented by the following chemical notation: $^{m}C_{es}T_{eo}G_{eo}T_{eo}T_{eo}T_{eo}T_{ds}A_{ds}{}^{m}C_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{eo}T_{es}{}^{m}C_{es}{}^{m}C_{e}$ (SEQ ID NO 12), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

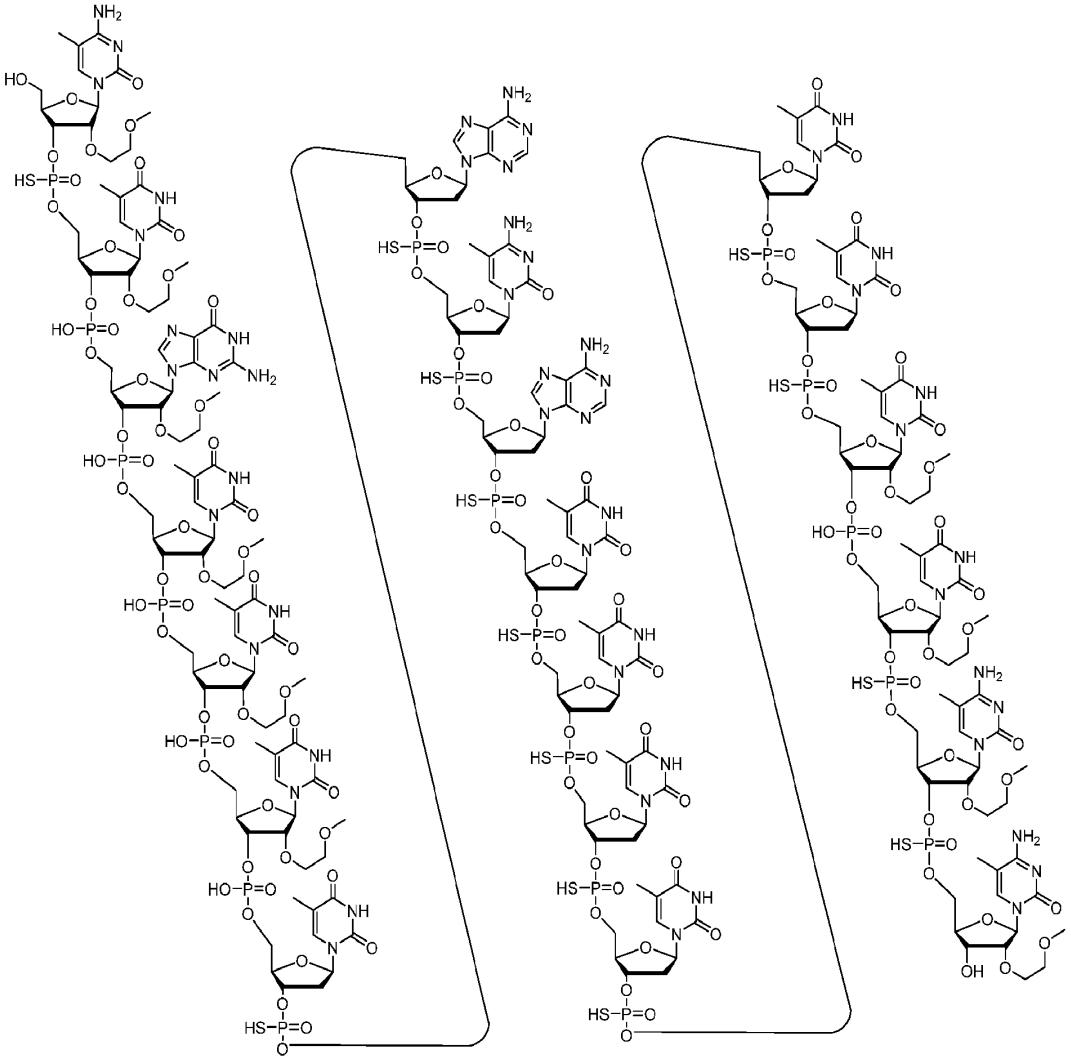
e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

In certain embodiments Compound No. 1489494 is represented by the following chemical structure:

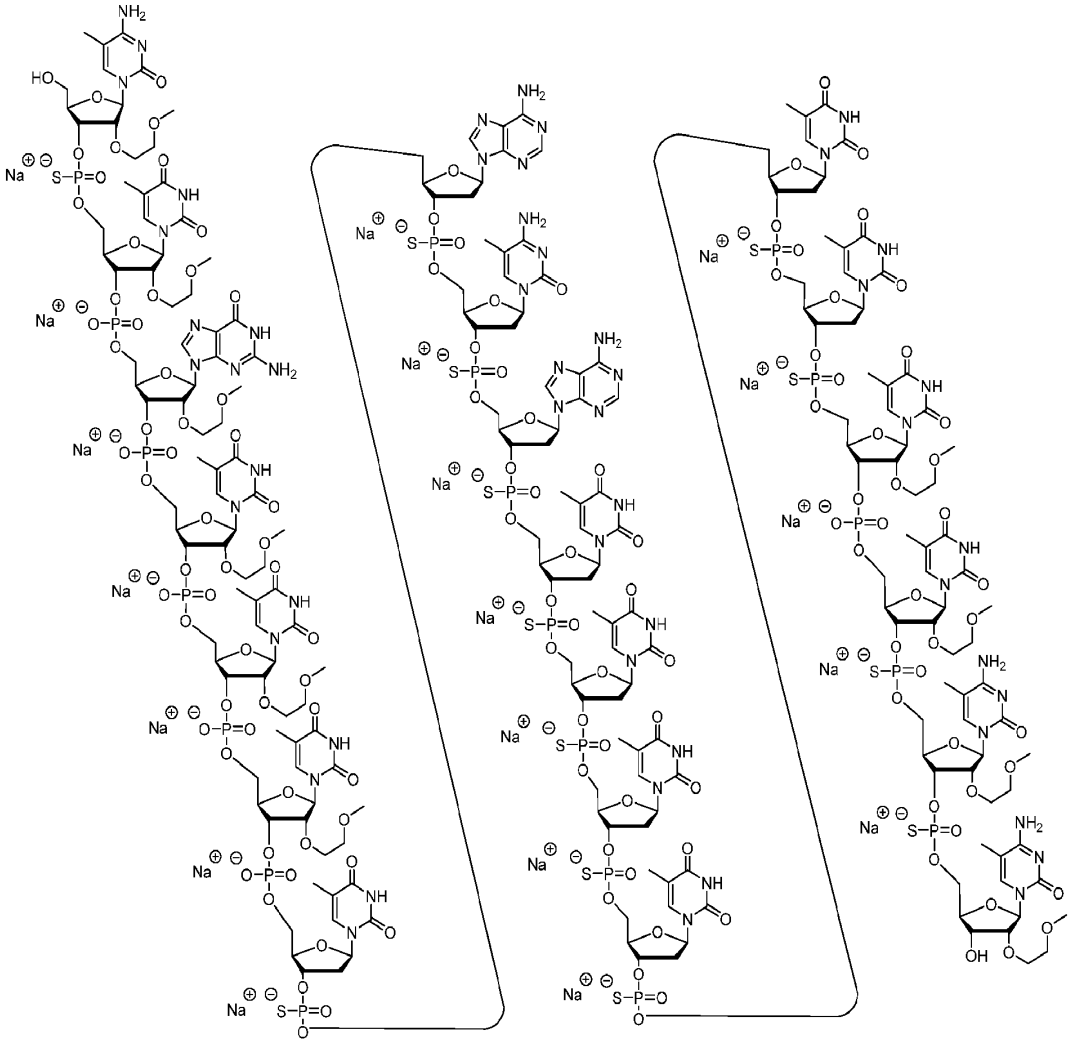


(SEQ ID NO 12).

Structure 3. Compound No. 1489494

In certain embodiments, an oligomeric compound comprises the sodium salt or the potassium salt of the modified oligonucleotide represented by Structure 3.

In certain embodiments the sodium salt of Compound No. 1489494 is represented by the following chemical structure:



(SEQ ID NO 12).

Structure 2. The sodium salt of Compound No. 1489494

3. Compound No. 1489525

In certain embodiments, Compound No. 1489525 is characterized as a 5-10-5 MOE gapmer having a sequence (from 5' to 3') of TTTATCCAATTATCCATCCC (SEQ ID NO 9), wherein each of nucleosides 1-5 and 16-20 (from 5' to 3') are 2'-MOE nucleosides and each of nucleosides 6-15 are 2'-β-D-deoxynucleosides, wherein the internucleoside linkages between nucleosides 2 to 3, 3 to 4, 4 to 5, 16 to 17, and 17 to 18 are phosphodiester internucleoside linkages, the internucleoside linkages between nucleosides 1 to 2, 5 to 6, 6 to 7, 7 to 8, 8 to 9, 9 to 10, 10 to 11, 11 to 12, 12 to 13, 13 to 14, 14 to 15, 15 to 16, 18 to 19, and 19 to 20 are phosphorothioate internucleoside linkages, and wherein each cytosine is a 5-methyl cytosine.

In certain embodiments, Compound No. 1489525 is represented by the following chemical notation: $T_{es}T_{eo}T_{eo}A_{eo}T_{es}{}^{m}C_{ds}{}^{m}C_{ds}A_{ds}A_{ds}T_{ds}T_{ds}A_{ds}T_{ds}{}^{m}C_{ds}{}^{m}C_{ds}A_{eo}T_{eo}{}^{m}C_{es}{}^{m}C_{es}{}^{m}C_{e}$ (SEQ ID NO 9), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

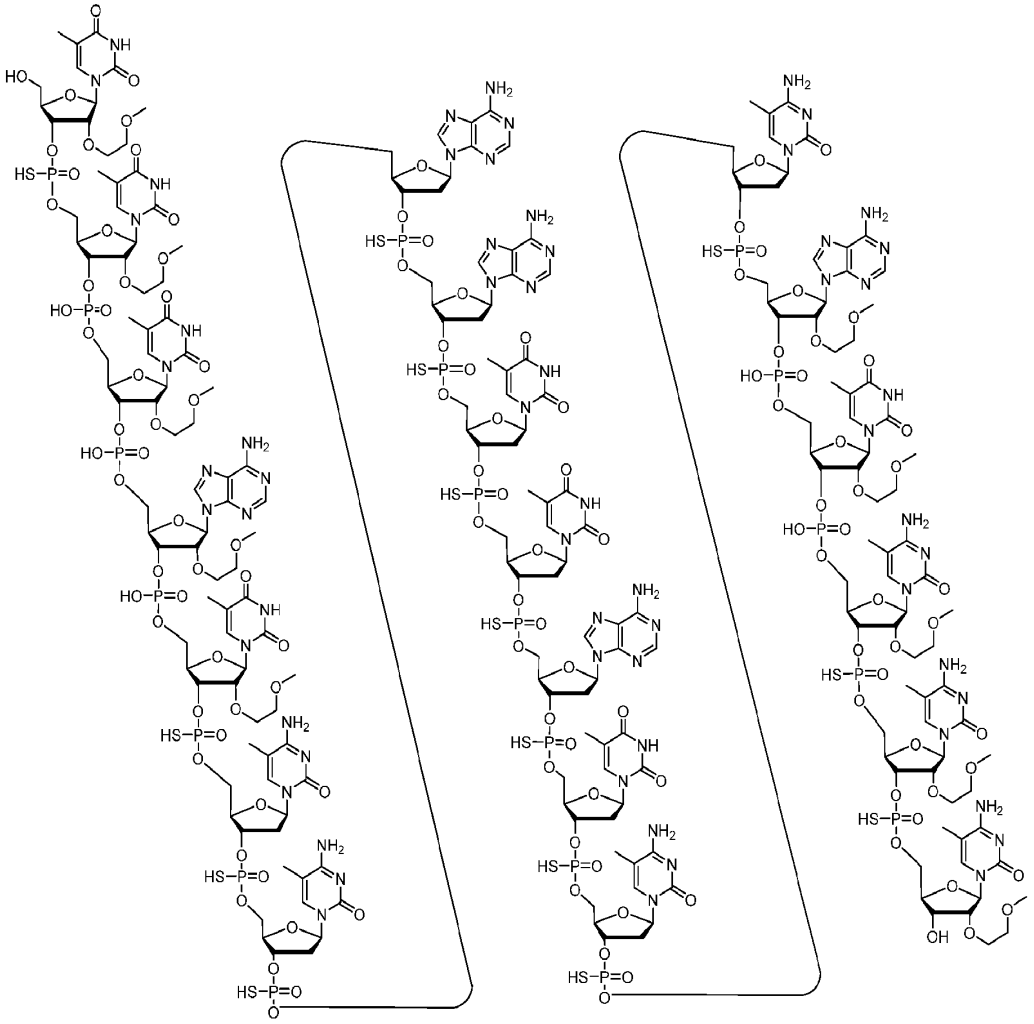
e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

In certain embodiments Compound No. 1489525 is represented by the following chemical structure:

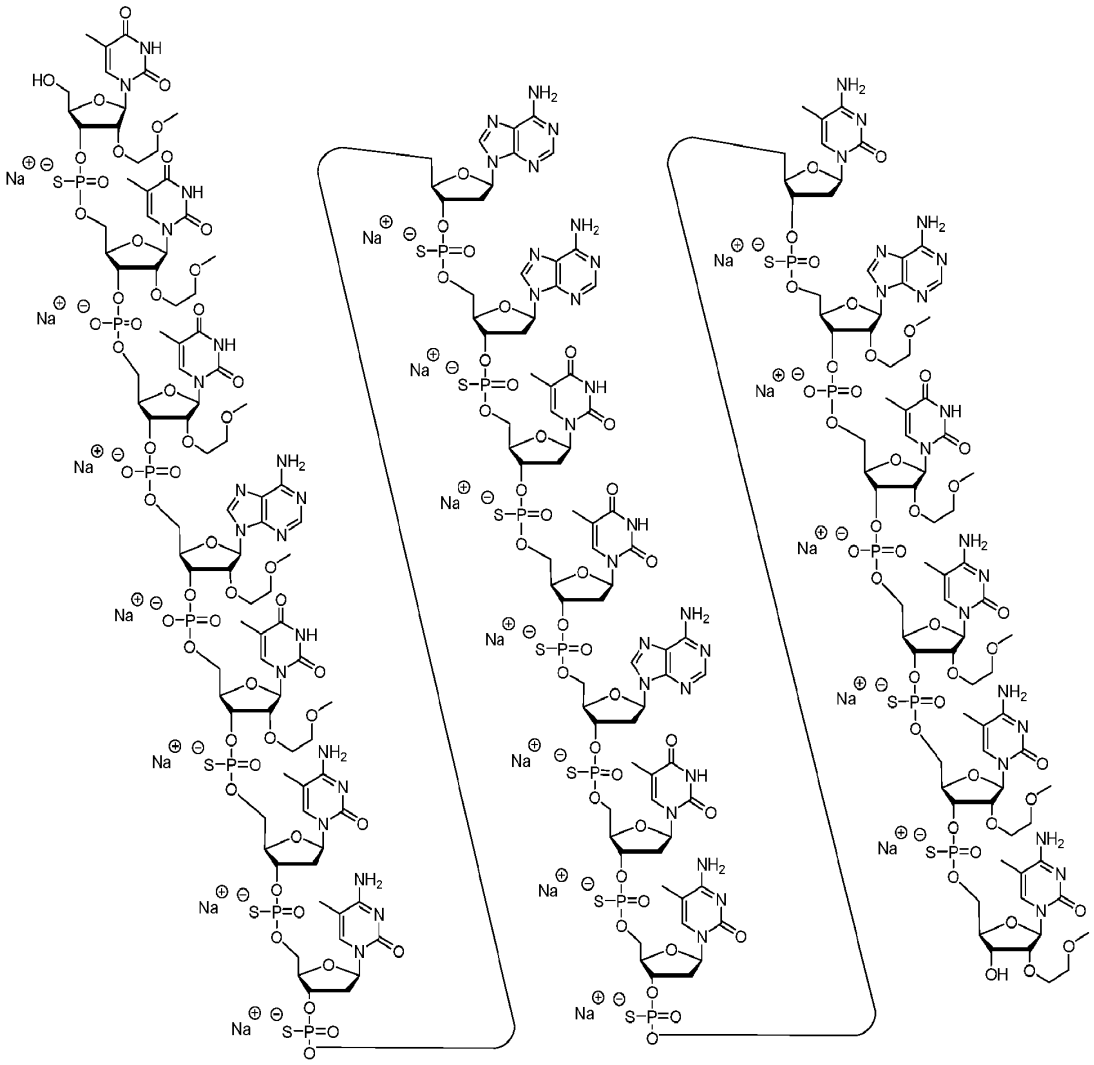


(SEQ ID NO 9).

Structure 5. Compound No. 1489525

In certain embodiments, an oligomeric compound comprises the sodium salt or the potassium salt of the modified oligonucleotide represented by Structure 5.

In certain embodiments the sodium salt of Compound No. 1489525 is represented by the following chemical structure:



(SEQ ID NO 9).

Structure 6. The sodium salt of Compound No. 1489525

4. Compound No. 1492069

In certain embodiments, Compound No. 1492069 is characterized as a 5-10-5 MOE gapmer having a sequence (from 5' to 3') of TCGCCTAATTTTTCTCTCAC (SEQ ID NO 10), wherein each of nucleosides 1-5 and 16-20 (from 5' to 3') are 2'-MOE nucleosides and each of nucleosides 6-15 are 2'-β-D-deoxynucleosides, wherein the internucleoside linkages between nucleosides 2 to 3, 3 to 4, 4 to 5, 16 to 17, and 17 to 18 are phosphodiester internucleoside linkages, the internucleoside linkages between nucleosides 1 to 2, 5 to 6, 6 to 7, 7 to 8, 8 to 9, 9 to 10, 10 to 11, 11 to 12, 12 to 13, 13 to 14, 14 to 15, 15 to 16, 18 to 19, and 19 to 20 are phosphorothioate internucleoside linkages, and wherein each cytosine is a 5-methyl cytosine.

In certain embodiments, Compound No. 1492069 is represented by the following chemical notation:

$T_{es}{}^{m}C_{eo}G_{eo}{}^{m}C_{eo}{}^{m}C_{es}T_{ds}A_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{eo}T_{eo}{}^{m}C_{es}A_{es}{}^{m}C_{e}$ (SEQ ID NO 10), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

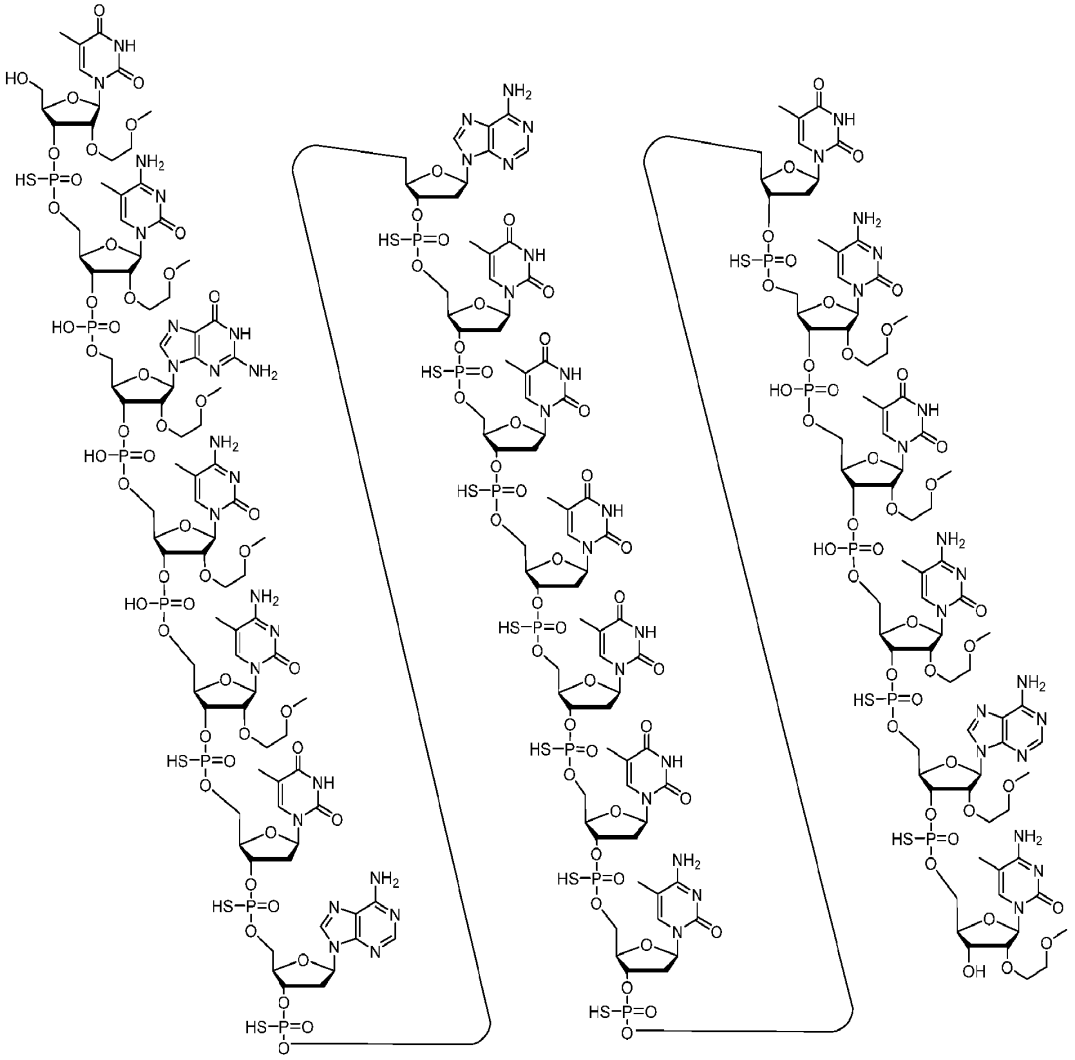
e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

In certain embodiments Compound No. 1492069 is represented by the following chemical structure:

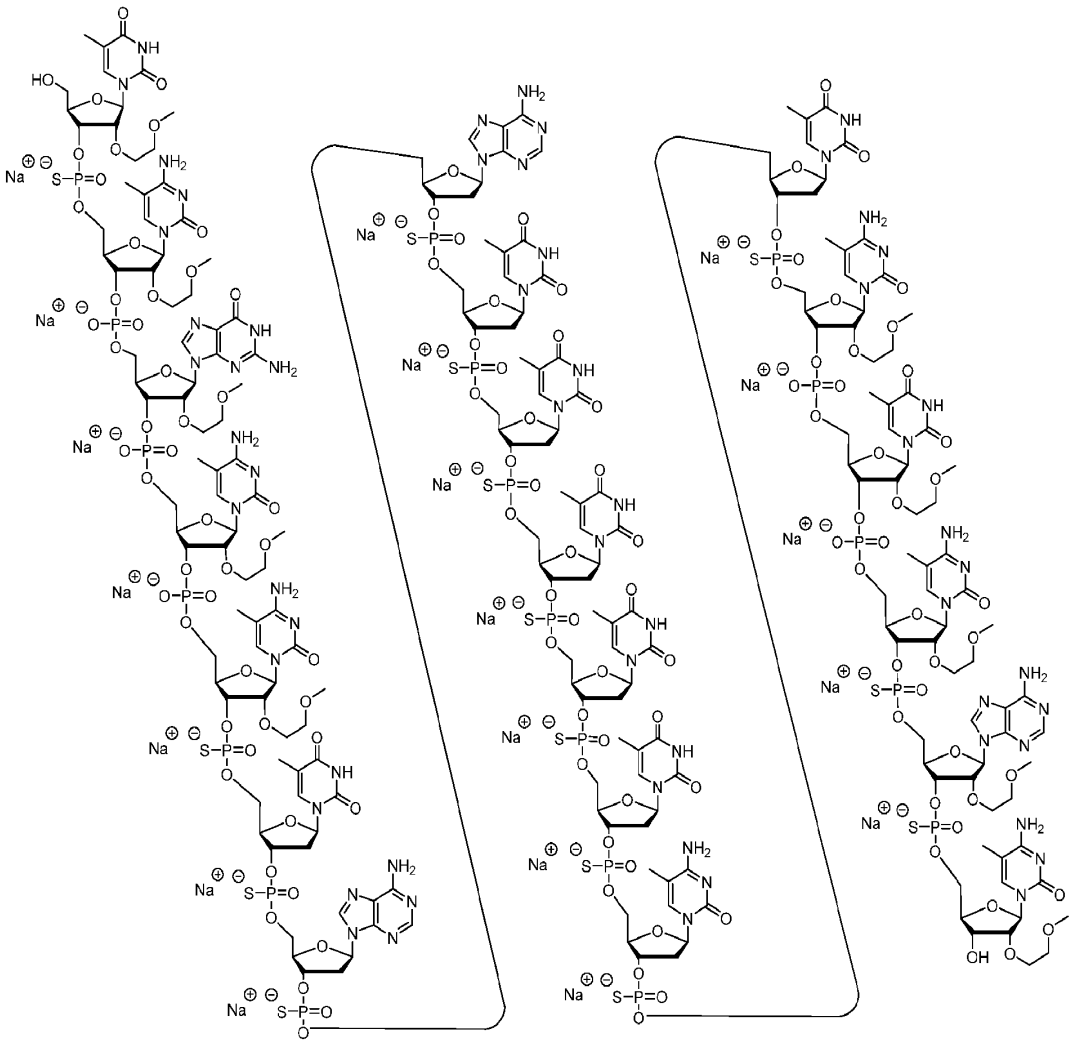


(SEQ ID NO 10).

Structure 7. Compound No. 1492069

In certain embodiments, an oligomeric compound comprises the sodium salt or the potassium salt of the modified oligonucleotide represented by Structure 7.

In certain embodiments the sodium salt of Compound No. 1492069 is represented by the following chemical structure:



(SEQ ID NO 10).

Structure 8. The sodium salt of Compound No. 1492069

5. Compound No. 1492082

In certain embodiments, Compound No. 1492082 is characterized as a 6-10-4 MOE gapmer having a sequence (from 5' to 3') of TTTCATATTTGTTACTTCCT (SEQ ID NO 13), wherein each of nucleosides 1-6 and 17-20 (from 5' to 3') are 2'-MOE nucleosides and each of nucleosides 7-16 are 2'-β-D-deoxynucleosides, wherein the internucleoside linkages between nucleosides 2 to 3, 3 to 4, 4 to 5, 5 to 6, 6 to 7, and 17 to 18 are phosphodiester internucleoside linkages, the internucleoside linkages between nucleosides 1 to 2, 7 to 8, 8 to 9, 9 to 10, 10 to 11, 11 to 12, 12 to 13, 13 to 14, 14 to 15, 15 to 16, 16 to 17, 18 to 19, and 19 to 20 are phosphorothioate internucleoside linkages, and wherein

each cytosine is a 5-methyl cytosine.

In certain embodiments, Compound No. 1492082 is represented by the following chemical notation: $T_{es}T_{eo}T_{eo}{}^{m}C_{eo}A_{eo}T_{eo}A_{ds}T_{ds}T_{ds}T_{ds}G_{ds}T_{ds}T_{ds}A_{ds}{}^{m}C_{ds}T_{ds}T_{eo}{}^{m}C_{es}{}^{m}C_{es}T_{e}$ (SEQ ID NO 13), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

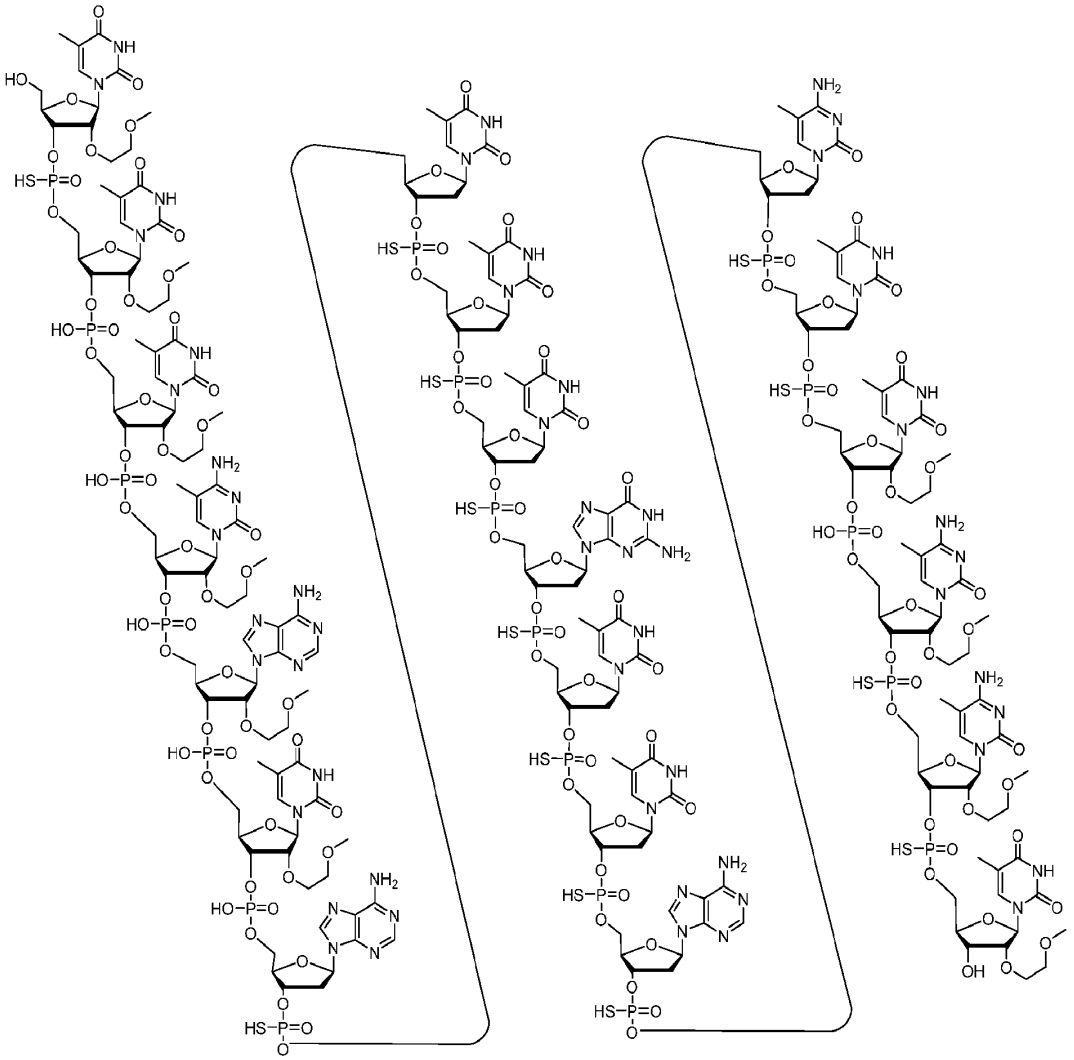
e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

In certain embodiments Compound No. 1492082 is represented by the following chemical structure:

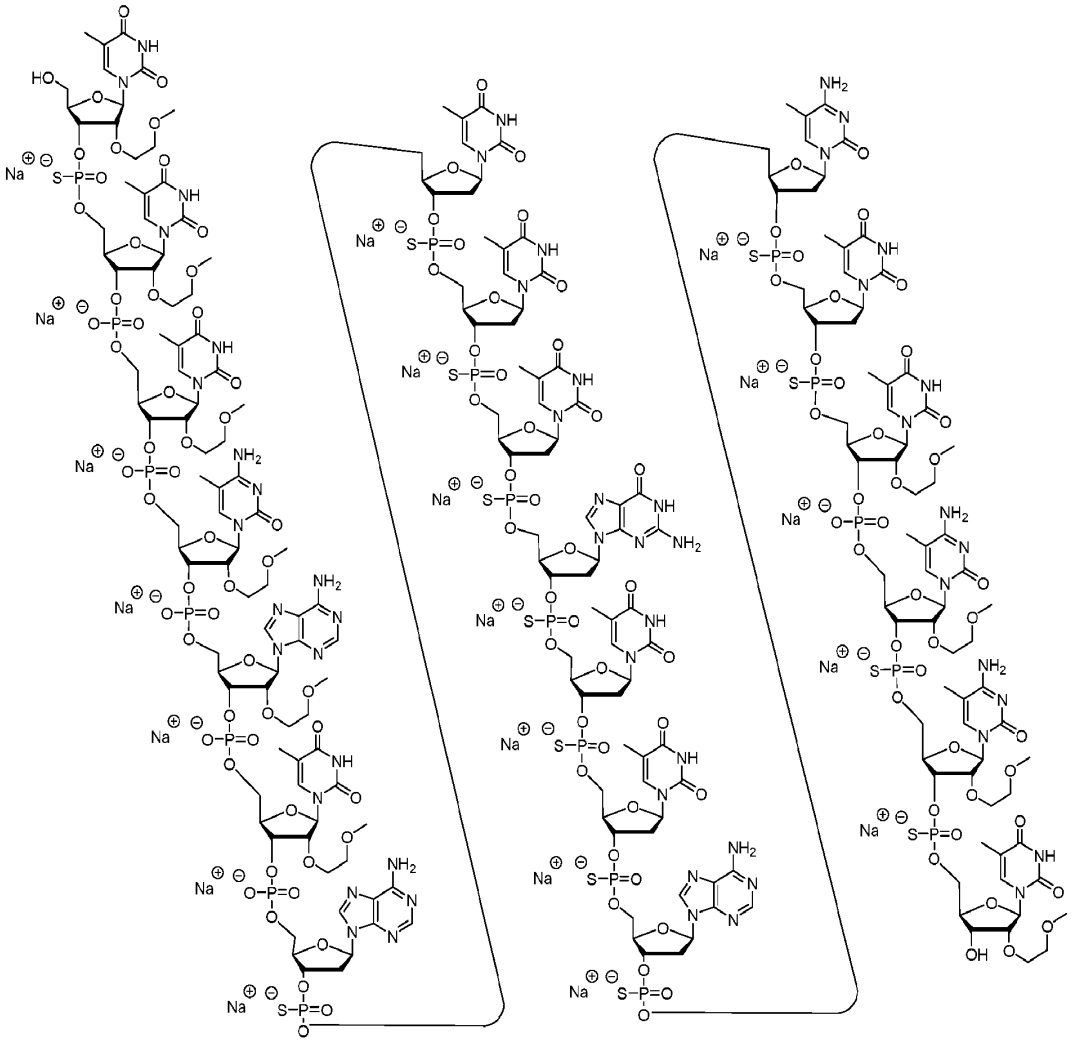


(SEQ ID NO 13).

Structure 9. Compound No. 1492082

In certain embodiments, an oligomeric compound comprises the sodium salt or the potassium salt of the modified oligonucleotide represented by Structure 9.

In certain embodiments the sodium salt of Compound No. 1492082 is represented by the following chemical structure:



(SEQ ID NO 13).

Structure 10. The sodium salt of Compound No. 1492082

6. Compound No. 1492131

In certain embodiments, Compound No. 1492131 is characterized as a 6-10-4 MOE gapmer having a sequence (from 5' to 3') of TTCGCCTAATTTTTCTCTCA (SEQ ID NO 14), wherein each of nucleosides 1-6 and 17-20 (from 5' to 3') are 2'-MOE nucleosides and each of nucleosides 7-16 are 2'-β-D-deoxynucleosides, wherein the internucleoside linkages between nucleosides 2 to 3, 3 to 4, 4 to 5, 5 to 6, 6 to 7, and 17 to 18 are phosphodiester internucleoside linkages, the internucleoside linkages between nucleosides 1 to 2, 7 to 8, 8 to 9, 9 to 10, 10 to 11, 11 to 12, 12 to 13, 13 to 14, 14 to 15, 15 to 16, 16 to 17, 18 to 19, and 19 to 20 are phosphorothioate internucleoside linkages,

and wherein each cytosine is a 5-methyl cytosine.

In certain embodiments, Compound No. 1492131 is represented by the following chemical notation: $T_{es}T_{eo}{}^{m}C_{eo}G_{eo}{}^{m}C_{eo}{}^{m}C_{eo}T_{ds}A_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{eo}T_{es}{}^{m}C_{es}A_{e}$ (SEQ ID NO 14), wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

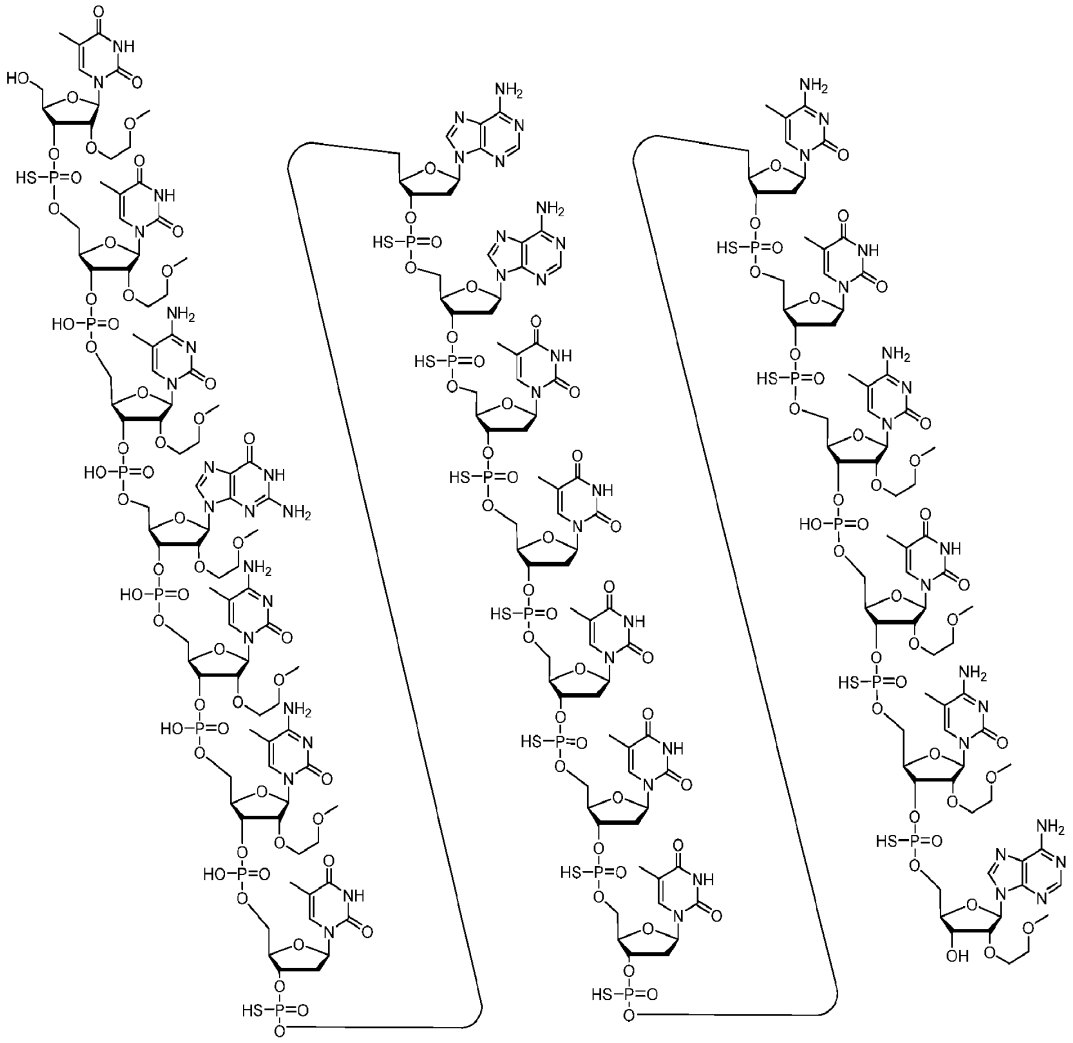
e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

In certain embodiments Compound No. 1492131 is represented by the following chemical structure:

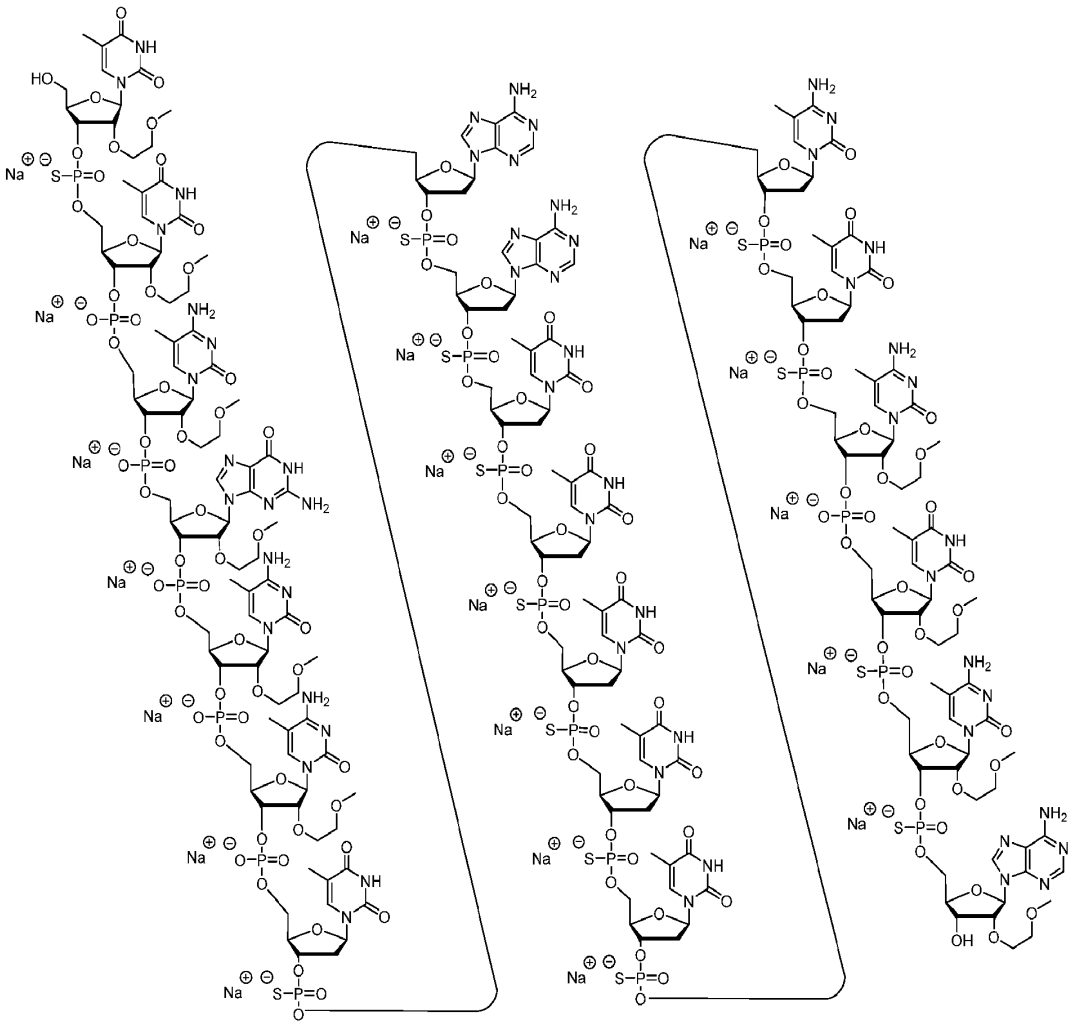


(SEQ ID NO 14).

Structure 11. Compound No. 1492131

In certain embodiments, an oligomeric compound comprises the sodium salt or the potassium salt of the modified oligonucleotide represented by Structure 11.

In certain embodiments the sodium salt of Compound No. 1492131 is represented by the following chemical structure:



(SEQ ID NO 14).

Structure 12. The sodium salt of Compound No. 1492131.

I. Certain Oligonucleotides

In certain embodiments, provided herein are oligomeric compounds comprising oligonucleotides, which consist of linked nucleosides. Oligonucleotides may be unmodified oligonucleotides (RNA or DNA) or may be modified oligonucleotides. Modified oligonucleotides comprise at least one modification relative to unmodified RNA or DNA. That is, modified oligonucleotides comprise at least one modified nucleoside (comprising a modified sugar moiety and/or a modified nucleobase) and/or at least one modified internucleoside linkage.

A. Certain Modified Nucleosides

Modified nucleosides comprise a modified sugar moiety or a modified nucleobase or both a modifed sugar moiety and a modified nucleobase.

1. Certain Sugar Moieties

In certain embodiments, modified sugar moieties are non-bicyclic modified sugar moieties comprising a furanosyl ring with one or more substituent groups none of which bridges two atoms of the furanosyl ring to form a bicyclic structure. Such non bridging substituents may be at any position of the furanosyl, including but not limited to substituents at the 2', 3', 4', and/or 5' positions. Examples of 2'-substituent groups suitable for non-bicyclic modified sugar moieties include but are not limited to 2'-$O(CH_2)_2OCH_3$ ("MOE" or "O-methoxyethyl").

In certain embodiments, modified furanosyl sugar moieties and nucleosides incorporating such modified furanosyl sugar moieties are further defined by isomeric configuration. For example, a 2'-deoxyfuranosyl sugar moiety may be in seven isomeric configurations other than the naturally occurring β-D-deoxyribosyl configuration. Such modified sugar moieties are described in, e.g., WO 2019/157531, incorporated by reference herein. A 2'-modified sugar moiety has an additional stereocenter at the 2'-position relative to a 2'-deoxyfuranosyl sugar moiety; therefore, such sugar moieties have a total of sixteen possible isomeric configurations. 2'-modified sugar moieties described herein are in the β-D-ribosyl isomeric configuration unless otherwise specified.

2. Certain Modified Nucleobases

In certain embodiments, modified oligonucleotides comprise one or more nucleosides comprising an unmodified nucleobase. In certain embodiments, modified oligonucleotides comprise one or more nucleosides comprising a modified nucleobase. Examples of modified nucleobases include 5-methylcytosine.

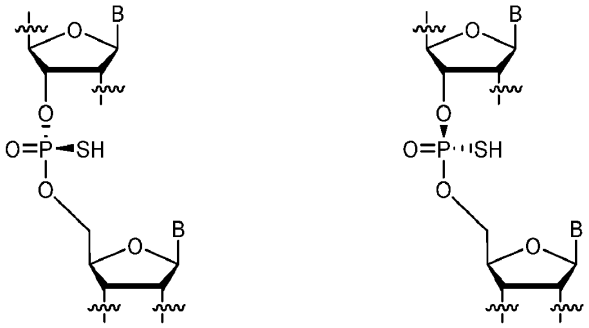
Publications that teach the preparation of certain modified nucleobases include without limitation, Manoharan et al., US2003/0158403; Manoharan et al., US2003/0175906; Dinh et al., U.S. 4,845,205; Spielvogel et al., U.S. 5,130,302; Rogers et al., U.S. 5,134,066; Bischofberger et al., U.S. 5,175,273; Urdea et al., U.S. 5,367,066; Benner et al., U.S. 5,432,272; Matteucci et al., U.S. 5,434,257; Gmeiner et al., U.S. 5,457,187; Cook et al., U.S. 5,459,255; Froehler et al., U.S. 5,484,908; Matteucci et al., U.S. 5,502,177; Hawkins et al., U.S. 5,525,711; Haralambidis et al., U.S. 5,552,540; Cook et al., U.S. 5,587,469; Froehler et al., U.S. 5,594,121; Switzer et al., U.S. 5,596,091; Cook et al., U.S. 5,614,617; Froehler et al., U.S. 5,645,985; Cook et al., U.S. 5,681,941; Cook et al., U.S. 5,811,534; Cook et al., U.S. 5,750,692; Cook et al., U.S. 5,948,903; Cook et al., U.S. 5,587,470; Cook et al., U.S. 5,457,191; Matteucci et al., U.S. 5,763,588; Froehler et al., U.S. 5,830,653; Cook et al., U.S. 5,808,027; Cook et al., U.S. 6,166,199; and Matteucci et al., U.S. 6,005,096.

3. Certain Modified Internucleoside Linkages

The naturally occurring internucleoside linkage of RNA and DNA is a 3' to 5' phosphodiester linkage. In certain embodiments, nucleosides of modified oligonucleotides may be linked together using one or more modified internucleoside linkages. The two main classes of internucleoside linking groups are defined by the presence or absence of a phosphorus atom. Representative phosphorus-containing internucleoside linkages include but are not limited to phosphates, which contain a phosphodiester bond ("P=O") (also referred to as unmodified or naturally occurring linkages), phosphotriesters, methylphosphonates, phosphoramidates, and phosphorothioates ("P=S"), and phosphorodithioates ("HS-P=S"). Modified internucleoside linkages, compared to naturally occurring phosphate linkages, can be used to alter, typically increase, nuclease resistance of the oligonucleotide. In certain embodiments, internucleoside linkages having a chiral atom can be prepared as a racemic mixture, or as separate enantiomers. Methods

of preparation of phosphorous-containing and non-phosphorous-containing internucleoside linkages are well known to those skilled in the art.

Representative internucleoside linkages having a chiral center include but are not limited to phosphorothioates. Modified oligonucleotides comprising internucleoside linkages having a chiral center can be prepared as populations of modified oligonucleotides comprising stereorandom internucleoside linkages, or as populations of modified oligonucleotides comprising phosphorothioate or other linkages containing chiral centers in particular stereochemical configurations. In certain embodiments, populations of modified oligonucleotides comprise phosphorothioate internucleoside linkages wherein all of the phosphorothioate internucleoside linkages are stereorandom. Such modified oligonucleotides can be generated using synthetic methods that result in random selection of the stereochemical configuration of each phosphorothioate linkage. Nonetheless, each individual phosphorothioate of each individual oligonucleotide molecule has a defined stereoconfiguration. In certain embodiments, populations of modified oligonucleotides are enriched for modified oligonucleotides comprising one or more particular phosphorothioate internucleoside linkages in a particular, independently selected stereochemical configuration. In certain embodiments, the particular configuration of the particular phosphorothioate linkage is present in at least 65% of the molecules in the population. In certain embodiments, the particular configuration of the particular phosphorothioate linkage is present in at least 70% of the molecules in the population. In certain embodiments, the particular configuration of the particular phosphorothioate linkage is present in at least 80% of the molecules in the population. In certain embodiments, the particular configuration of the particular phosphorothioate linkage is present in at least 90% of the molecules in the population. In certain embodiments, the particular configuration of the particular phosphorothioate linkage is present in at least 99% of the molecules in the population. Such chirally enriched populations of modified oligonucleotides can be generated using synthetic methods known in the art, *e.g.*, methods described in Oka et al., *JACS* 125, 8307 (2003), Wan et al. *Nuc. Acid. Res.* 42, 13456 (2014), and WO 2017/015555. In certain embodiments, a population of modified oligonucleotides is enriched for modified oligonucleotides having at least one indicated phosphorothioate in the (*S*p) configuration. In certain embodiments, a population of modified oligonucleotides is enriched for modified oligonucleotides having at least one phosphorothioate in the (*R*p) configuration. In certain embodiments, modified oligonucleotides comprising (*R*p) and/or (*S*p) phosphorothioates comprise one or more of the following formulas, respectively, wherein "B" indicates a nucleobase:



(R_p) (S_p)

Unless otherwise indicated, chiral internucleoside linkages of modified oligonucleotides described herein can be stereorandom or in a particular stereochemical configuration.

B. Certain Motifs

In certain embodiments, modified oligonucleotides comprise one or more modified nucleosides comprising a modified sugar moiety. In certain embodiments, modified oligonucleotides comprise one or more modified nucleosides comprising a modified nucleobase. In certain embodiments, modified oligonucleotides comprise one or more modified internucleoside linkage. In such embodiments, the modified, unmodified, and differently modified sugar moieties, nucleobases, and/or internucleoside linkages of a modified oligonucleotide define a pattern or motif. In certain embodiments, the patterns of sugar moieties, nucleobases, and internucleoside linkages are each independent of one another. Thus, a modified oligonucleotide may be described by its sugar motif, nucleobase motif and/or internucleoside linkage motif (as used herein, nucleobase motif describes the modifications to the nucleobases independent of the sequence of nucleobases).

1. **Certain Sugar Motifs**

In certain embodiments, oligonucleotides comprise one or more type of modified sugar and/or unmodified sugar moiety arranged along the oligonucleotide or region thereof in a defined pattern or sugar motif. In certain instances, such sugar motifs include but are not limited to any of the sugar modifications discussed herein.

Gapmer Oligonucleotides

In certain embodiments, modified oligonucleotides comprise or consist of a region having a gapmer motif, which is defined by two external regions or "wings" and a central or internal region or "gap." The three regions of a gapmer motif (the 5'-wing, the gap, and the 3'-wing) form a contiguous sequence of nucleosides wherein at least some of the sugar moieties of the nucleosides of each of the wings differ from at least some of the sugar moieties of the nucleosides of the gap. Specifically, at least the sugar moieties of the nucleosides of each wing that are closest to the gap (the 3'-most nucleoside of the 5'-wing and the 5'-most nucleoside of the 3'-wing) differ from the sugar moiety of the neighboring gap nucleosides, thus defining the boundary between the wings and the gap (i.e., the wing/gap junction). In certain embodiments, the sugar moieties within the gap are the same as one another. In certain embodiments, the gap includes one or more nucleoside having a sugar moiety that differs from the sugar moiety of one or more other nucleosides of the gap. In certain embodiments, the sugar motifs of the two wings are the same as one another (symmetric gapmer). In certain embodiments, the sugar motif of the 5'-wing differs from the sugar motif of the 3'-wing (asymmetric gapmer).

In certain embodiments, the wings of a gapmer comprise 1-6 nucleosides. In certain embodiments, each nucleoside of each wing of a gapmer comprises a modified sugar moiety. In certain embodiments, at least one nucleoside of each wing of a gapmer comprises a modified sugar moiety. In certain embodiments, at least two nucleosides of each wing of a gapmer comprises a modified sugar moiety. In certain embodiments, at least three nucleosides of each wing of a gapmer comprises a modified sugar moiety. In certain embodiments, at least four nucleosides of each wing of a gapmer comprises a modified sugar moiety.

In certain embodiments, the gap of a gapmer comprises 7-12 nucleosides. In certain embodiments, each nucleoside of the gap of a gapmer comprises a 2'-β-D-deoxyribosyl sugar moiety. In certain embodiments, at least one nucleoside of the gap of a gapmer comprises a modified sugar moiety.

In certain embodiments, the gapmer is a deoxy gapmer. In certain embodiments, the nucleosides on the gap side of each wing/gap junction comprise 2'- deoxyribosyl sugar moieties and the nucleosides on the wing sides of each

wing/gap junction comprise modified sugar moieties. In certain embodiments, each nucleoside of the gap comprises a 2'-β-D-deoxyribosyl sugar moiety. In certain embodiments, each nucleoside of each wing of a gapmer comprises a modified sugar moiety. In certain embodiments, at least one nucleoside of the gap of a gapmer comprises a modified sugar moiety. In certain embodiments, one nucleoside of the gap comprises a modified sugar moiety and each remaining nucleoside of the gap comprises a 2'-deoxyribosyl sugar moiety. In certain embodiments, at least one nucleoside of the gap of a gapmer comprises a 2'-OMe sugar moiety.

Herein, the lengths (number of nucleosides) of the three regions of a gapmer may be provided using the notation [# of nucleosides in the 5'-wing] – [# of nucleosides in the gap] – [# of nucleosides in the 3'-wing]. Thus, a 3-10-3 gapmer consists of 3 linked nucleosides in each wing and 10 linked nucleosides in the gap. Where such nomenclature is followed by a specific modification, that modification is the modification in each sugar moiety of each wing and the gap nucleosides comprise 2'-β-D-deoxyribosyl sugar moieties. Thus, a 5-10-5 MOE gapmer consists of 5 linked 2'-MOE nucleosides in the 5'-wing, 10 linked 2'- β-D-deoxynucleosides in the gap, and 5 linked 2'-MOE nucleosides in the 3'-wing. A 6-10-4 MOE gapmer consists of 6 linked 2'-MOE nucleosides in the 5'-wing, 10 linked 2'- β-D-deoxynucleosides in the gap, and 4 linked 2'-MOE nucleosides in the 3'-wing. A 3-10-3 cEt gapmer consists of 3 linked cEt nucleosides in the 5'-wing, 10 linked 2'- β-D-deoxynucleosides in the gap, and 3 linked cEt nucleosides in the 3'-wing.

In certain embodiments, modified oligonucleotides are 5-10-5 MOE gapmers. In certain embodiments, modified oligonucleotides are 6-10-4 MOE gapmers.

In certain embodiments, modified oligonucleotides have a sugar motif selected from 5' to 3': eeeeeddddddddddeeeee; wherein each "d" represents a 2'-β-D-deoxyribosyl sugar moiety, and each "e" represents a 2'-MOE sugar moiety.

In certain embodiments, modified oligonucleotides have a sugar motif selected from 5' to 3': eeeeeeddddddddddeeeee; wherein each "d" represents a 2'-β-D-deoxyribosyl sugar moiety, and each "e" represents a 2'-MOE sugar moiety.

In certain embodiments, modified oligonucleotides have the sugar motif from 5' to 3': kkkddddddddddkkk; wherein each "d" represents a 2'-β-D-deoxyribosyl sugar moiety, and each "k" represents a cEt modified sugar moiety.

2. Certain Nucleobase Motifs

In certain embodiments, oligonucleotides comprise modified and/or unmodified nucleobases arranged along the oligonucleotide or region thereof in a defined pattern or motif. In certain embodiments, each nucleobase is modified. In certain embodiments, none of the nucleobases are modified. In certain embodiments, each purine or each pyrimidine is modified. In certain embodiments, each cytosine is modified. In certain embodiments, some or all of the cytosine nucleobases in a modified oligonucleotide are 5-methyl cytosines. In certain embodiments, all of the cytosine nucleobases are 5-methyl cytosines and all of the other nucleobases of the modified oligonucleotide are unmodified nucleobases.

In certain embodiments, oligonucleotides having a gapmer motif comprise a nucleoside comprising a modified nucleobase. In certain such embodiments, one nucleoside comprising a modified nucleobase is in the central gap of an oligonucleotide having a gapmer motif. In certain such embodiments, the sugar moiety of said nucleoside is a 2'-deoxyribosyl sugar moiety.

3. Certain Internucleoside Linkage Motifs

In certain embodiments, oligonucleotides comprise modified and/or unmodified internucleoside linkages arranged along the oligonucleotide or region thereof in a defined pattern or motif. In certain embodiments, each internucleoside linking group is a phosphodiester internucleoside linkage (P=O). In certain embodiments, each internucleoside linking group of a modified oligonucleotide is a phosphorothioate internucleoside linkage (P=S). In certain embodiments, each internucleoside linkage of a modified oligonucleotide is independently selected from a phosphorothioate internucleoside linkage and phosphodiester internucleoside linkage. In certain embodiments, each phosphorothioate internucleoside linkage is independently selected from a stereorandom phosphorothioate, a (*S*p) phosphorothioate, and a (*R*p) phosphorothioate.

In certain embodiments, the sugar motif of a modified oligonucleotide is a gapmer and the internucleoside linkages within the gap are all modified. In certain such embodiments, some, or all of the internucleoside linkages in the wings are unmodified phosphodiester internucleoside linkages. In certain embodiments, the terminal internucleoside linkages are modified. In certain embodiments, the sugar motif of a modified oligonucleotide is a gapmer, and the internucleoside linkage motif comprises at least one phosphodiester internucleoside linkage in at least one wing, wherein the at least one phosphodiester linkage is not a terminal internucleoside linkage, and the remaining internucleoside linkages are phosphorothioate internucleoside linkages. In certain such embodiments, all of the phosphorothioate linkages are stereorandom. In certain embodiments, all of the phosphorothioate linkages in the wings are (Sp) phosphorothioates, and the gap comprises at least one Sp, Sp, Rp motif. In certain embodiments, populations of modified oligonucleotides are enriched for modified oligonucleotides comprising such internucleoside linkage motifs.

In certain embodiments, modified oligonucleotides have an internucleoside linkage motif of (5' to 3'): sooossssssssssooss phosphorothioate internucleoside linkage, wherein each "s" represents a phosphorothioate internucleoside linkage and each "o" represents a phosphodiester internucleoside linkage. In certain embodiments, modified oligonucleotides have an internucleoside linkage motif of (5' to 3'): sooooossssssssssoss, wherein each "s" represents a phosphorothioate internucleoside linkage and each "o" represents a phosphodiester internucleoside linkage.

II. Certain Oligomeric Compounds

In certain embodiments, provided herein are oligomeric compounds, which consist of an oligonucleotide (modified or unmodified) and optionally one or more conjugate groups and/or terminal groups. Conjugate groups consist of one or more conjugate moiety and a conjugate linker which links the conjugate moiety to the oligonucleotide. Conjugate groups may be attached to either or both ends of an oligonucleotide and/or at any internal position. In certain embodiments, conjugate groups are attached to the 2'-position of a nucleoside of a modified oligonucleotide. In certain embodiments, conjugate groups that are attached to either or both ends of an oligonucleotide are terminal groups. In certain such embodiments, conjugate groups or terminal groups are attached at the 3' and/or 5'-end of oligonucleotides. In certain such embodiments, conjugate groups (or terminal groups) are attached at the 3'-end of oligonucleotides. In certain embodiments, conjugate groups are attached near the 3'-end of oligonucleotides. In certain embodiments, conjugate groups (or terminal groups) are attached at the 5'-end of oligonucleotides. In certain embodiments, conjugate groups are attached near the 5'-end of oligonucleotides.

Examples of terminal groups include but are not limited to conjugate groups, capping groups, phosphate moieties, protecting groups, modified or unmodified nucleosides, and two or more nucleosides that are independently modified or unmodified.

A. Certain Conjugate Groups

In certain embodiments, oligonucleotides are covalently attached to one or more conjugate groups. In certain embodiments, conjugate groups modify one or more properties of the attached oligonucleotide, including but not limited to pharmacodynamics, pharmacokinetics, stability, binding, absorption, tissue distribution, cellular distribution, cellular uptake, charge and clearance.

In certain embodiments, conjugation of one or more carbohydrate moieties to a modified oligonucleotide can optimize one or more properties of the modified oligonucleotide. In certain embodiments, the carbohydrate moiety is attached to a modified subunit of the modified oligonucleotide. For example, the ribose sugar of one or more ribonucleotide subunits of a modified oligonucleotide can be replaced with another moiety, e.g. a non-carbohydrate (preferably cyclic) carrier to which is attached a carbohydrate ligand. A ribonucleotide subunit in which the ribose sugar of the subunit has been so replaced is referred to herein as a ribose replacement modification subunit (RRMS), which is a modified sugar moiety. A cyclic carrier may be a carbocyclic ring system, i.e., one or more ring atoms may be a heteroatom, e.g., nitrogen, oxygen, sulphur. The cyclic carrier may be a monocyclic ring system, or may contain two or more rings, e.g. fused rings. The cyclic carrier may be a fully saturated ring system, or it may contain one or more double bonds. In certain embodiments, the modified oligonucleotide is a gapmer.

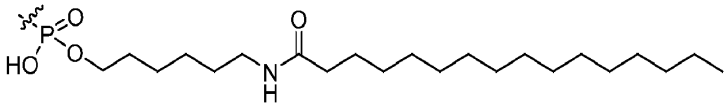
In certain embodiments, conjugate groups impart a new property on the attached oligonucleotide, *e.g.*, fluorophores or reporter groups that enable detection of the oligonucleotide. Certain conjugate groups and conjugate moieties have been described previously, for example: cholesterol moiety (Letsinger et al., Proc. Natl. Acad. Sci. USA, 1989, 86, 6553-6556), cholic acid (Manoharan et al., *Bioorg. Med. Chem. Lett.*, 1994, *4*, 1053-1060), a thioether, *e.g.*, hexyl-S-tritylthiol (Manoharan et al., *Ann. N.Y. Acad. Sci.*, 1992, *660*, 306-309; Manoharan et al., *Bioorg. Med. Chem. Lett.*, 1993, *3*, 2765-2770), a thiocholesterol (Oberhauser et al., *Nucl. Acids Res.*, 1992, *20*, 533-538), an aliphatic chain, *e.g.*, do-decan-diol or undecyl residues (Saison-Behmoaras et al., *EMBO J.*, 1991, *10*, 1111-1118; Kabanov et al., *FEBS Lett.*, 1990, *259*, 327-330; Svinarchuk et al., *Biochimie*, 1993, *75*, 49-54), a phospholipid, e.g., di-hexadecyl-rac-glycerol or triethyl-ammonium 1,2-di-O-hexadecyl-rac-glycero-3-H-phosphonate (Manoharan et al., *Tetrahedron Lett.*, 1995, *36*, 3651-3654; Shea et al., *Nucl. Acids Res.*, 1990, *18*, 3777-3783), a polyamine or a polyethylene glycol chain (Manoharan et al., *Nucleosides & Nucleotides*, 1995, *14*, 969-973), or adamantane acetic acid a palmityl moiety (Mishra et al., *Biochim. Biophys. Acta*, 1995, *1264*, 229-237), an octadecylamine or hexylamino-carbonyl-oxycholesterol moiety (Crooke et al., *J. Pharmacol. Exp. Ther.*, 1996, *277*, 923-937), a tocopherol group (Nishina et al., *Molecular Therapy Nucleic Acids*, 2015, *4*, e220; and Nishina et al., *Molecular Therapy*, 2008, *16*, 734-740), or a GalNAc cluster (*e.g.*, WO2014/179620).

In certain embodiments, the conjugate group may comprise a conjugate moiety selected from any of a C22 alkyl, C20 alkyl, C16 alkyl, C10 alkyl, C21 alkyl, C19 alkyl, C18 alkyl, C17 alkyl, C15 alkyl, C14 alkyl, C13 alkyl, C12 alkyl, C11 alkyl, C9 alkyl, C8 alkyl, C7 alkyl, C6 alkyl, C5 alkyl, C22 alkenyl, C20 alkenyl, C16 alkenyl, C10 alkenyl, C21 alkenyl, C19 alkenyl, C18 alkenyl, 17 alkenyl, C15 alkenyl, C14 alkenyl, C13 alkenyl, C12 alkenyl, C11 alkenyl, C9 alkenyl, C8 alkenyl, C7 alkenyl, C6 alkenyl, or C5 alkenyl.

In certain embodiments, the conjugate group may comprise a conjugate moiety selected from any of a C22 alkyl, C20 alkyl, C16 alkyl, C10 alkyl, C21 alkyl, C19 alkyl, C18 alkyl, C17 alkyl, C15 alkyl, C14 alkyl, C13 alkyl, C12

alkyl, C11 alkyl, C9 alkyl, C8 alkyl, C7 alkyl, C6 alkyl, or C5 alkyl, where the alkyl chain has one or more unsaturated bonds.

In certain embodiments, a conjugate group is a lipid having the following structure:



1. Conjugate Moieties

Conjugate moieties include, without limitation, intercalators, reporter molecules, polyamines, polyamides, peptides, carbohydrates (e.g., GalNAc), vitamin moieties, polyethylene glycols, thioethers, polyethers, cholesterols, thiocholesterols, cholic acid moieties, folate, lipids, phospholipids, biotin, phenazine, phenanthridine, anthraquinone, adamantane, acridine, fluoresceins, rhodamines, coumarins, fluorophores, and dyes.

In certain embodiments, a conjugate moiety comprises an active drug substance, for example, aspirin, warfarin, phenylbutazone, ibuprofen, suprofen, fen-bufen, ketoprofen, (*S*)-(+)-pranoprofen, carprofen, dansylsarcosine, 2,3,5-triiodobenzoic acid, fingolimod, flufenamic acid, folinic acid, a benzothiadiazide, chlorothiazide, a diazepine, indo-methicin, a barbiturate, a cephalosporin, a sulfa drug, an antidiabetic, an antibacterial or an antibiotic.

2. Conjugate Linkers

Conjugate moieties are attached to oligonucleotides through conjugate linkers. In certain oligomeric compounds, the conjugate linker is a single chemical bond (i.e., the conjugate moiety is attached directly to an oligonucleotide through a single bond). In certain embodiments, the conjugate linker comprises a chain structure, such as a hydrocarbyl chain, or an oligomer of repeating units such as ethylene glycol, nucleosides, or amino acid units.

In certain embodiments, a conjugate linker comprises pyrrolidine.

In certain embodiments, a conjugate linker comprises one or more groups selected from alkyl, amino, oxo, amide, disulfide, polyethylene glycol, ether, thioether, and hydroxylamino. In certain such embodiments, the conjugate linker comprises one or more groups selected from alkyl, amino, oxo, amide, and ether groups. In certain embodiments, the conjugate linker comprises one or more groups selected from alkyl and amide groups. In certain embodiments, the conjugate linker comprises one or more groups selected from alkyl and ether groups. In certain embodiments, the conjugate linker comprises at least one phosphorus moiety. In certain embodiments, the conjugate linker comprises at least one phosphate group. In certain embodiments, the conjugate linker includes at least one neutral linking group.

In certain embodiments, conjugate linkers, including the conjugate linkers described above, are bifunctional linking moieties, *e.g.*, those known in the art to be useful for attaching conjugate moieties to compounds, such as the oligonucleotides provided herein. In general, a bifunctional linking moiety comprises at least two functional groups. One of the functional groups is selected to react with a particular site on a compound and the other is selected to react with a conjugate moiety. Examples of functional groups used in a bifunctional linking moiety include but are not limited to electrophiles for reacting with nucleophilic groups and nucleophiles for reacting with electrophilic groups. In certain embodiments, bifunctional linking moieties comprise one or more groups selected from amino, hydroxyl, carboxylic acid, thiol, alkyl, alkenyl, and alkynyl.

Examples of conjugate linkers include but are not limited to pyrrolidine, 8-amino-3,6-dioxaoctanoic acid (ADO), succinimidyl 4-(N-maleimidomethyl) cyclohexane-1-carboxylate (SMCC) and 6-aminohexanoic acid (AHEX or AHA). Other conjugate linkers include but are not limited to a substituted or unsubstituted C_1-C_{10} alkyl, a substituted or unsubstituted C_2-C_{10} alkenyl or a substituted or unsubstituted C_2-C_{10} alkynyl, wherein a nonlimiting list of preferred substituent groups includes hydroxyl, amino, alkoxy, carboxy, benzyl, phenyl, nitro, thiol, thioalkoxy, halogen, alkyl, aryl, alkenyl, and alkynyl.

In certain embodiments, conjugate linkers comprise 1-10 linker-nucleosides. In certain embodiments, conjugate linkers comprise 2-5 linker-nucleosides. In certain embodiments, conjugate linkers comprise exactly 3 linker-nucleosides. In certain embodiments, conjugate linkers comprise the TCA motif. In certain embodiments, such linker-nucleosides are modified nucleosides. In certain embodiments such linker-nucleosides comprise a modified sugar moiety. In certain embodiments, linker-nucleosides are unmodified. In certain embodiments, linker-nucleosides comprise an optionally protected heterocyclic base selected from a purine, substituted purine, pyrimidine or substituted pyrimidine. In certain embodiments, a cleavable moiety is a nucleoside selected from uracil, thymine, cytosine, 4-N-benzoylcytosine, 5-methyl cytosine, 4-N-benzoyl-5-methyl cytosine, adenine, 6-N-benzoyladenine, guanine and 2-N-isobutyrylguanine. It is typically desirable for linker-nucleosides to be cleaved from the oligomeric compound after it reaches a target tissue. Accordingly, linker-nucleosides are typically linked to one another and to the remainder of the oligomeric compound through cleavable bonds. In certain embodiments, such cleavable bonds are phosphodiester bonds.

Herein, linker-nucleosides are not considered to be part of the oligonucleotide. Accordingly, in embodiments in which an oligomeric compound comprises an oligonucleotide consisting of a specified number or range of linked nucleosides and/or a specified percent complementarity to a reference nucleic acid and the oligomeric compound also comprises a conjugate group comprising a conjugate linker comprising linker-nucleosides, those linker-nucleosides are not counted toward the length of the oligonucleotide and are not used in determining the percent complementarity of the oligonucleotide for the reference nucleic acid. For example, an oligomeric compound may comprise (1) a modified oligonucleotide consisting of 8-30 nucleosides and (2) a conjugate group comprising 1-10 linker-nucleosides that are contiguous with the nucleosides of the modified oligonucleotide. The total number of contiguous linked nucleosides in such an oligomeric compound is more than 30. Alternatively, an oligomeric compound may comprise a modified oligonucleotide consisting of 8-30 nucleosides and no conjugate group. The total number of contiguous linked nucleosides in such an oligomeric compound is no more than 30. Unless otherwise indicated conjugate linkers comprise no more than 10 linker-nucleosides. In certain embodiments, conjugate linkers comprise no more than 5 linker-nucleosides. In certain embodiments, conjugate linkers comprise no more than 3 linker-nucleosides. In certain embodiments, conjugate linkers comprise no more than 2 linker-nucleosides. In certain embodiments, conjugate linkers comprise no more than 1 linker-nucleoside.

In certain embodiments, it is desirable for a conjugate group to be cleaved from the oligonucleotide. For example, in certain circumstances oligomeric compounds comprising a particular conjugate moiety are better taken up by a particular cell type, but once the oligomeric compound has been taken up, it is desirable that the conjugate group be cleaved to release the unconjugated or parent oligonucleotide. Thus, certain conjugate linkers may comprise one or more cleavable moieties. In certain embodiments, a cleavable moiety is a cleavable bond. In certain embodiments, a cleavable moiety is a group of atoms comprising at least one cleavable bond. In certain embodiments, a cleavable moiety comprises a group of atoms having one, two, three, four, or more than four cleavable bonds. In certain embodiments, a

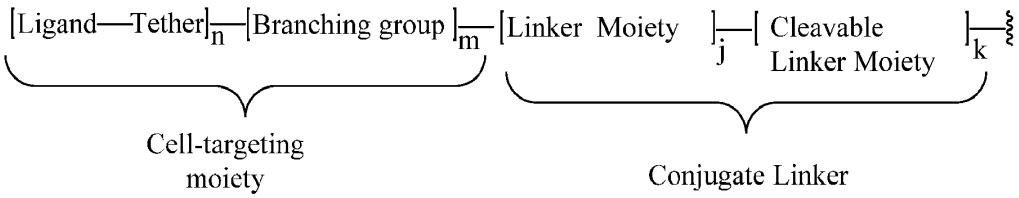
cleavable moiety is selectively cleaved inside a cell or subcellular compartment, such as a lysosome. In certain embodiments, a cleavable moiety is selectively cleaved by endogenous enzymes, such as nucleases.

In certain embodiments, a cleavable bond is selected from among an amide, an ester, an ether, one or both esters of a phosphodiester, a phosphate ester, a carbamate, or a disulfide. In certain embodiments, a cleavable bond is one or both of the esters of a phosphodiester. In certain embodiments, a cleavable moiety comprises a phosphate or phosphodiester. In certain embodiments, the cleavable moiety is a phosphate linkage between an oligonucleotide and a conjugate moiety or conjugate group.

In certain embodiments, a cleavable moiety comprises or consists of one or more linker-nucleosides. In certain such embodiments, the one or more linker-nucleosides are linked to one another and/or to the remainder of the oligomeric compound through cleavable bonds. In certain embodiments, such cleavable bonds are unmodified phosphodiester bonds. In certain embodiments, a cleavable moiety is 2'-deoxynucleoside that is attached to either the 3' or 5'-terminal nucleoside of an oligonucleotide by a phosphate internucleoside linkage and covalently attached to the remainder of the conjugate linker or conjugate moiety by a phosphate or phosphorothioate linkage. In certain such embodiments, the cleavable moiety is 2'-deoxyadenosine.

3. **Cell-Targeting Moieties**

In certain embodiments, a conjugate group comprises a cell-targeting moiety. In certain embodiments, a conjugate group has the general formula:



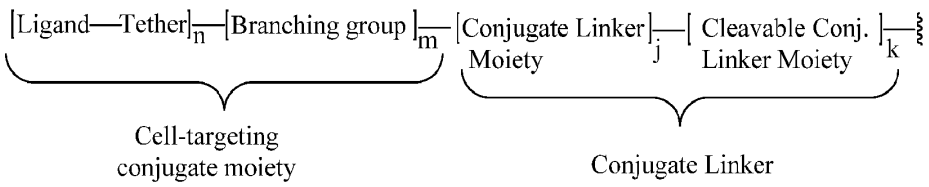
wherein n is from 1 to about 3, m is 0 when n is 1, m is 1 when n is 2 or greater, j is 1 or 0, and k is 1 or 0.

In certain embodiments, n is 1, j is 1 and k is 0. In certain embodiments, n is 1, j is 0 and k is 1. In certain embodiments, n is 1, j is 1 and k is 1. In certain embodiments, n is 2, j is 1 and k is 0. In certain embodiments, n is 2, j is 0 and k is 1. In certain embodiments, n is 2, j is 1 and k is 1. In certain embodiments, n is 3, j is 1 and k is 0. In certain embodiments, n is 3, j is 0 and k is 1. In certain embodiments, n is 3, j is 1 and k is 1.

In certain embodiments, conjugate groups comprise cell-targeting moieties that have at least one tethered ligand. In certain embodiments, cell-targeting moieties comprise two tethered ligands covalently attached to a branching group.

In certain embodiments, each ligand of a cell-targeting moiety has an affinity for at least one type of receptor on a target cell. In certain embodiments, each ligand has an affinity for at least one type of receptor on the surface of a mammalian liver cell. In certain embodiments, each ligand has an affinity for the hepatic asialoglycoprotein receptor (ASGP-R). In certain embodiments, each ligand is a carbohydrate.

In certain embodiments, a conjugate group comprises a cell-targeting conjugate moiety. In certain embodiments, a conjugate group has the general formula:



wherein n is from 1 to about 3, m is 0 when n is 1, m is 1 when n is 2 or greater, j is 1 or 0, and k is 1 or 0.

In certain embodiments, n is 1, j is 1 and k is 0. In certain embodiments, n is 1, j is 0 and k is 1. In certain embodiments, n is 1, j is 1 and k is 1. In certain embodiments, n is 2, j is 1 and k is 0. In certain embodiments, n is 2, j is 0 and k is 1. In certain embodiments, n is 2, j is 1 and k is 1. In certain embodiments, n is 3, j is 1 and k is 0. In certain embodiments, n is 3, j is 0 and k is 1. In certain embodiments, n is 3, j is 1 and k is 1.

In certain embodiments, conjugate groups comprise cell-targeting moieties that have at least one tethered ligand. In certain embodiments, cell-targeting moieties comprise two tethered ligands covalently attached to a branching group. In certain embodiments, cell-targeting moieties comprise three tethered ligands covalently attached to a branching group.

III. Certain Terminal Groups

In certain embodiments, oligomeric compounds comprise one or more terminal groups. In certain such embodiments, oligomeric compounds comprise a stabilized 5'-phosphate. Stabilized 5'-phosphates include, but are not limited to 5'-phosphonates, including, but not limited to 5'-vinylphosphonates. In certain embodiments, terminal groups comprise one or more abasic sugar moieties and/or inverted nucleosides. In certain embodiments, terminal groups comprise one or more 2'-linked nucleosides or sugar moieties. In certain such embodiments, the 2'-linked group is an abasic sugar moiety.

IV. Antisense Activity

In certain embodiments, oligomeric compounds and oligomeric duplexes are capable of hybridizing to a target nucleic acid, resulting in at least one antisense activity; such oligomeric compounds and oligomeric duplexes are antisense compounds. In certain embodiments, antisense compounds have antisense activity when they reduce or inhibit the amount or activity of a target nucleic acid by 25% or more in the standard cell assay. In certain embodiments, antisense compounds selectively affect one or more target nucleic acid. Such antisense compounds comprise a nucleobase sequence that hybridizes to one or more target nucleic acid, resulting in one or more desired antisense activity and does not hybridize to one or more non-target nucleic acid or does not hybridize to one or more non-target nucleic acid in such a way that results in significant undesired antisense activity.

In certain antisense activities, hybridization of an antisense compound to a target nucleic acid results in recruitment of a protein that cleaves the target nucleic acid. For example, certain antisense compounds result in RNase H mediated cleavage of the target nucleic acid. RNase H is a cellular endonuclease that cleaves the RNA strand of an RNA:DNA duplex. The DNA in such an RNA:DNA duplex need not be unmodified DNA. In certain embodiments, described herein are antisense compounds that are sufficiently "DNA-like" to elicit RNase H activity. In certain embodiments, one or more non-DNA-like nucleoside in the gap of a gapmer is tolerated.

In certain antisense activities, an antisense compound or a portion of an antisense compound is loaded into an RNA-induced silencing complex (RISC), ultimately resulting in cleavage of the target nucleic acid. For example,

certain antisense compounds result in cleavage of the target nucleic acid by Argonaute. Antisense compounds that are loaded into RISC are RNAi compounds. RNAi compounds may be double-stranded (siRNA or dsRNAi) or single-stranded (ssRNA).

In certain embodiments, hybridization of an antisense compound to a target nucleic acid does not result in recruitment of a protein that cleaves that target nucleic acid. In certain embodiments, hybridization of the antisense compound to the target nucleic acid results in alteration of splicing of the target nucleic acid. In certain embodiments, hybridization of an antisense compound to a target nucleic acid results in inhibition of a binding interaction between the target nucleic acid and a protein or other nucleic acid. In certain embodiments, hybridization of an antisense compound to a target nucleic acid results in alteration of translation of the target nucleic acid.

Antisense activities may be observed directly or indirectly. In certain embodiments, observation or detection of an antisense activity involves observation or detection of a change in an amount of a target nucleic acid or protein encoded by such target nucleic acid, a change in the ratio of splice variants of a nucleic acid or protein and/or a phenotypic change in a cell or animal.

V. Certain Target Nucleic Acids

In certain embodiments, oligomeric compounds comprise or consist of an oligonucleotide comprising a region that is complementary to a target nucleic acid. In certain embodiments, the target nucleic acid is an endogenous RNA molecule. In certain embodiments, the target nucleic acid encodes a protein. In certain such embodiments, the target nucleic acid is selected from: a mature mRNA and a pre-mRNA, including intronic, exonic and untranslated regions. In certain embodiments, the target RNA is a mature mRNA. In certain embodiments, the target nucleic acid is a pre-mRNA. In certain embodiments, the target region is entirely within an intron. In certain embodiments, the target region spans an intron/exon junction. In certain embodiments, the target region is at least 50% within an intron.

A. IFNAR1

In certain embodiments, oligomeric compounds comprise or consist of an oligonucleotide comprising a region that is complementary to a target nucleic acid, wherein the target nucleic acid is an IFNAR1 nucleic acid. In certain embodiments, an IFNAR1 nucleic acid has the sequence set forth in SEQ ID NO: 1 (GENBANK Accession No. NC_000021.9, truncated from 33321001 to 33363000) or SEQ ID NO: 2 (GENBANK Accession No. NM_000629.2). In certain embodiments, contacting a cell with an oligomeric compound complementary to SEQ ID NO: 1 or SEQ ID NO: 2 reduces the amount of IFNAR1 RNA, and in certain embodiments reduces the amount of IFNAR1 protein. In certain embodiments, the oligomeric compound consists of a modified oligonucleotide. In certain embodiments, the oligomeric compound consists of a modified oligonucleotide and a conjugate group.

B. Certain Target Nucleic Acids in Certain Tissues

In certain embodiments, oligomeric compounds comprise or consist of an oligonucleotide comprising a region that is complementary to a target nucleic acid, wherein the target nucleic acid is expressed in a pharmacologically relevant tissue. In certain embodiments, the pharmacologically relevant tissues are the brain and spinal cord. In certain embodiments, the target nucleic acid is expressed in a pharmacologically relevant cell. In certain embodiments the

pharmacologically relevant cell is a neuron or a glial cell. In certain embodiments, the pharmacologically relevant cell is an astrocyte or a microglial cell. In certain embodiments, the pharmacologically relevant cell is a vascular smooth muscle cell a vascular endothelial cell, or a pericyte.

VI. Certain Methods and Uses

Certain embodiments provided herein relate to methods of inhibiting IFNAR1 expression, which can be useful for treating a disease associated with neuroinflammation, for example, a disease associated with elevated type I interferon signaling, or with over-expression of a type I interferons in a subject, by administration of an oligomeric compound, modified oligonucleotide, or oligomeric duplex, any of which comprising a modified oligonucleotide having a nucleobase sequence complementary to an IFNAR1 nucleic acid.

Examples of diseases treatable with the oligomeric compounds, modified oligonucleotides, oligomeric duplexes, and methods provided herein include neurological diseases or conditions associated with neuroinflammation, for example, a disease associated with elevated type I interferon signaling, or with over-expression of type I interferons, selected from Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia. In certain embodiments, a method comprises administering to a subject an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex, any of which having a nucleobase sequence complementary to an IFNAR1 nucleic acid. In certain embodiments, the subject has a neurological disease or condition associated with neuroinflammation selected from Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia. In certain embodiments, a method of treating neurological diseases or conditions associated with neuroinflammation selected from Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia in a subject comprises administering to the subject a therapeutically effective amount of an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex, any of which having a nucleobase sequence complementary to an IFNAR1 nucleic acid, thereby treating the subject. In certain embodiments, administering the therapeutically effective amount of the oligomeric compound, or modified oligonucleotide improves a symptom or hallmark of a disease or condition associated with neuroinflammation. In certain embodiments, the symptom or hallmark is selected from seizures, difficulty feeding, dystonia, spasticity, delayed motor development, delayed language development, delayed social skill development, white matter abnormalities, T cell infiltration, B cell infiltration, striatal necrosis, brain atrophy, basal ganglia calcification, and microencephaly. In certain embodiments, administering the therapeutically effective amount of the oligomeric compound or the modified oligonucleotide reduces type I IFN signaling or lymphocytosis in cerebrospinal fluid in the subject.

In certain embodiments, a method of inhibiting expression of IFNAR1 nucleic acid, such as RNA, in a subject having a disease associated with neuroinflammation, for example, a disease associated with elevated type I interferon

signaling, or with over-expression of type I interferons, comprises administering to the subject an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex, any of which having a nucleobase sequence complementary to an IFNAR1 nucleic acid, thereby inhibiting expression of IFNAR1 nucleic acid in the subject. In certain embodiments, administering the oligomeric compound, modified oligonucleotide, or oligomeric duplex inhibits expression of IFNAR1 in the brain or spinal cord. In certain embodiments, the subject has a neurological disease or condition associated with neuroinflammation selected from Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia. In certain embodiments, a method of inhibiting expression of IFNAR1 nucleic acid in a cell comprises contacting the cell with an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex, any of which having a nucleobase sequence complementary to an IFNAR1 nucleic acid, thereby inhibiting expression of IFNAR1 nucleic acid in the cell. In certain embodiments, the cell is glial cell, for example, an astrocyte or a microglial cell. In certain embodiments, the cell is in a subject having a neurological disease or condition associated with neuroinflammation selected from Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia.

Certain embodiments are drawn to an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex, any of which having a nucleobase sequence complementary to an IFNAR1 nucleic acid, for use in treating a disease associated with neuroinflammation associated with neuroinflammation, for example, a disease associated with elevated type I interferon signaling, or with over-expression of IFNa. In certain embodiments, the disease is a neurological disease or condition associated with neuroinflammation selected from Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia. In certain embodiments, an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex is for use in improving a symptom or hallmark of a disease or condition associated with neuroinflammation selected from Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia . In certain embodiments, the symptom or hallmark is selected from seizures, difficulty feeding, dystonia, spasticity, delayed motor development, delayed language development, delayed social skill development, white matter abnormalities, T cell infiltration, B cell infiltration, striatal necrosis, brain atrophy, basal ganglia calcification, and microencephaly. In certain embodiments, an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex is for use in reducing type I IFN signaling or lymphocytosis in the cerebrospinal fluid in a subject.

Certain embodiments are drawn to an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex, any of which comprising a modified oligonucleotide having a nucleobase sequence complementary to an IFNAR1 nucleic acid, for the manufacture or preparation of a medicament for treating a disease associated with neuroinflammation, for example, a disease associated with elevated type I interferon signaling, or with over-expression

of IFNa. In certain embodiments, the disease is a neurological disease or condition associated with neuroinflammation selected from Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia. In certain embodiments, an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex is for the manufacture or preparation of a medicament for improving symptoms or hallmarks associated with Aicardi-Goutières Syndrome, stroke, neuropsychiatric systemic lupus erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, and ataxia telangiectasia. In certain embodiments, the symptom or hallmark is selected from seizures, difficulty feeding, dystonia, spasticity, delayed motor development, delayed language development, delayed social skill development, white matter abnormalities, T cell infiltration, B cell infiltration, striatal necrosis, brain atrophy, basal ganglia calcification, and microencephaly. In certain embodiments, an oligomeric compound, a modified oligonucleotide, or an oligomeric duplex is for the manufacture or preparation of a medicament for use in reducing type I IFN signaling or lymphocytosis in the cerebrospinal fluid in a subject.

In any of the methods or uses described herein, the oligomeric compound, modified oligonucleotide, or oligomeric duplex can be any described herein.

VII. Certain Pharmaceutical Compositions

In certain embodiments, described herein are pharmaceutical compositions comprising one or more oligomeric compounds. In certain embodiments, the one or more oligomeric compounds each consists of a modified oligonucleotide. In certain embodiments, the pharmaceutical composition comprises a pharmaceutically acceptable diluent or carrier. In certain embodiments, a pharmaceutical composition comprises or consists of a sterile saline solution and one or more oligomeric compound. In certain embodiments, the sterile saline is pharmaceutical grade saline. In certain embodiments, a pharmaceutical composition comprises or consists of one or more oligomeric compound and sterile water. In certain embodiments, the sterile water is pharmaceutical grade water. In certain embodiments, a pharmaceutical composition comprises or consists of one or more oligomeric compound and phosphate-buffered saline (PBS). In certain embodiments, the sterile PBS is pharmaceutical grade PBS. In certain embodiments, a pharmaceutical composition comprises or consists of one or more oligomeric compound and artificial cerebrospinal fluid. In certain embodiments, the artificial cerebrospinal fluid is pharmaceutical grade artificial cerebrospinal fluid.

In certain embodiments, a pharmaceutical composition comprises a modified oligonucleotide and PBS. In certain embodiments, a pharmaceutical composition consists of a modified oligonucleotide and PBS. In certain embodiments, a pharmaceutical composition consists essentially of a modified oligonucleotide and PBS. In certain embodiments, the PBS is pharmaceutical grade.

In certain embodiments, a pharmaceutical composition comprises a modified oligonucleotide and artificial cerebrospinal fluid. In certain embodiments, a pharmaceutical composition consists of a modified oligonucleotide and artificial cerebrospinal fluid. In certain embodiments, a pharmaceutical composition consists essentially of a modified oligonucleotide and artificial cerebrospinal fluid. In certain embodiments, the artificial cerebrospinal fluid is pharmaceutical grade.

In certain embodiments, pharmaceutical compositions comprise one or more oligomeric compound and one or more excipients. In certain embodiments, excipients are selected from water, salt solutions, alcohol, polyethylene glycols, gelatin, lactose, amylase, magnesium stearate, talc, silicic acid, viscous paraffin, hydroxymethylcellulose, and polyvinylpyrrolidone.

In certain embodiments, oligomeric compounds may be admixed with pharmaceutically acceptable active and/or inert substances for the preparation of pharmaceutical compositions or formulations. Compositions and methods for the formulation of pharmaceutical compositions depend on a number of criteria, including, but not limited to, route of administration, extent of disease, or dose to be administered.

In certain embodiments, pharmaceutical compositions comprising an oligomeric compound encompass any pharmaceutically acceptable salts of the oligomeric compound, esters of the oligomeric compound, or salts of such esters. In certain embodiments, pharmaceutical compositions comprising oligomeric compounds comprising one or more oligonucleotide, upon administration to an animal, including a human, are capable of providing (directly or indirectly) the biologically active metabolite or residue thereof. Accordingly, for example, the disclosure is also drawn to pharmaceutically acceptable salts of oligomeric compounds, prodrugs, pharmaceutically acceptable salts of such prodrugs, and other bioequivalents. Suitable pharmaceutically acceptable salts include, but are not limited to, sodium and potassium salts. In certain embodiments, prodrugs comprise one or more conjugate group attached to an oligonucleotide, wherein the conjugate group is cleaved by endogenous nucleases within the body.

Lipid moieties have been used in nucleic acid therapies in a variety of methods. In certain such methods, the nucleic acid, such as an oligomeric compound, is introduced into preformed liposomes or lipoplexes made of mixtures of cationic lipids and neutral lipids. In certain methods, DNA complexes with mono- or poly-cationic lipids are formed without the presence of a neutral lipid. In certain embodiments, a lipid moiety is selected to increase distribution of a pharmaceutical agent to a particular cell or tissue. In certain embodiments, a lipid moiety is selected to increase distribution of a pharmaceutical agent to fat tissue. In certain embodiments, a lipid moiety is selected to increase distribution of a pharmaceutical agent to muscle tissue.

In certain embodiments, pharmaceutical compositions comprise a delivery system. Examples of delivery systems include, but are not limited to, liposomes and emulsions. Certain delivery systems are useful for preparing certain pharmaceutical compositions including those comprising hydrophobic compounds. In certain embodiments, certain organic solvents such as dimethylsulfoxide are used.

In certain embodiments, pharmaceutical compositions comprise one or more tissue-specific delivery molecules designed to deliver the one or more pharmaceutical agents of the present invention to specific tissues or cell types. For example, in certain embodiments, pharmaceutical compositions include liposomes coated with a tissue-specific antibody.

In certain embodiments, pharmaceutical compositions comprise a co-solvent system. Certain of such co-solvent systems comprise, for example, benzyl alcohol, a nonpolar surfactant, a water-miscible organic polymer, and an aqueous phase. In certain embodiments, such co-solvent systems are used for hydrophobic compounds. A non-limiting example of such a co-solvent system is the VPD co-solvent system, which is a solution of absolute ethanol comprising 3% w/v benzyl alcohol, 8% w/v of the nonpolar surfactant Polysorbate 80™ and 65% w/v polyethylene glycol 300. The proportions of such co-solvent systems may be varied considerably without significantly altering their solubility and toxicity characteristics. Furthermore, the identity of co-solvent components may be varied: for example, other

surfactants may be used instead of Polysorbate 80™; the fraction size of polyethylene glycol may be varied; other biocompatible polymers may replace polyethylene glycol, e.g., polyvinyl pyrrolidone; and other sugars or polysaccharides may substitute for dextrose.

In certain embodiments, pharmaceutical compositions are prepared for oral administration. In certain embodiments, pharmaceutical compositions are prepared for buccal administration. In certain embodiments, a pharmaceutical composition is prepared for administration by injection (e.g., intravenous, subcutaneous, intramuscular, intrathecal (IT), intracerebroventricular (ICV), etc.). In certain of such embodiments, a pharmaceutical composition comprises a carrier and is formulated in aqueous solution, such as water or physiologically compatible buffers such as Hanks's solution, Ringer's solution, or physiological saline buffer. In certain embodiments, other ingredients are included (e.g., ingredients that aid in solubility or serve as preservatives). In certain embodiments, injectable suspensions are prepared using appropriate liquid carriers, suspending agents and the like. Certain pharmaceutical compositions for injection are presented in unit dosage form, e.g., in ampoules or in multi-dose containers. Certain pharmaceutical compositions for injection are suspensions, solutions or emulsions in oily or aqueous vehicles, and may contain formulatory agents such as suspending, stabilizing and/or dispersing agents. Certain solvents suitable for use in pharmaceutical compositions for injection include, but are not limited to, lipophilic solvents and fatty oils, such as sesame oil, synthetic fatty acid esters, such as ethyl oleate or triglycerides, and liposomes.

Under certain conditions, certain compounds disclosed herein act as acids. Although such compounds may be drawn or described in protonated (free acid) form, or ionized and in association with a cation (salt) form, aqueous solutions of such compounds exist in equilibrium among such forms. For example, a phosphate linkage of an oligonucleotide in aqueous solution exists in equilibrium among free acid, anion and salt forms. Unless otherwise indicated, compounds described herein are intended to include all such forms. Moreover, certain oligonucleotides have several such linkages, each of which is in equilibrium. Thus, oligonucleotides in solution exist in an ensemble of forms at multiple positions all at equilibrium. The term "oligonucleotide" is intended to include all such forms. Drawn structures necessarily depict a single form. Nevertheless, unless otherwise indicated, such drawings are likewise intended to include corresponding forms. Herein, a structure depicting the free acid of a compound followed by the term "or a salt thereof" expressly includes all such forms that may be fully or partially protonated/de-protonated/in association with a cation. In certain instances, one or more specific cation is identified.

In certain embodiments, modified oligonucleotides or oligomeric compounds are in aqueous solution with sodium. In certain embodiments, modified oligonucleotides or oligomeric compounds are in aqueous solution with potassium. In certain embodiments, modified oligonucleotides or oligomeric compounds are in PBS. In certain embodiments, modified oligonucleotides or oligomeric compounds are in water. In certain such embodiments, the pH of the solution is adjusted with NaOH and/or HCl to achieve a desired pH.

Herein, certain specific doses are described. A dose may be in the form of a dosage unit. For clarity, a dose (or dosage unit) of a modified oligonucleotide or an oligomeric compound in milligrams indicates the mass of the free acid form of the modified oligonucleotide or oligomeric compound. As described above, in aqueous solution, the free acid is in equilibrium with anionic and salt forms. However, for the purpose of calculating dose, it is assumed that the modified oligonucleotide or oligomeric compound exists as a solvent-free, sodium-acetate free, anhydrous, free acid. For example, where a modified oligonucleotide or an oligomeric compound is in solution comprising sodium (e.g., saline), the modified oligonucleotide or oligomeric compound may be partially or fully de-protonated and in association with

Na+ ions. However, the mass of the protons are nevertheless counted toward the weight of the dose, and the mass of the Na+ ions are not counted toward the weight of the dose. Thus, for example, a dose, or dosage unit, of 10 mg of Compound No. 1492069, equals the number of fully protonated molecules that weighs 10 mg. This would be equivalent to 10.59 mg of solvent-free, sodium acetate-free, anhydrous sodiated Compound No. 1492069. When an oligomeric compound comprises a conjugate group, the mass of the conjugate group is included in calculating the dose of such oligomeric compound. If the conjugate group also has an acid, the conjugate group is likewise assumed to be fully protonated for the purpose of calculating dose.

Nonlimiting disclosure and incorporation by reference

Each of the literature and patent publications listed herein is incorporated by reference in its entirety.

While certain compounds, compositions and methods described herein have been described with specificity in accordance with certain embodiments, the following examples serve only to illustrate the compounds described herein and are not intended to limit the same. Each of the references, GenBank accession numbers, ENSEMBL identifiers, and the like recited in the present application is incorporated herein by reference in its entirety.

Although the sequence listing accompanying this filing identifies each sequence as either "RNA" or "DNA" as required, in reality, those sequences may be modified with any combination of chemical modifications. One of skill in the art will readily appreciate that such designation as "RNA" or "DNA" to describe modified oligonucleotides is, in certain instances, arbitrary. For example, an oligonucleotide comprising a nucleoside comprising a 2'-OH sugar moiety and a thymine base could be described as a DNA having a modified sugar (2'-OH in place of one 2'-H of DNA) or as an RNA having a modified base (thymine (methylated uracil) in place of an uracil of RNA). Accordingly, nucleic acid sequences provided herein, including, but not limited to those in the sequence listing, are intended to encompass nucleic acids containing any combination of natural or modified RNA and/or DNA, including, but not limited to such nucleic acids having modified nucleobases. By way of further example and without limitation, an oligomeric compound having the nucleobase sequence "ATCGATCG" encompasses any oligomeric compounds having such nucleobase sequence, whether modified or unmodified, including, but not limited to, such compounds comprising RNA bases, such as those having sequence "AUCGAUCG" and those having some DNA bases and some RNA bases such as "AUCGATCG" and oligomeric compounds having other modified nucleobases, such as "AT^{m}CGAUCG," wherein ^{m}C indicates a cytosine base comprising a methyl group at the 5-position.

Certain compounds described herein (e.g., modified oligonucleotides) have one or more asymmetric center and thus give rise to enantiomers, diastereomers, and other stereoisomeric configurations that may be defined, in terms of absolute stereochemistry, as (*R*) or (*S*), as α or β such as for sugar anomers, or as (D) or (L), such as for amino acids, etc. Compounds provided herein that are drawn or described as having certain stereoisomeric configurations include only the indicated compounds. Compounds provided herein that are drawn or described with undefined stereochemistry include all such possible isomers, including their stereorandom and optically pure forms, unless specified otherwise. Likewise, tautomeric forms of the compounds herein are also included unless otherwise indicated. Unless otherwise indicated, compounds described herein are intended to include corresponding salt forms.

The compounds described herein include variations in which one or more atoms are replaced with a non-radioactive isotope or radioactive isotope of the indicated element. For example, compounds herein that comprise

hydrogen atoms encompass all possible deuterium substitutions for each of the ^{1}H hydrogen atoms. Isotopic substitutions encompassed by the compounds herein include but are not limited to: ^{2}H or ^{3}H in place of ^{1}H, ^{13}C or ^{14}C in place of ^{12}C, ^{15}N in place of ^{14}N, ^{17}O or ^{18}O in place of ^{16}O, and ^{33}S, ^{34}S, ^{35}S, or ^{36}S in place of ^{32}S. In certain embodiments, non-radioactive isotopic substitutions may impart new properties on the oligomeric compound that are beneficial for use as a therapeutic or research tool. In certain embodiments, radioactive isotopic substitutions may make the compound suitable for research or diagnostic purposes such as imaging.

EXAMPLES

The following examples illustrate certain embodiments of the present disclosure and are not limiting. Moreover, where specific embodiments are provided, the inventors have contemplated generic application of those specific embodiments. For example, disclosure of an oligonucleotide having a particular motif provides reasonable support for additional oligonucleotides having the same or similar motif. And, for example, where a particular high-affinity modification appears at a particular position, other high-affinity modifications at the same position are considered suitable, unless otherwise indicated.

Example 1: Design of modified oligonucleotides complementary to human IFNAR1 nucleic acid

Modified oligonucleotides complementary to a human IFNAR1 nucleic acid were designed, as described in the tables below. "Start site" indicates the 5'-most nucleoside to which the modified oligonucleotide is complementary in the target nucleic acid sequence. "Stop site" indicates the 3'-most nucleoside to which the modified oligonucleotide is complementary in the target nucleic acid sequence. Each modified oligonucleotide listed in the tables below is 100% complementary to SEQ ID NO 1 (GENBANK Accession No. NC_000021.9, truncated from 33321001 to 33363000), to SEQ ID NO 2 (GENBANK Accession No. NM_000629.2), or to both. 'N/A' indicates that the modified oligonucleotide is not 100% complementary to that particular target nucleic acid sequence.

The modified oligonucleotides in the table below are 5-10-5 MOE gapmers. The gapmers are 20 nucleosides in length, wherein the sugar motif for the gapmers is (from 5' to 3'): eeeeeddddddddddeeeee; wherein each "d" represents a 2'-β-D-deoxyribosyl sugar moiety, and each "e" represents a 2'-MOE sugar moiety. The gapmers have an internucleoside linkage motif of (from 5' to 3'): sooosssssssssssooss; wherein each "s" represents a phosphorothioate internucleoside linkage, and each "o" represents a phosphodiester internucleoside linkage. Each cytosine residue is a 5-methyl cytosine.

Table 1

5-10-5 MOE gapmers with mixed PO/PS internucleoside linkages complementary to human IFNAR1

Compound Number	Sequence (5' to 3')	SEQ ID NO 1 Start Site	SEQ ID NO 1 Stop Site	SEQ ID NO 2 Start Site	SEQ ID NO 2 Stop Site	SEQ ID NO
1489525	TTTATCCAATTATCCATCCC	20003	20022	352	371	9
1492069	TCGCCTAATTTTTCTCTCAC	22455	22474	N/A	N/A	10
1492037	TTTGCATATGTATAATCCCA	24314	24333	889	908	15

The modified oligonucleotides in the table below are 6-10-4 MOE gapmers. The gapmers are 20 nucleosides in length, wherein the sugar motif for the gapmers is (from 5' to 3'): eeeeeeddddddddddeeee; wherein each "d" represents a 2'-β-D-deoxyribosyl sugar moiety, and each "e" represents a 2'-MOE sugar moiety. The gapmers have an internucleoside linkage motif of (from 5' to 3'): sooooossssssssssoss; wherein each "s" represents a phosphorothioate internucleoside linkage, and each "o" represents a phosphodiester internucleoside linkage. Each cytosine residue is a 5-methyl cytosine.

Table 2

6-10-4 MOE gapmers with mixed PO/PS internucleoside linkages complementary to human IFNAR1

Compound Number	Sequence (5' to 3')	SEQ ID NO 1 Start Site	SEQ ID NO 1 Stop Site	SEQ ID NO 2 Start Site	SEQ ID NO 2 Stop Site	SEQ ID NO
1489477	CTTTTTCTGCTCTTATACGC	20104	20123	453	472	11
1489494	CTGTTTTACATTTTTTTTCC	20591	20610	N/A	N/A	12
1492082	TTTCATATTTGTTACTTCCT	29981	30000	N/A	N/A	13
1492131	TTCGCCTAATTTTTCTCTCA	22456	22475	N/A	N/A	14

Example 2: Activity of modified oligonucleotides complementary to human IFNAR1 in transgenic mice

Modified oligonucleotides described above were tested in a human IFNAR1 transgenic mouse model. Transgenic mice that express a human IFNAR1 transcript were generated.

Exons 1-6 and ~4.9kB of upstream sequence of the human IFNAR1 gene from fosmid ABCS-41091_400N2 was subcloned into a BAC, CTD-2289N21, containing exons 7-11 of the human IFNAR1 genes and 56 kB of downstream sequence, to generate a complete IFNAR1 transgene. The engineered BAC was digested with Not1 to remove the BAC backbone. The purified BAC fragment, containing the complete human IFNAR1 gene, was introduced into fertilized eggs from C57BL/6 mice by pronuclear injection to produce three founder lines. Line 17505 was used in the experiments described herein.

Treatment

Transgenic mice were divided into groups of 2 mice each. Each mouse received a single ICV bolus of 300 μg of modified oligonucleotide. A group of 2-4 mice received PBS as a negative control.

RNA analysis

Two weeks post treatment, mice were sacrificed, and RNA was extracted from cortical brain tissue and spinal cord for RTPCR analysis to measure amount of IFNAR1 RNA using human primer probe set RTS44352 (forward sequence CTTTCAAGTTCAGTGGCTCCA, designated herein as SEQ ID NO 6; reverse sequence CGTTTTGAGGAAAGACACACTG, designated herein as SEQ ID NO 7; probe sequence AGTTTTGACATTTTCACAGTCAGGTATTTGTTTCC, designated herein as SEQ ID NO 8). Results are presented as percent human IFNAR1 relative to PBS control, normalized to 18S ribosomal RNA. 18S ribosomal RNA was amplified

using mouse 18S prime probe set PPS54360 (forward sequence GGAACTGAGGCCATGATTAAGA, designated herein as SEQ ID NO: 3; reverse sequence ACCTCCGACTTTCGTTCTTG, designated herein as SEQ ID NO: 4; probe sequence AAGACGGACCAGAGCGAAAGCAT, designated herein as SEQ ID NO: 5).

Table 3

Reduction of human IFNAR1 RNA in transgenic mice (n=2) treated with 300 µg of modified oligonucleotide

Compound ID	IFNAR1 RNA (% control)	
	Spinal Cord	Cortex
PBS	100	100
1489494	18	8
1489525	32	25
1492069	23	24
1492131	20	28

‡ Indicates fewer than 2 samples available

Table 4

Reduction of human IFNAR1 RNA in transgenic mice (n=2) treated with 300 µg of modified oligonucleotide

Compound ID	IFNAR1 RNA (% control)	
	Spinal Cord	Cortex
PBS	100	100
1489477	32	27
1492082	19	10
1492069	20	18

Example 3: Potency of modified oligonucleotides complementary to human IFNAR1 RNA in transgenic mice

Modified oligonucleotides described above were tested in human IFNAR1 transgenic mice (described herein above).

Treatment

Human IFNAR1 transgenic mice were divided into groups of 4 mice each. Each mouse received a single ICV bolus of modified oligonucleotide at the doses indicated in tables below. A group of 4 mice received PBS as a negative control.

RNA analysis

Two weeks post treatment, mice were sacrificed, and RNA was extracted from the spinal cord, cortex, and cerebellum for quantitative real-time RTPCR analysis of RNA expression of IFNAR1 using primer probe set RTS44352 (described herein above). Results are presented as percent human IFNAR1 RNA relative to PBS control, adjusted to 18S PCR (described herein above).

The half maximal effective dose (ED_{50}) of each modified oligonucleotide was calculated using GraphPad Prism 7 software (GraphPad Software, San Diego, CA). ED_{50} values were calculated from dose and individual animal IFNAR1 RNA levels using custom equation: Agonist vs response – Variable slope (four parameters) Y=Bottom + (Top-Bottom)/(1+ (10^logED50 /X)^HillSlope), with the following constraints: bottom > 0, top = 100.

As shown in the table below, treatment with modified oligonucleotides resulted in dose-responsive reduction of IFNAR1 RNA in comparison to the PBS control.

Table 5

Reduction of human IFNAR1 RNA in transgenic mice

Compound ID	Dose (µg)	Spinal Cord		Cortex		Cerebellum	
		IFNAR1 RNA (% control)	ED_{50} (µg)	IFNAR1 RNA (% control)	ED_{50} (µg)	IFNAR1 RNA (% control)	ED_{50} (µg)
PBS	N/A	100	N/A	100	N/A	100	N/A
1489494	10	100	79	85	92	81	105
	30	73		83		75	
	100	49		50		51	
	300	22		15		31	
	700	13		6		19	
1489525	10	77	319	79	31	78	215
	30	60		32		51	
	100	75		63		71	
	300	50		24		46	
	700	43		21		37	
1492037	10	118	114	85	88	81	133
	30	73		39		64	
	100	60		37		61	
	300	37		24		43	
	700	26		16		29	
1492069	10	96	104	84	47	74	129
	30	80		69		75	
	100	60		34		48	
	300	28		20		43	
	700	23‡		12		29	
1492082	10	98	177	75	50	76	142
	30	53		46		55	
	100	71		46		66	
	300	41		15		39	
	700	29		14		33	
1492131	10	114	83	77	32	77	105
	30	92		63		68	
	100	57		24		48	
	300	39		21		40	
	700	27		13		23	

‡ Indicates fewer than 4 samples available

Table 6

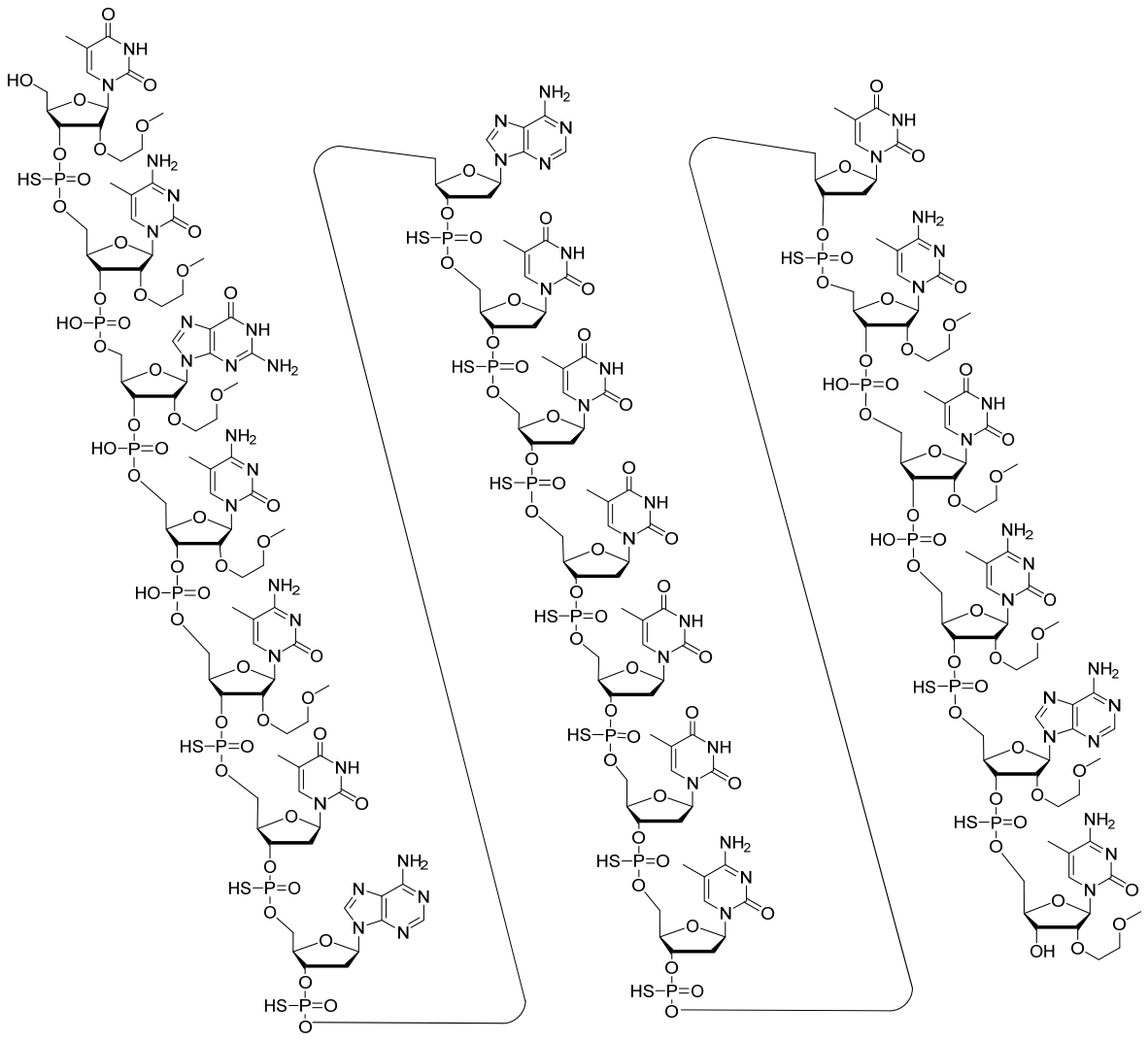
Reduction of human IFNAR1 RNA in transgenic mice

Compound ID	Dose (µg)	Spinal Cord		Cortex		Cerebellum	
		IFNAR1 RNA (% control)	ED_{50} (µg)	IFNAR1 RNA (% control)	ED_{50} (µg)	IFNAR1 RNA (% control)	ED_{50} (µg)
PBS	N/A	100	N/A	100	N/A	100	N/A
1489477	10	86	91.9	100‡	245	98	480
	30	77		96		88	
	100	54		72		74	
	300	29		51		62	
	700	24		28		41	

‡ Indicates fewer than 4 samples available

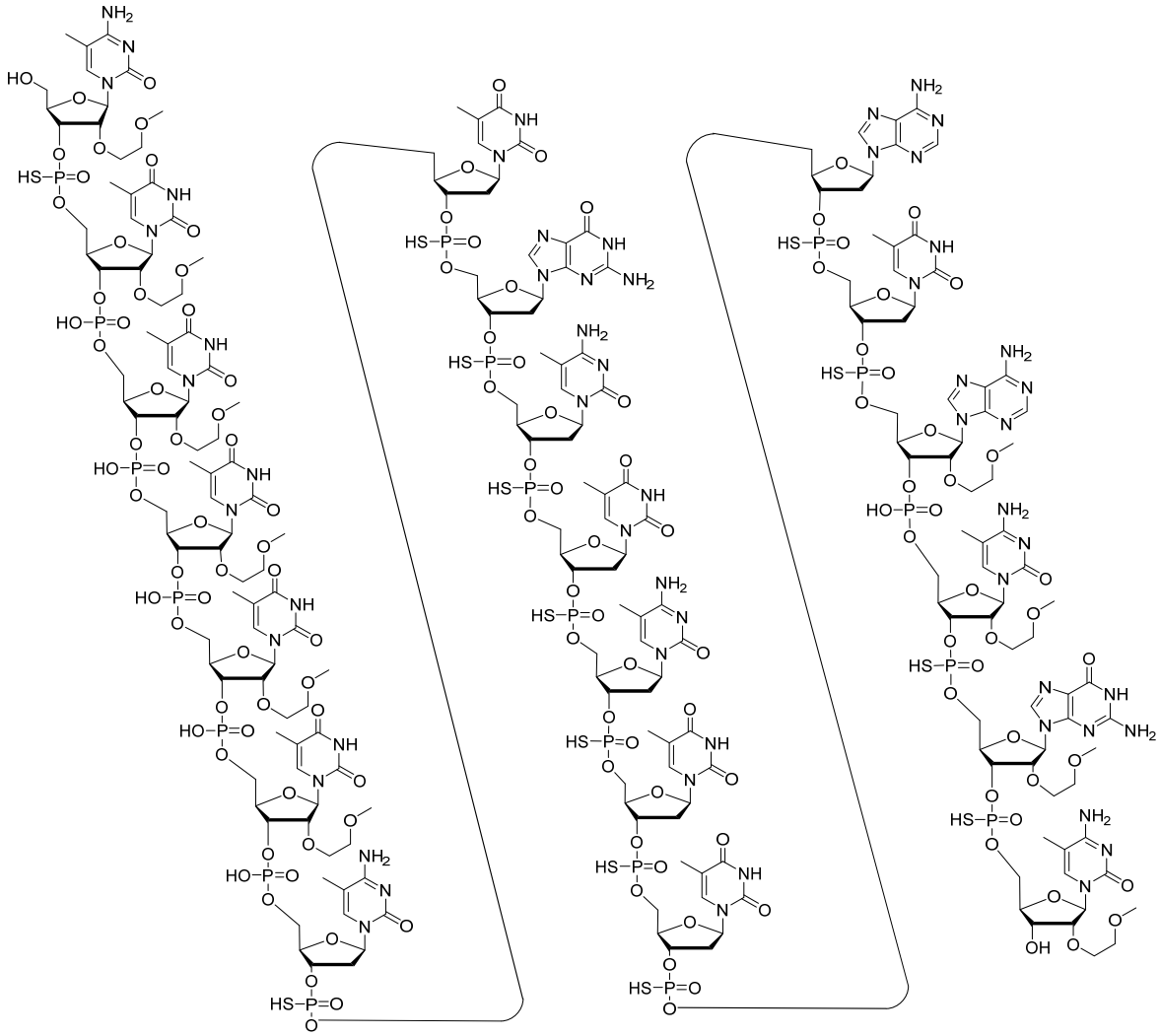
CLAIMS:

1. A modified oligonucleotide according to the following chemical structure:



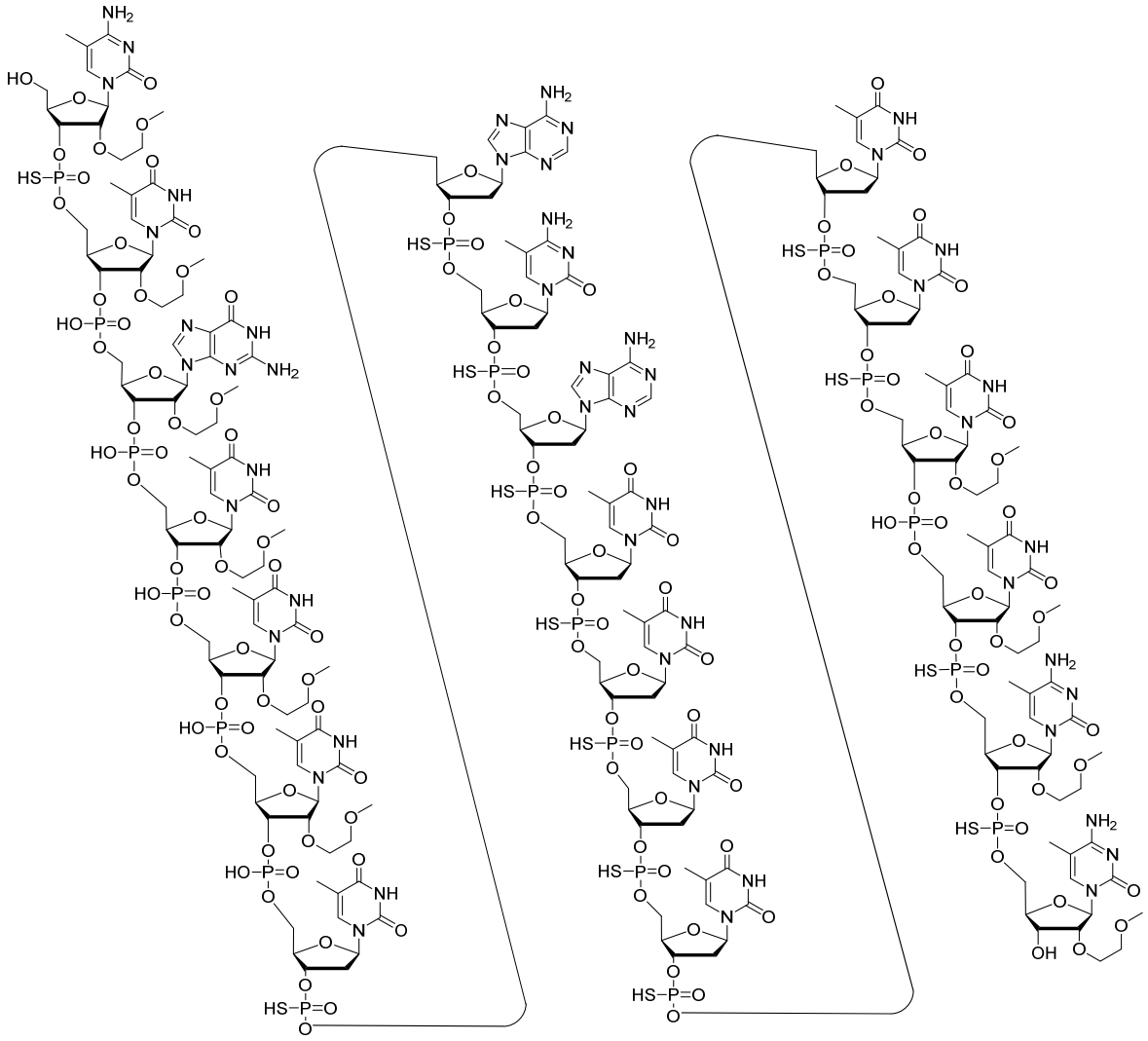
(SEQ ID NO 10), or a salt thereof; or

a modified oligonucleotide according to the following chemical structure:



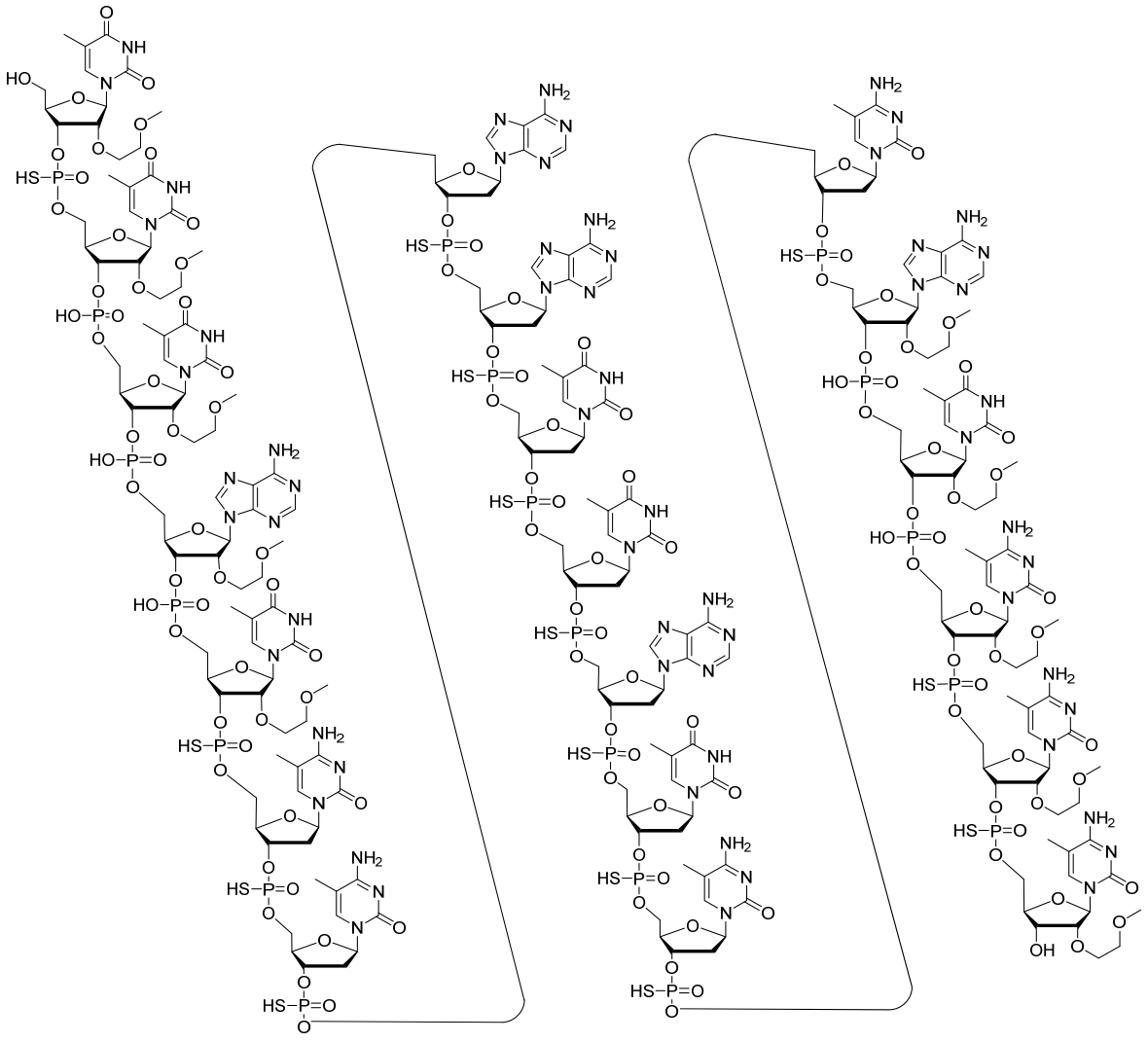
(SEQ ID NO 11), or a salt thereof; or

a modified oligonucleotide according to the following chemical structure:



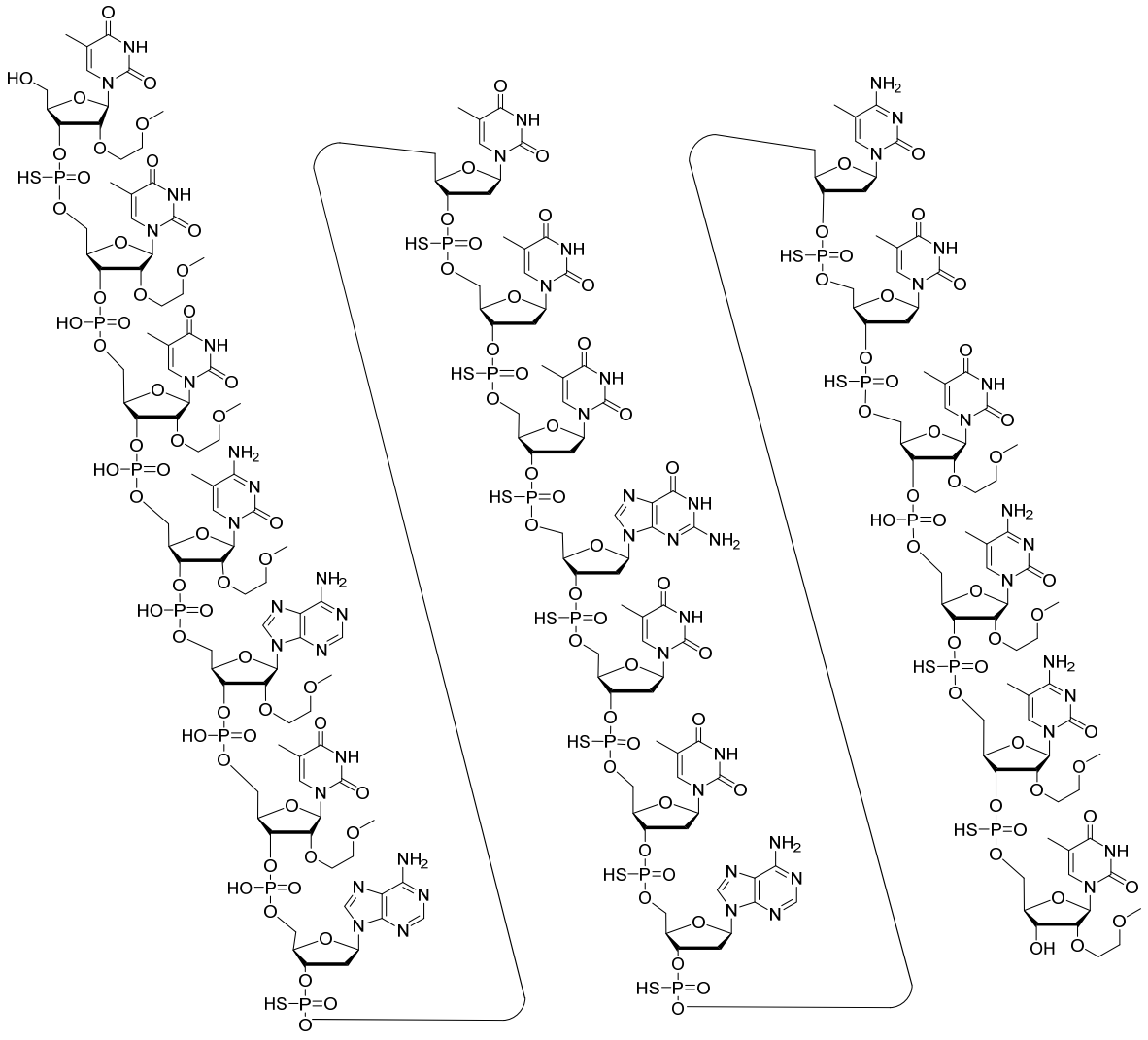
(SEQ ID NO 12), or a salt thereof; or

a modified oligonucleotide according to the following chemical structure:



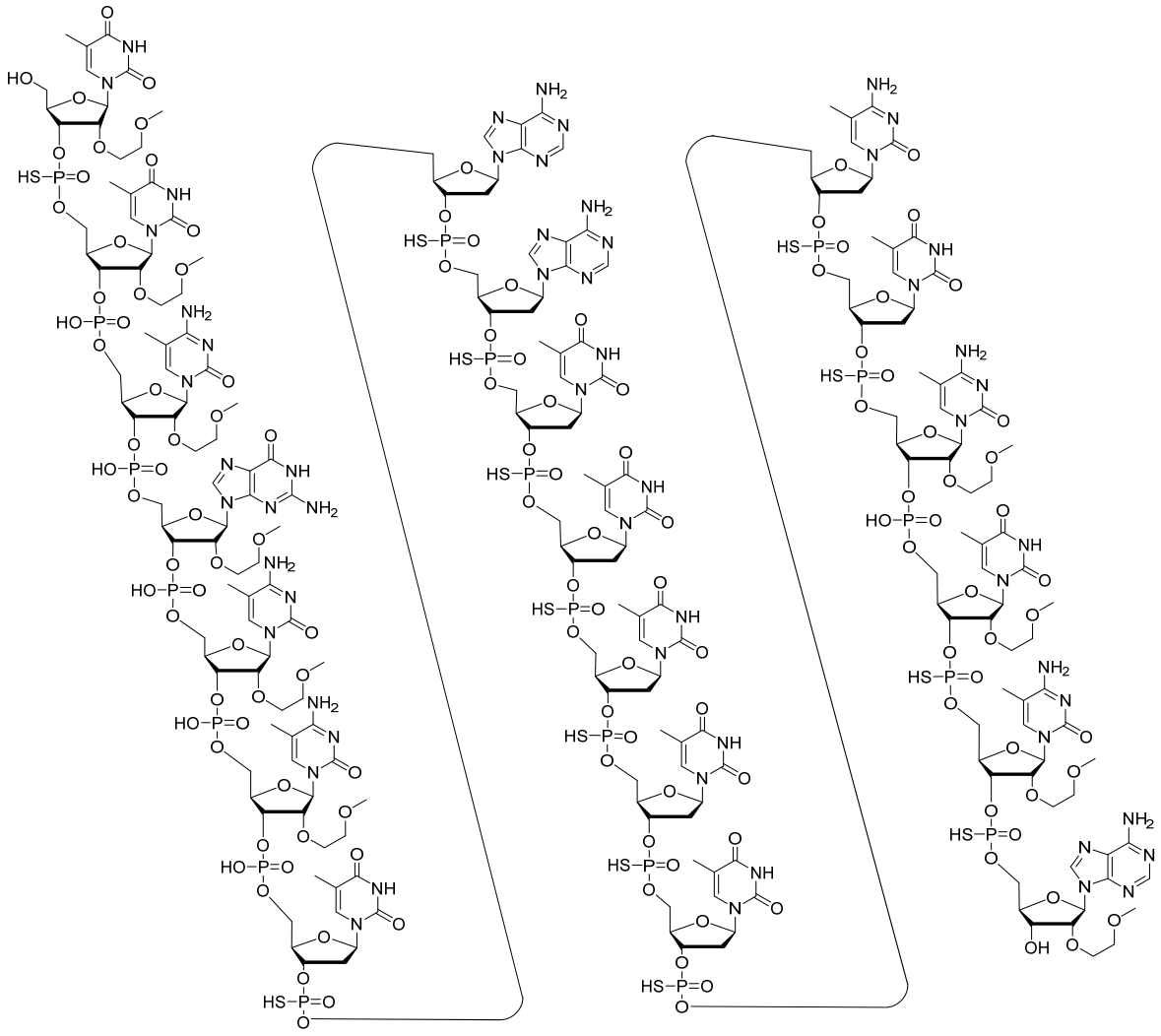
(SEQ ID NO 9), or a salt thereof; or

a modified oligonucleotide according to the following chemical structure:



(SEQ ID NO 13), or a salt thereof; or

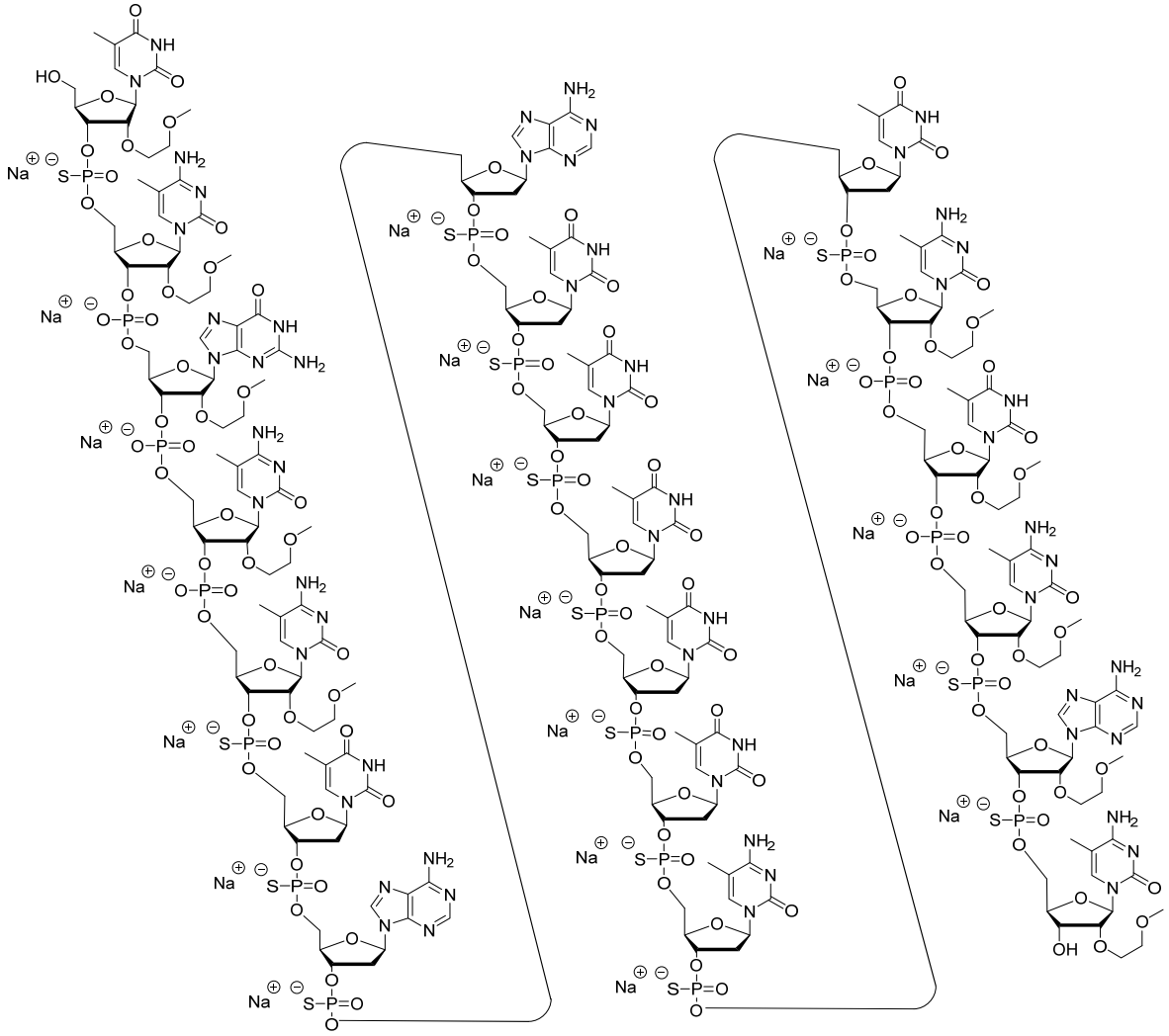
a modified oligonucleotide according to the following chemical structure:



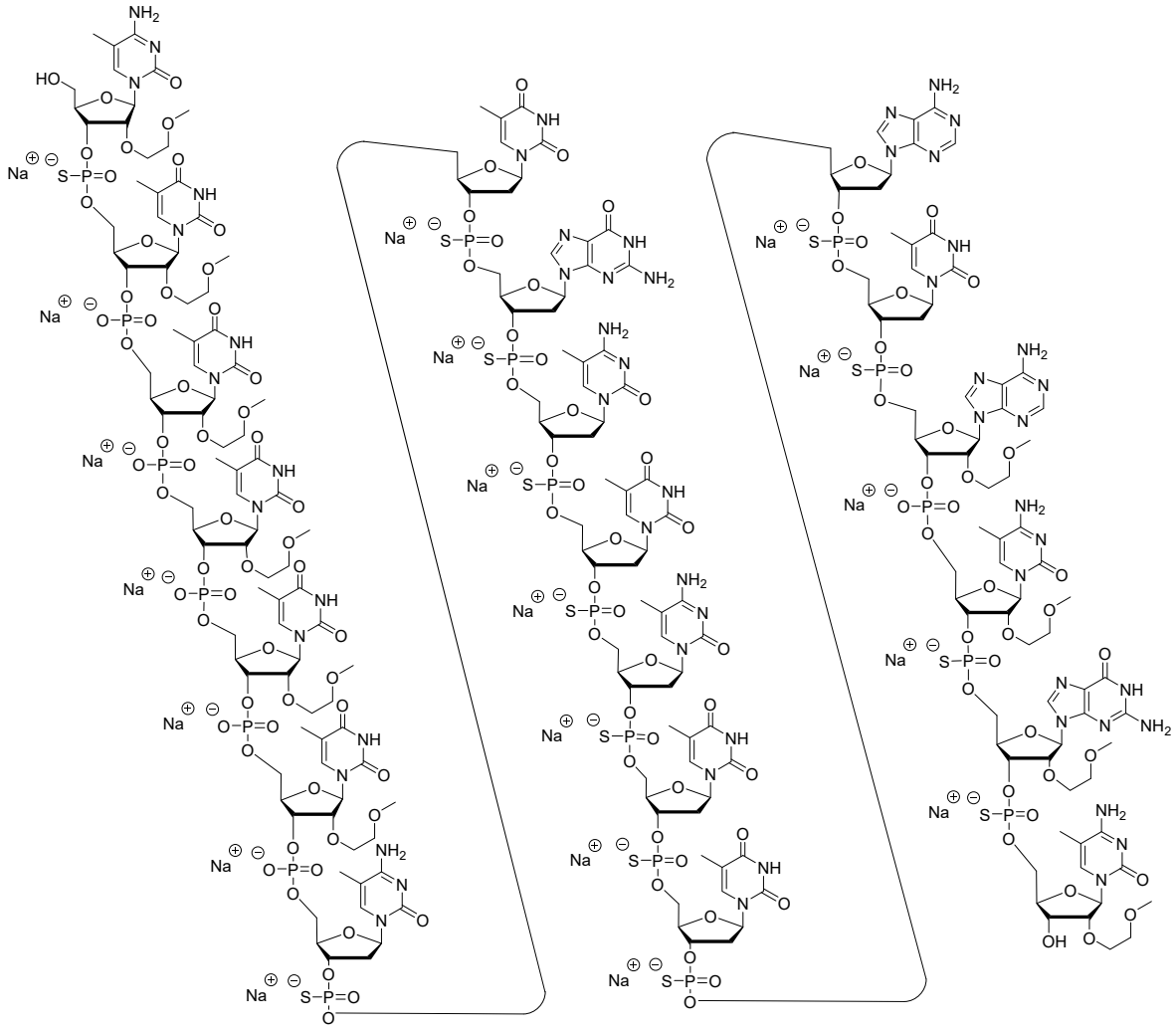
(SEQ ID NO 14), or a salt thereof.

2. The modified oligonucleotide of claim 1, which is the sodium salt or the potassium salt.

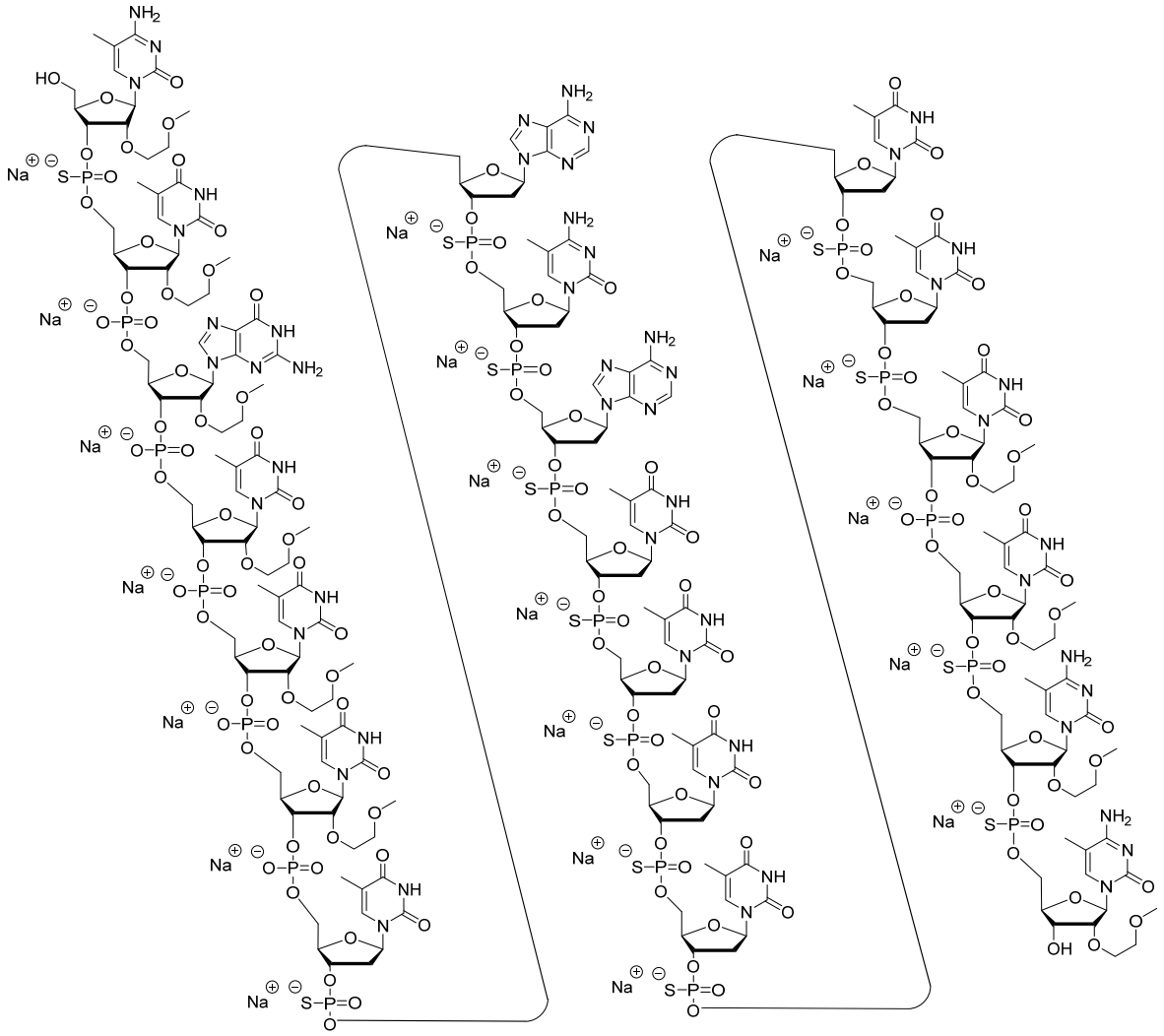
3. A modified oligonucleotide according to the following chemical structure:



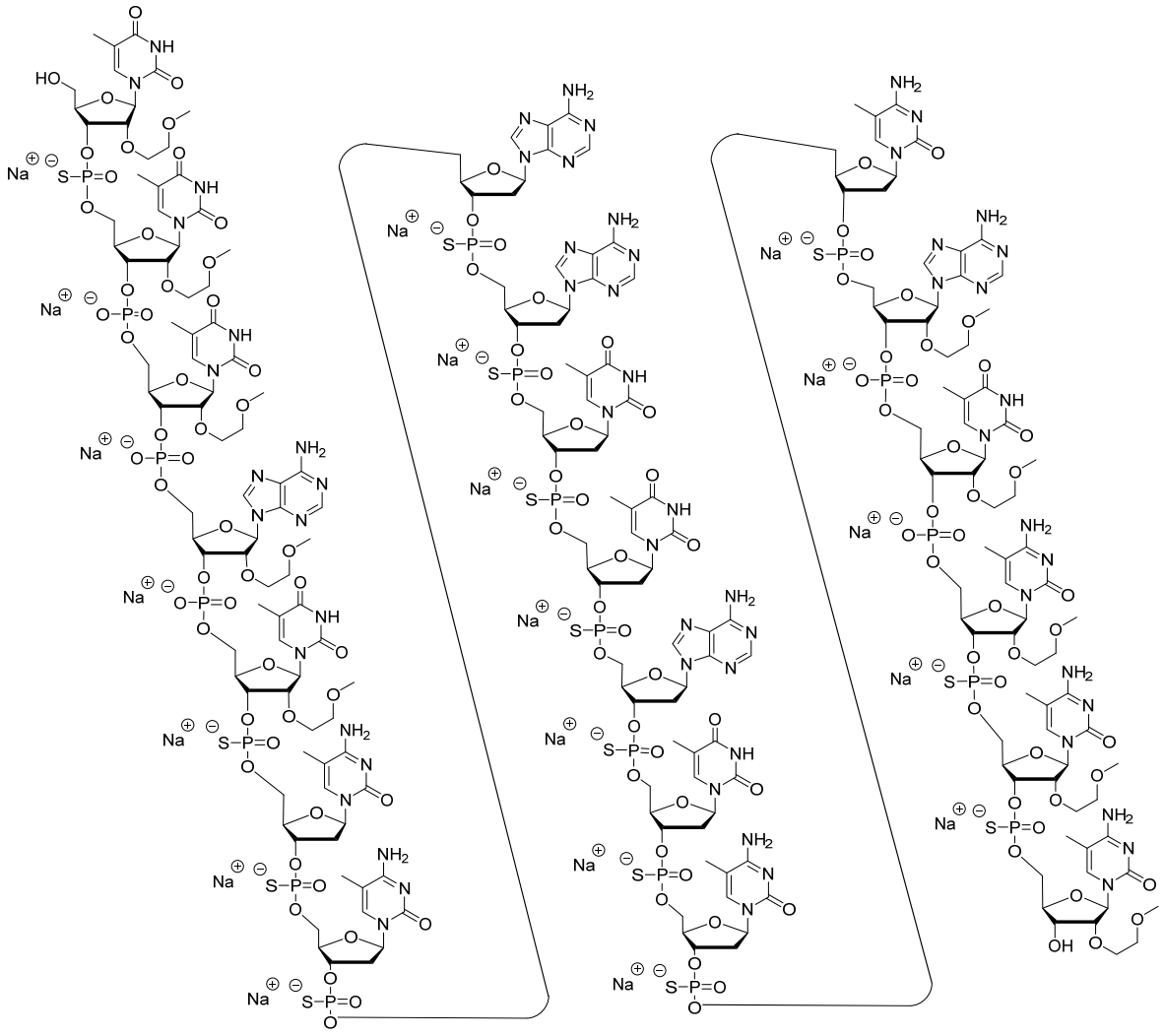
(SEQ ID NO 10); or



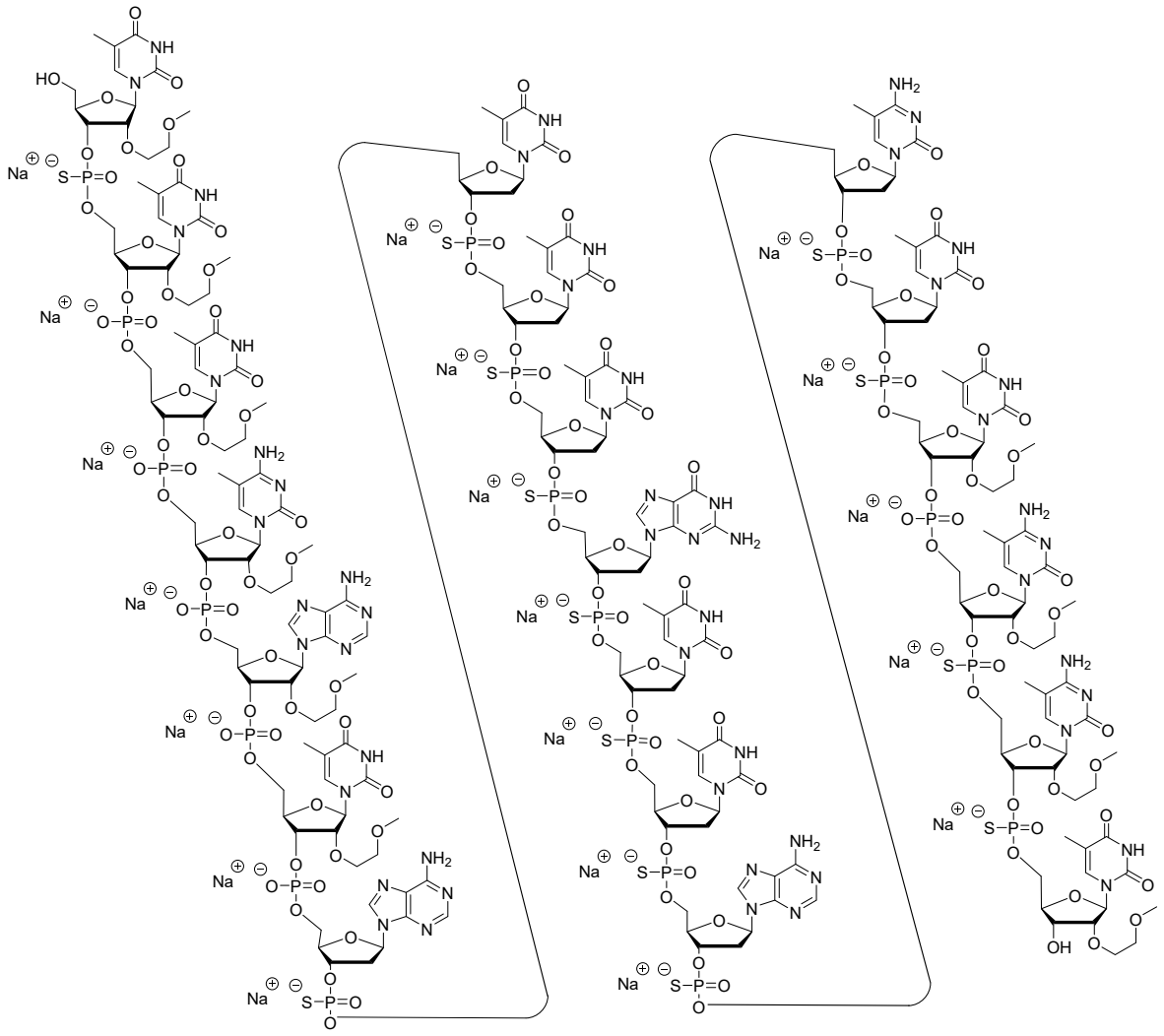
(SEQ ID NO 11); or



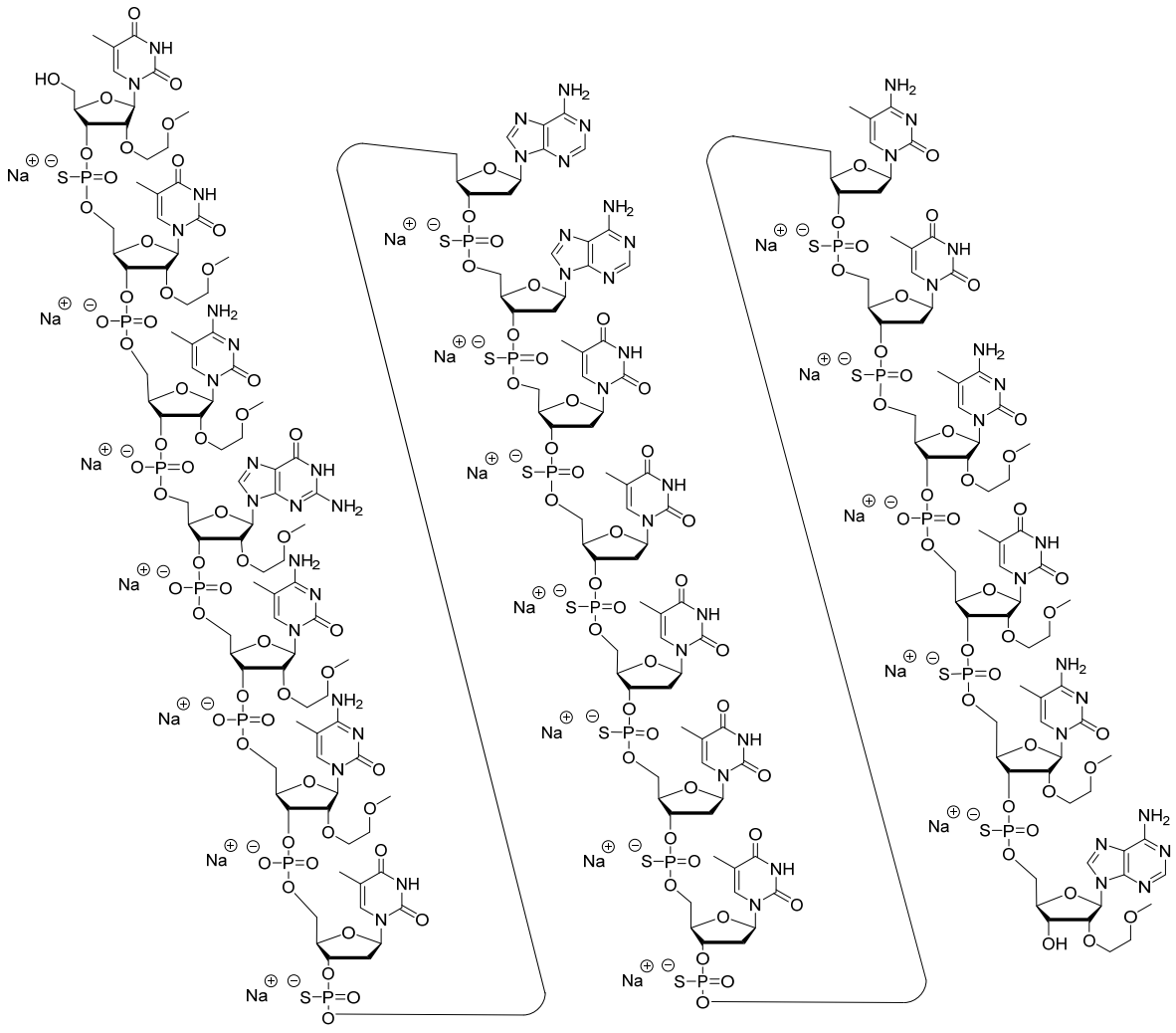
(SEQ ID NO 12); or



(SEQ ID NO 9); or



(SEQ ID NO 13); or



(SEQ ID NO 14).

4. An oligomeric compound comprising a modified oligonucleotide according to the following chemical notation:

$T_{es}{}^{m}C_{eo}G_{eo}{}^{m}C_{eo}{}^{m}C_{es}T_{ds}A_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{eo}T_{eo}{}^{m}C_{es}A_{es}{}^{m}C_{e}$ (SEQ ID NO 10);

$^{m}C_{es}T_{eo}T_{eo}T_{eo}T_{eo}T_{eo}{}^{m}C_{ds}T_{ds}G_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{ds}T_{ds}T_{ds}A_{ds}T_{ds}A_{eo}{}^{m}C_{es}G_{es}{}^{m}C_{e}$ (SEQ ID NO 11);

$^{m}C_{es}T_{eo}G_{eo}T_{eo}T_{eo}T_{eo}T_{ds}A_{ds}{}^{m}C_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{eo}T_{es}{}^{m}C_{es}{}^{m}C_{e}$ (SEQ ID NO 12);

$T_{es}T_{eo}T_{eo}A_{eo}T_{es}{}^{m}C_{ds}{}^{m}C_{ds}A_{ds}A_{ds}T_{ds}T_{ds}A_{ds}T_{ds}{}^{m}C_{ds}{}^{m}C_{ds}A_{eo}T_{eo}{}^{m}C_{es}{}^{m}C_{es}{}^{m}C_{e}$ (SEQ ID NO 9);

$T_{es}T_{eo}T_{eo}{}^{m}C_{eo}A_{eo}T_{eo}A_{ds}T_{ds}T_{ds}T_{ds}G_{ds}T_{ds}T_{ds}A_{ds}{}^{m}C_{ds}T_{ds}T_{eo}{}^{m}C_{es}{}^{m}C_{es}T_{e}$ (SEQ ID NO 13); or

$T_{es}T_{eo}{}^{m}C_{eo}G_{eo}{}^{m}C_{eo}{}^{m}C_{eo}T_{ds}A_{ds}A_{ds}T_{ds}T_{ds}T_{ds}T_{ds}T_{ds}{}^{m}C_{ds}T_{ds}{}^{m}C_{eo}T_{es}{}^{m}C_{es}A_{e}$ (SEQ ID NO 14),

wherein:

A = an adenine nucleobase,

^{m}C = a 5-methyl cytosine nucleobase,

G = a guanine nucleobase,

T = a thymine nucleobase,

e = a 2'-MOE sugar moiety,

d = a 2'-β-D-deoxyribosyl sugar moiety,

s = a phosphorothioate internucleoside linkage, and

o = a phosphodiester internucleoside linkage.

5. A population of modified oligonucleotides of any of claims 1-3 or a population of oligomeric compounds of claim 4, wherein all of the phosphorothioate internucleoside linkages of the modified oligonucleotide are stereorandom.

6. A pharmaceutical composition comprising a modified oligonucleotide of any of claims 1-3, an oligomeric compound of claim 4, or a population of modified oligonucleotides or population of oligomeric compounds of claim 5, and a pharmaceutically acceptable diluent.

7. The pharmaceutical composition of claim 6, wherein the pharmaceutically acceptable diluent is artificial cerebrospinal fluid, phosphate-buffered saline or sterile water.

8. The pharmaceutical composition of claim 7, wherein the pharmaceutical composition consists essentially of the modified oligonucleotide, the oligomeric compound, or the population of modified oligonucleotides or population of oligomeric compounds, and artificial cerebrospinal fluid, phosphate-buffered saline or sterile water

9. A modified oligonucleotide of any of claims 1-3, an oligomeric compound of claim 4, a population of modified oligonucleotides or population of oligomeric compounds of claim 5, or a pharmaceutical composition of any of claims 6-8 for use as a medicament.

10. Use of a modified oligonucleotide of any of claims 1-3, an oligomeric compound of claim 4, a population of modified oligonucleotides or population of oligomeric compounds of claim 5, or a pharmaceutical composition of any of claims 6-8; in the manufacture of a medicament for the treatment of a disease associated with type I interferon signaling, wherein a therapeutically effective amount of the modified oligonucleotide, the oligomeric compound, the population of modified oligonucleotides or population of oligomeric compounds is to be administered to a subject having the disease associated with type I interferon signaling.

11. The use of claim 10, wherein the disease associated with type I interferon signaling is Aicardi-Goutières Syndrome, stroke, Neuropsychiatric Systemic Lupus Erythematosus, neuroinflammation following traumatic brain injury, neuro-autoimmune disorders, Alzheimer's disease, post-operative delirium and cognitive decline, cranial radiation-induced cognitive decline, viral infection-induced cognitive decline, neuromyelitis optica, or ataxia telangiectasia.

12. The use of claim 10 or claim 11, wherein the disease is associated with an elevated level of interferon-alpha.

13. The use of any of claims 10-12, wherein administration of the modified oligonucleotide, the oligomeric compound, the population of modified oligonucleotides or population of oligomeric compounds, or the pharmaceutical composition reduces seizures, dystonia, spasticity, white matter abnormalities, T cell infiltration, B cell infiltration, striatal necrosis, brain atrophy, basal ganglia calcification, or microencephaly in the subject; improves feeding, motor development, language development, or social skill development in the subject; or reduces interferon alpha or lymphocytosis in the cerebrospinal fluid of the subject.

14. The use of claim 13, wherein the subject is human.