[0009]

Current treatments for FSHD include rehabilitation (stretching and exercise) as a symptomatic treatment, administration of NSAIDs, respiratory care, and the like. However, effects thereof are insufficient and burden on a patient is large. Therefore, it is an object herein to provide a compound, a composition and a method for treating FSHD.

[Related Art]

[Patent Document]

[0010]

[Patent Document 1] International Publication No. 2013/016352.

[Patent Document 2] International Publication No. 2017/007886.

[Patent Document 3] U.S. Patent Application Publication No. 2012/0225034.

[Non-Patent Documents]

[0011]

[Non-Patent Document 1] Snider et al., PLoS 2010, Vol.6 (10) p1.

[Non-Patent Document 2] Ferreboeuf et al., Human Molecular Genetics 2013, Vol. 23 (1), p171.

[Non-Patent Document 3] Sacconi et al., Biochim. Biophys. Acta 2015, p607.

The entire contents of these publications are incorporated herein by reference.

SUMMARY

[0011a]

In one aspect of the present disclosure, there is provided a modified oligonucleotide consisting 12 – 30 residues, comprising:

a nucleobase sequence that includes at least 8 contiguous nucleobase sequences and is complementary to an equal length portion at positions 126 – 147, 232 – 248, 1306 – 1325 or 1480 – 1495 from a 5’ end of a nucleobase sequence of a mature mRNA of DUX4 of SEQ ID NO: 1,

wherein the nucleobase sequence of the modified oligonucleotide has at least 90% complementarity to the equal length portion in the nucleobase sequence of the mature mRNA

of DUX4 of SEQ ID NO: 1, and when the at least 8 contiguous nucleobase sequences include a nucleobase sequence that is complementary to the equal length portion at the positions 1480 – 1495 from the 5' end of the nucleobase sequence of SEQ ID NO: 1, the modified oligonucleotide consists of a nucleobase sequence having at a 3’ end a complementary base of a base of the position 1480 from the 5’ end of the nucleobase of SEQ ID NO: 1.

[0011b]

In another aspect of the present disclosure, there is provided a modified oligonucleotide consisting of 12-30 residues, comprising:

a nucleobase sequence that includes at least 8 contiguous nucleobase sequences and is complementary to an equal length portion at positions 1472 – 1495 from a 5' end of a nucleobase sequence of a mature mRNA of DUX4 of SEQ ID NO: 1,

wherein the nucleobase sequence of the modified oligonucleotide has at least 90% complementarity to the equal length portion in the nucleobase sequence of the mature mRNA of DUX4 of SEQ ID NO: 1, and the modified oligonucleotide includes at least one nucleoside that includes a modified sugar selected from the group consisting of GuNA, ALNA [Ms], ALNA [mU], ALNA [ipU], ALNA [Oxz], and ALNA [Trz].

[0011c]

In a further aspect of the present disclosure, there is provided a pharmaceutical composition, comprising:

the modified oligonucleotide disclosed herein or a pharmaceutically acceptable salt thereof; and

a pharmaceutically acceptable carrier.

[0011d]

In another aspect of the present disclosure, there is provided a pharmaceutical composition disclosed herein, for use in therapeutically treating, preventing, or delaying progress of a DUX4-related disease.

[0011e]

In a further aspect of the present disclosure, there is provided a use of a modified oligonucleotide disclosed herein, in manufacture of a medicament for therapeutically treating, preventing or delaying progress of a DUX4-related disease.

[Problems to Be Solved by the Invention]

[0012]

An object of the present invention is to provide a compound, a method and a pharmaceutical composition for inhibiting expression of DUX4 and for treating, that is, therapeutically treating, preventing, delaying or ameliorating, DUX4-related diseases and/or symptoms thereof. The compound and pharmaceutical composition disclosed herein also inhibit mutant DUX4 such as SNP and DUX4 splicing variants.

[0013]

Claims

[Claim 1]

A modified oligonucleotide consisting 12 – 30 residues, comprising:

a nucleobase sequence that includes at least 8 contiguous nucleobase sequences and is complementary to an equal length portion at positions 126 – 147, 232 – 248, 1306 – 1325 or 1480 – 1495 from a 5’ end of a nucleobase sequence of a mature mRNA of DUX4 of SEQ ID NO: 1,

wherein the nucleobase sequence of the modified oligonucleotide has at least 90% complementarity to the equal length portion in the nucleobase sequence of the mature mRNA of DUX4 of SEQ ID NO: 1, and when the at least 8 contiguous nucleobase sequences include a nucleobase sequence that is complementary to the equal length portion at the positions 1480 – 1495 from the 5' end of the nucleobase sequence of SEQ ID NO: 1, the modified oligonucleotide consists of a nucleobase sequence having at a 3’ end a complementary base of a base of the position 1480 from the 5’ end of the nucleobase of SEQ ID NO: 1.

[Claim 2]

The modified oligonucleotide according to claim 1, wherein one or more modified nucleotides of the modified oligonucleotide each include a modified sugar.

[Claim 3]

The modified oligonucleotide according to claim 2, wherein the modified sugar is selected from a group consisting of a bicyclic sugar, a 2'-O-methoxyethyl modified sugar, and a 2'-O-methyl modified sugar.

[Claim 4]

The modified oligonucleotide according to claim 3, wherein the bicyclic sugar is selected from a group consisting of LNA, GuNA, ALNA [Ms], ALNA [mU], ALNA [ipU], ALNA [Oxz], and ALNA [Trz].

[Claim 5]

A modified oligonucleotide consisting of 12-30 residues, comprising:

a nucleobase sequence that includes at least 8 contiguous nucleobase sequences and is complementary to an equal length portion at positions 1472 – 1495 from a 5' end of a nucleobase sequence of a mature mRNA of DUX4 of SEQ ID NO: 1,

wherein the nucleobase sequence of the modified oligonucleotide has at least 90% complementarity to the equal length portion in the nucleobase sequence of the mature mRNA of DUX4 of SEQ ID NO: 1, and the modified oligonucleotide includes at least one nucleoside that includes a modified sugar selected from the group consisting of GuNA, ALNA [Ms], ALNA [mU], ALNA [ipU], ALNA [Oxz], and ALNA [Trz].

[Claim 6]

The modified oligonucleotide according to claim 5, further comprising:

a 2'-O-methoxyethyl modified sugar and/or a 2'-O-methyl modified sugar.

[Claim 7]

The modified oligonucleotide according to any one of claims 1 – 6, wherein at least one modified nucleotide of the modified oligonucleotide includes a modified nucleobase.

[Claim 8]

The modified oligonucleotide according to claim 7, wherein the modified nucleobase is a 5-methylcytosine.

[Claim 9]

The modified oligonucleotide according to any one of claims 1 – 8, wherein at least one internucleoside linkage is a modified internucleoside linkage.

[Claim 10]

The modified oligonucleotide according to claim 9, wherein the modified internucleoside linkage is a phosphorothioate internucleoside linkage.

[Claim 11]

The modified oligonucleotide according to any one of claims 1 – 10, comprising:

1) a gap segment;

2) a 5' wing segment; and

3) a 3' wing segment,

wherein the gap segment is positioned between the 5' wing segment and the 3' wing segment, all nucleosides of the 5' wing segment and the 3' wing segment each include at least one modified sugar, and the gap segment includes only nucleosides that contain no modified sugar, or includes one or two nucleosides that each contain a modified sugar, and includes other nucleosides that contain no modified sugar.

[Claim 12]

The modified oligonucleotide according to any one of claims 1 – 11, consisting of:

a nucleobase sequence that is complementary to a nucleobase sequence of positions 128 – 143 from the 5' end of the nucleobase sequence, a nucleobase sequence of positions 232 – 247 from the 5 'end, a nucleobase sequence of positions 233 – 248 from the 5' end, a nucleobase sequence of positions 1309 – 1323 from the 5' end, or a nucleobase sequence of positions 1480 – 1495 from the 5' end of the mature mRNA of DUX4 of SEQ ID NO: 1.

[Claim 13]

The modified oligonucleotide according to any one of claims 1 – 12, consisting of:

a base sequence of gtggcgatgc ccgggt (SEQ ID NO: 75), gagattcccg cnggtg (SEQ ID NO: 78: n represents a 5-methylcytosine), ngagattcccgccggt (SEQ ID NO: 2: n represents a 5-methylcytosine), gnagttctccgcggt (SEQ ID NO: 3: n represents a 5-methylcytosine), or gnntagacagcgtngg (SEQ ID NO: 4: n represents a 5-methylcytosine).

[Claim 14]

The modified oligonucleotide according to claim 13 represented by the following formula,

GlsMlsMlsTdsAdsGdsAdsCdsAdsGdsCdsGdsTdsMlsGlsGl,

wherein nucleobases are represented by the following symbols: A = adenine, T = thymine, G = guanine, C = cytosine, and M = 5-methylcytosine; sugar moieties are represented by the following symbols: l = LNA, and d = 2'-deoxyribose; and internucleoside linkages are represented according to the following symbol: s = phosphorothioate.

[Claim 15]

The modified oligonucleotide according to claim 13 represented by the following formula,

GmsMmsMmsTdsAdsGdsAdsCdsAdsGdsCdsGdsTdsMmsGmsGm,

wherein nucleobases are represented by the following symbols: A = adenine, T = thymine, G = guanine, C = cytosine, and M = 5-methylcytosine; sugar moieties are represented by the following symbols: m = ALNA [Ms], and d = 2'-deoxyribose; and internucleoside linkages are represented by the following symbol: s = phosphorothioate.

[Claim 16]

The modified oligonucleotide according to claim 13 represented by the following formula,

GmsMmsAmsGdsTdsTdsCdsTdsCdsCdsGdsCdsGmsGmsTm,

wherein nucleobases are represented by the following symbols: A = adenine, T = thymine, G = guanine, C = cytosine, and M = 5-methylcytosine; sugar moieties are represented by the following symbols: m = ALNA [Ms], and d = 2'-deoxyribose; and internucleoside linkages are represented by the following symbol: s = phosphorothioate.

[Claim 17]

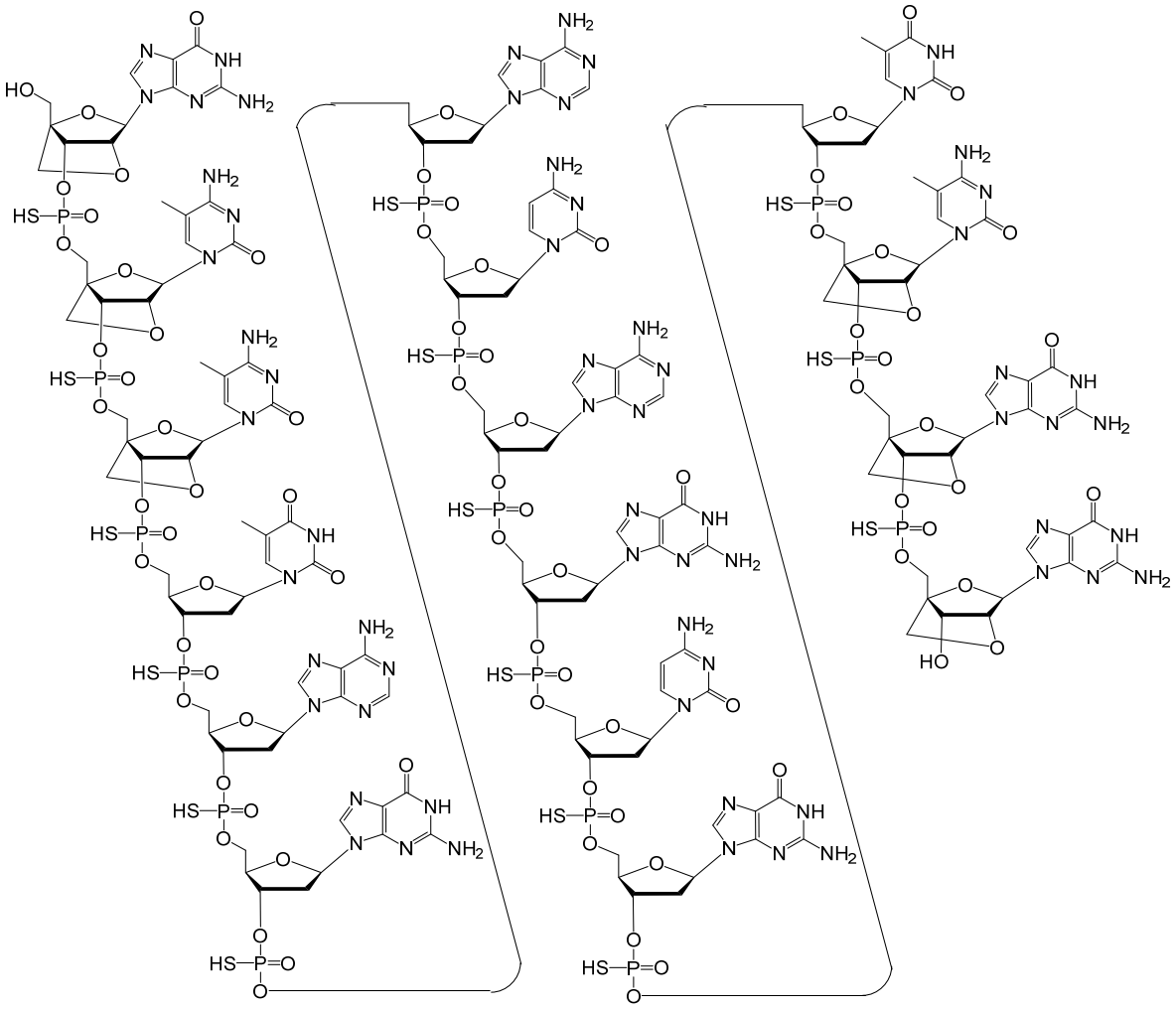
The modified oligonucleotide according to claim 13 represented by the following formula,

MlsGlsAlsGdsAdsTdsTdsCdsCdsCdsGdsCdsCdsGlsGlsTl,

wherein nucleobases are represented by the following symbols: A = adenine, T = thymine, G = guanine, C = cytosine, and M = 5-methylcytosine; sugar moieties are represented by the following symbols: l = LNA, and d = 2'-deoxyribose; and internucleoside linkages are represented by the following symbol: s = phosphorothioate.

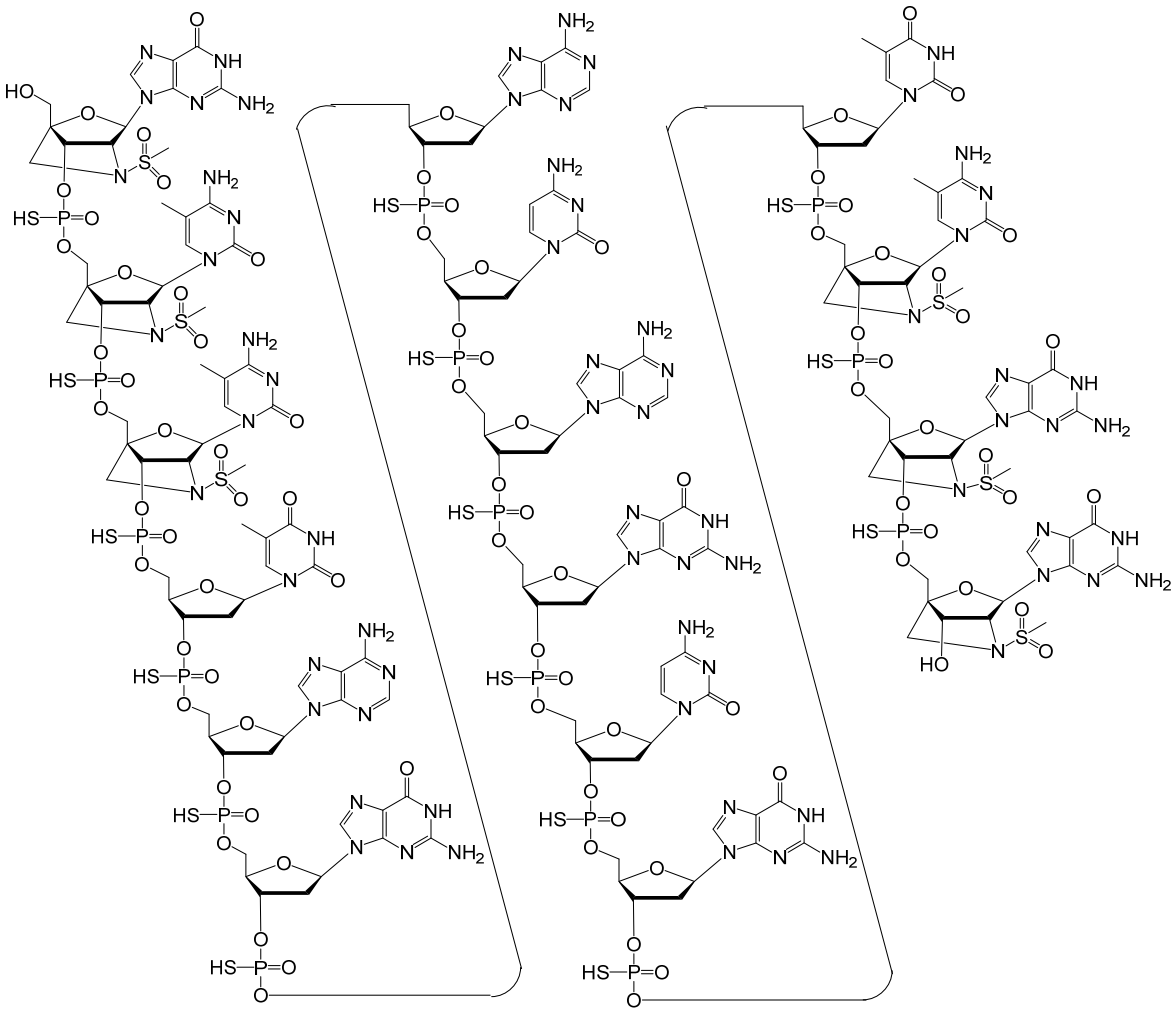
[Claim 18]

The modified oligonucleotide according to claim 14 represented by the following formula or a salt thereof,



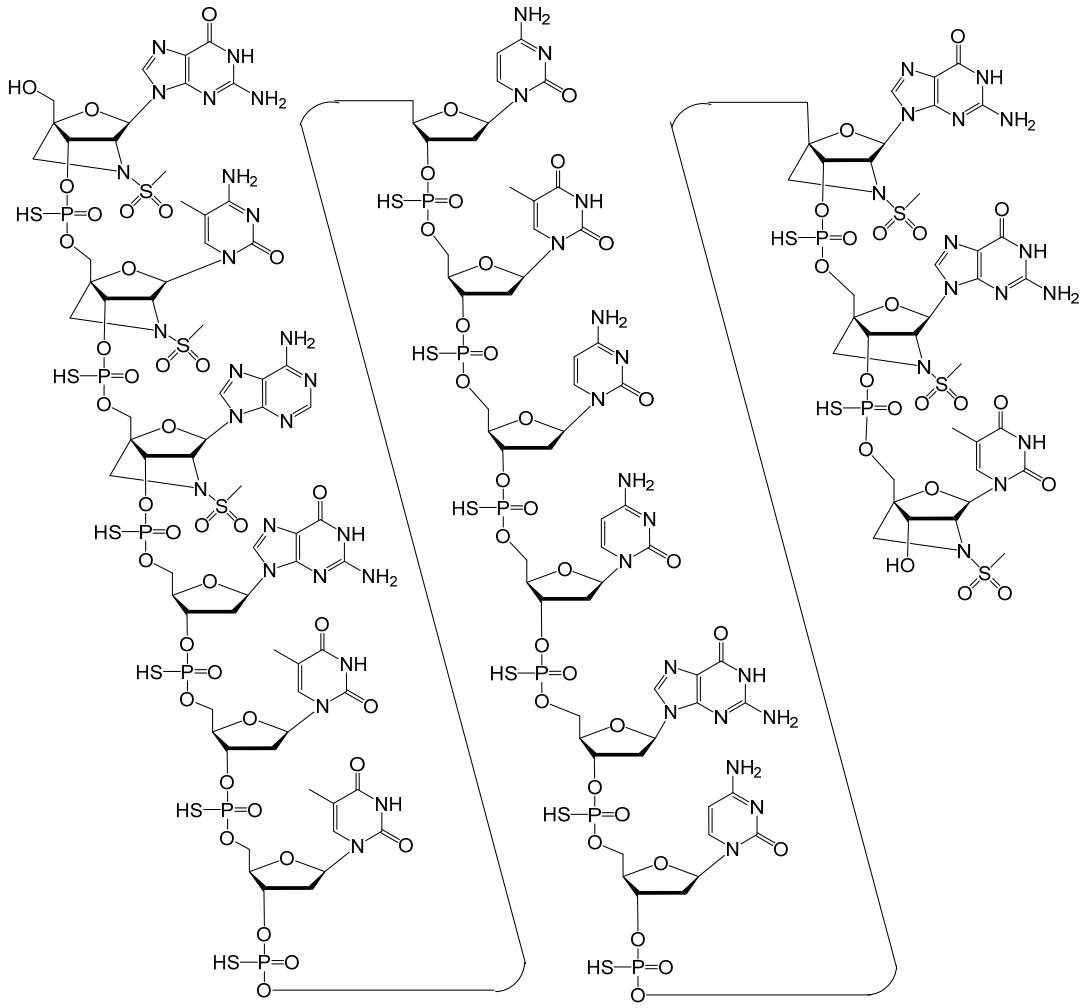
[Claim 19]

The modified oligonucleotide according to claim 15 represented by the following formula or a salt thereof,



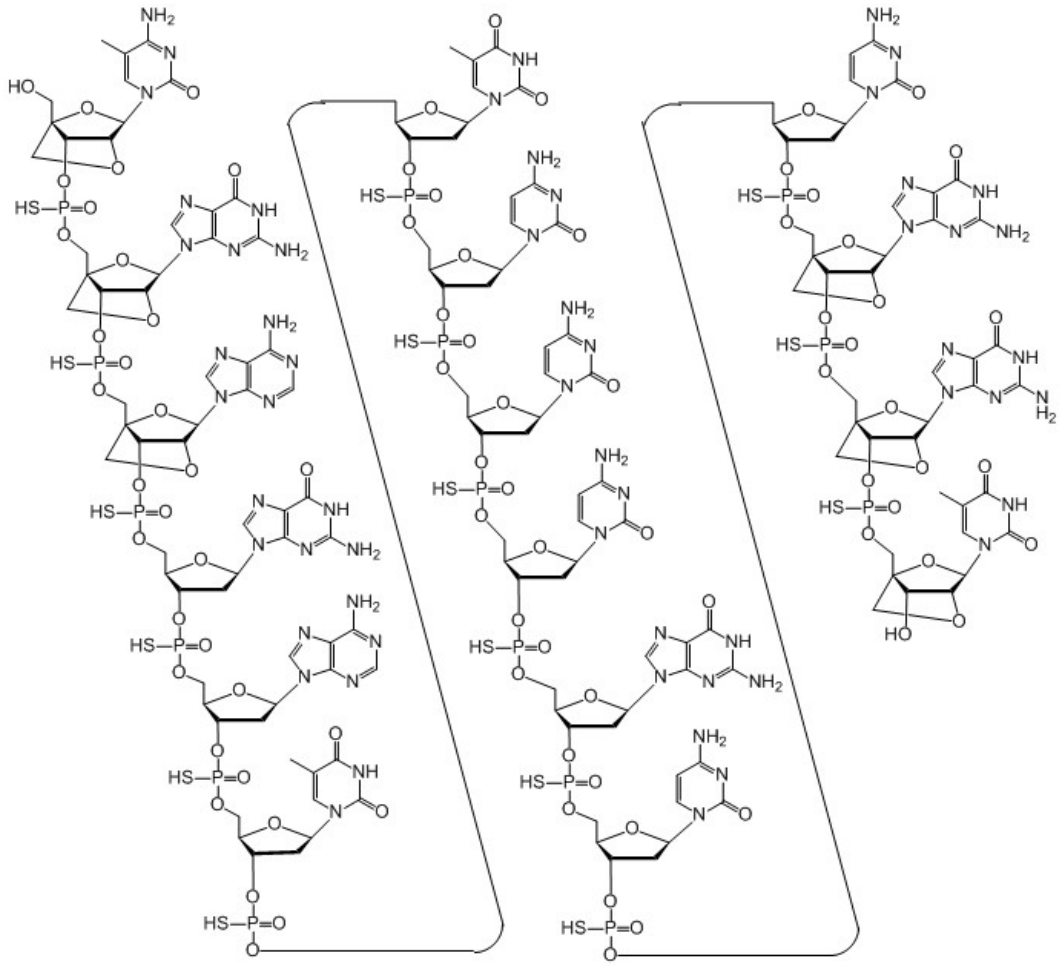
[Claim 20]

The modified oligonucleotide according to claim 16 represented by the following formula or a salt thereof,



[Claim 21]

The modified oligonucleotide according to claim 17 represented by the following formula or a salt thereof,



[Claim 22]

A pharmaceutical composition, comprising:

the modified oligonucleotide according to any one of claims 1 – 21 or a pharmaceutically acceptable salt thereof; and

a pharmaceutically acceptable carrier.

[Claim 23]

The pharmaceutical composition according to claim 22, for use in therapeutically treating, preventing, or delaying progress of a DUX4-related disease.

[Claim 24]

The pharmaceutical composition for use according to claim 23, wherein the DUX4-related disease is facioscapulohumeral muscular dystrophy.

[Claim 25]

Use of the modified oligonucleotide according to any one of claims 1 – 21, in manufacture of a medicament for therapeutically treating, preventing or delaying progress of a DUX4-related disease.

[Claim 26]

The use according to claim 25, wherein the DUX4-related disease is facioscapulohumeral muscular dystrophy.