What is claimed is:

1. An immunogenic composition, comprising a ribonucleic acid (RNA) of a respiratory syncytial virus (RSV), wherein the RNA encodes a variant of a wild-type RSV F protein;

wherein the variant is based on SEQ ID NO: 1 with the following mutations:

a) substitutions P102A, I379V, M447V, A149C, S155C, S290C, Y458C, S190F, V296I, E92D, K465Q, D486S, S46G, S215P, and L373R;

b) amino acids at positions 550 to 574 are truncated;

c) amino acids at positions 104 to 144 are substituted with a GS linker; and,

d) (i) substitution V152I, (ii) substitutions C69Y, D73E, A74V, N88S and V152I, or (iii) no other mutations

.2. The composition according to claim 1, wherein an amino acid sequence of the variant of the RSV F protein is: SEQ ID NO: 204, SEQ ID NO: 12 or SEQ ID NO: 208; or,

a nucleotide sequence of an open reading frame (ORF) encoding the variant of the RSV F protein is: SEQ ID NO: 203, SEQ ID NO: 11 or SEQ ID NO: 207; or,

a sequence of the RNA of the RSV is: SEQ ID NO: 205, SEQ ID NO: 13 or SEQ ID NO: 209; or,

a DNA sequence encoding the variant of the RSV F protein is: SEQ ID NO: 202, SEQ ID NO: 10 or SEQ ID NO: 206.

3. The composition according to claim 1, wherein the RNA of the RSV further comprises a 5' untranslated region (UTR).

4. The composition according to claim 3, wherein a sequence of the 5' untranslated region is: SEQ ID NO: 217, SEQ ID NO: 218, SEQ ID NO: 219, SEQ ID NO: 220, or SEQ ID NO: 221.

5. The composition according to claim 1, wherein the RNA of the RSV further comprises a 3' untranslated region (UTR).

6. The composition according to claim 5, wherein a sequence of the 3' untranslated region is: SEQ ID NO: 222, SEQ ID NO: 223, SEQ ID NO: 224, or SEQ ID NO: 225.

7. The composition according to claim 1, wherein the RNA of the RSV further comprises a poly(A) tail.

8. The composition according to claim 1, wherein the RNA of the RSV further comprises a 5' cap structure.

9. The composition according to claim 8, wherein the 5' cap structure is: 7mG(5')ppp(5')NlmpNp.

10. The composition according to claim 1, wherein a sequence of an open reading frame (ORF) encoding the variant of the RSV F protein or the variant thereof in the RSV RNA is codon-optimized.

11. The composition according to claim 10, wherein the sequence of the ORF comprises at least one base modification.

12. The composition according to claim 11, wherein the base modification comprises any one or more selected from the following: pseudouridine, N1-methylpseudouridine, N1-ethylpseudouridine, 2-thiouridine, 4'-thiouridine, 5-methylcytosine, 2-thio-1-methyl-1-deaza-pseudouridine, 2-thio-1-methyl-pseudouridine, 2-thio-5-aza-uridine, 2-thio-dihydropseudouridine, 2-thio-dihydrouridine, 2-thio-pseudouridine, 4-methoxy-2-thio-pseudouridine, 4-methoxy-pseudouridine, 4-thio-1-methyl-pseudouridine, 4-thio-

pseudouridine, 5-aza-uridine, dihydropseudouridine, 5-methoxyuridine, and 2'-O-methyluridine.

13. The composition according to claim 1, wherein the composition is a vaccine and further comprises a pharmaceutically acceptable excipient.

14. The composition according to claim 13, wherein the pharmaceutically acceptable excipient comprises a lipid mixture, and the lipid mixture is a lipid nanoparticle (LNP).

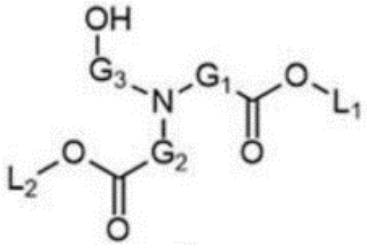
15. The composition according to claim 13, wherein the vaccine is an mRNA vaccine; or,

an effective dose of the RSV RNA is 25 to 200 μg; or,

an effective dose of the RSV RNA is 50 to 100 μg.

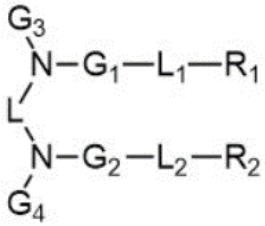
16. The composition according to claim 14, wherein the lipid nanoparticle comprises a cationic lipid, a neutral lipid, a structural lipid, and a polymer-conjugated lipid.

17. The composition according to claim 16, wherein the cationic lipid is a compound with a structure of formula I, or a N-oxide, a solvate, a pharmaceutically acceptable salt or a stereoisomer thereof, wherein G_1 is C_{1-6} alkylene; G_2 is C_{2-8} alkylene; G_3 is C_{1-3} alkylene; L_1 is C_{6-15} linear alkyl; L_2 is C_{12-25} branched alkyl



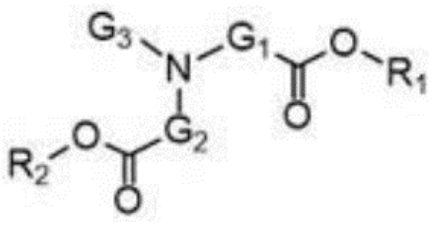
formula I ; or,

the cationic lipid is a compound with a structure of formula II, or a N-oxide, a solvate, a pharmaceutically acceptable salt or a stereoisomer thereof, wherein G_1 is C_{2-8} alkylene; G_2 is C_{2-8} alkylene; L_1 is -C(O)O- or -OC(O)-; L_2 is -C(O)O- or -OC(O)-; R_1 is C_{6-25} linear or branched alkyl; R_2 is C_{6-25} linear or branched alkyl; G_3 is $HO(CH_2)_2$- or $HO(CH_2)_3$-; G_4 is $HO(CH_2)_2$- or $HO(CH_2)_3$-; L is $(CH_2)_2$- or -$(CH_2)_3$- or -$(CH_2)_4$-



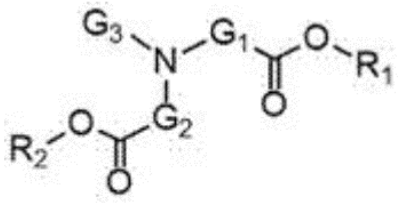
formula II ; or,

the cationic lipid is a compound with a structure of formula III, or a N-oxide, a solvate, a pharmaceutically acceptable salt or a stereoisomer thereof, wherein G_1 is C_{1-6} alkylene; G_2 is C_{2-8} alkylene; R_1 is C_{6-20} linear or branched alkyl; R_2 is C_{12-25} branched alkyl; G_3 is: $HO(CH_2)_2N(CH_3)(CH_2)_2$-, $HO(CH_2)_2N(CH_2CH_3)(CH_2)_2$-, $(HO(CH_2)_2)_2N(CH_2)_2$-, $CH_3O(CH_2)_2N(CH_3)(CH_2)_2$-, $(CH_3)_2N(CH_2)_3SC(O)O(CH_2)_2$-, $(CH_3)_2N(CH_2)_3SC(O)$-, $CH_3NH(CH_2)_2N(CH_3)(CH_2)_2$-, or $CH_3CH_2NH(CH_2)_2$-



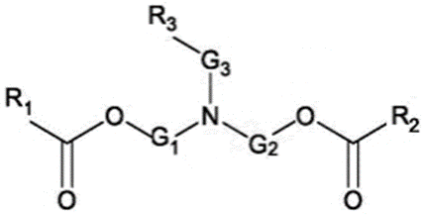
formula III ; or,

the cationic lipid is a compound with a structure of formula IV, or a N-oxide, a solvate, a pharmaceutically acceptable salt or a stereoisomer thereof, wherein G_1 is C_{1-8} alkylene; G_2 is C_{2-8} alkylene; R_1 is C_{6-25} linear or branched alkyl; R_2 is C_{12-25} linear or branched alkyl; G_3 is $HO(CH_2)_2N(R_3)CH_2CH(OH)CH_2$-, wherein R_3 is $-CH_3$ or $-CH_2CH_3$ or $-CH_2CH_2OH$



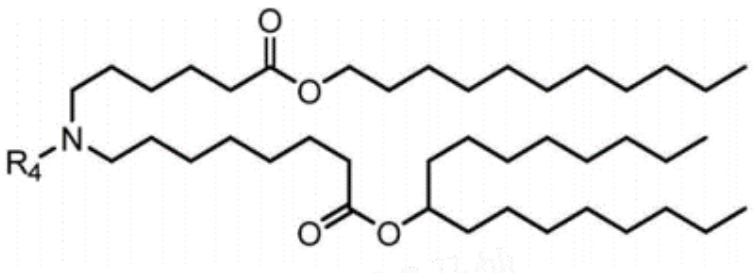
formula IV ; or,

the cationic lipid is a compound with a structure of formula V, or a N-oxide, a solvate, a pharmaceutically acceptable salt or a stereoisomer thereof, wherein G_1 and G_2 are each independently unsubstituted C_6-C_{10} alkylene; G_3 is unsubstituted C_1-C_{12} alkylene; R_1 and R_2 are each independently C_6-C_{24} alkyl or C_6-C_{24} alkenyl; R_3 is OR_5, N, $-C(=O)OR_4$, $-OC(=O)R_4$, or $-NR_5C(=O)R_4$; R_4 is C_1-C_{12} alkyl; and R_5 is H or C_1-C_6 alkyl



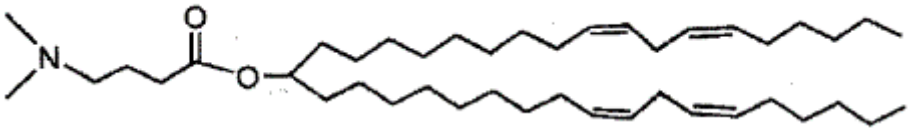
formula V ; or,

the cationic lipid is a compound with a structure of formula VI, or a N-oxide, a solvate, a pharmaceutically acceptable salt or a stereoisomer thereof, wherein R_4 is selected from $-(CH_2)_nQ$ and $-(CH_2)_nCHQR$; Q is selected from the group consisting of: -OR, -OH, $-O(CH_2)_nN(R)_2$, -OC(O)R, $-CX_3$, -CN, -N(R)C(O)R, -N(H)C(O)R, $-N(R)S(O)_2R$, $-N(H)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(H)C(O)N(R)_2$, -N(H)C(O)N(H)(R), $-N(R)C(S)N(R)_2$, $-N(H)C(S)N(R)_2$, -N(H)C(S)N(H)(R), $-N(R)S(O)_2R_8$, and a heterocyclic ring; n is 1, 2, or 3; wherein R is hydrogen, C_{1-3} alkyl, C_{2-3} alkenyl, or $(CH_2)_qOR^*$, wherein q is 1, 2, or 3, R^* is C_{1-12} alkyl or C_{2-12} alkenyl; X is fluoro, chloro, bromo, or iodo; R_8 is C_{3-6} cycloalkyl or a heterocyclic ring



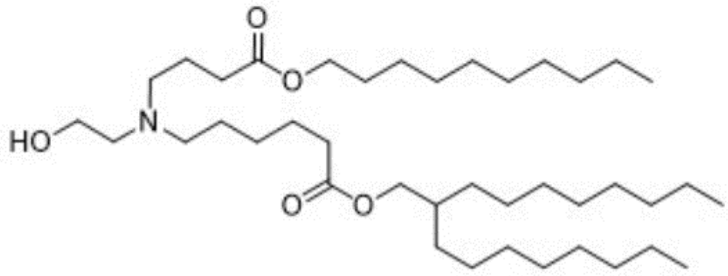
formula VI ; or,

the cationic lipid is a compound with a structure of formula VII, or a N-oxide, a solvate, a pharmaceutically acceptable salt, or a stereoisomer thereof:

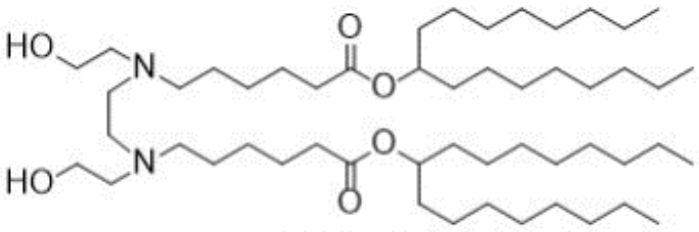


formula VII ; or,

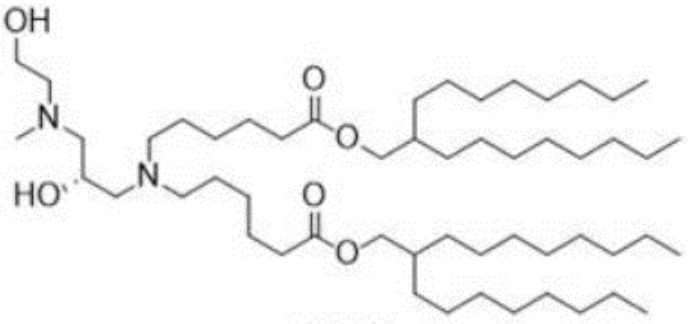
the cationic lipid is selected from the following compounds: YK-009, YK-401, YK-305, ALC0315, SM102, DLIN-MC3



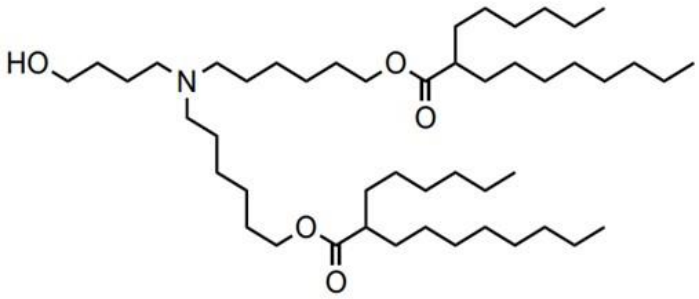
YK-009



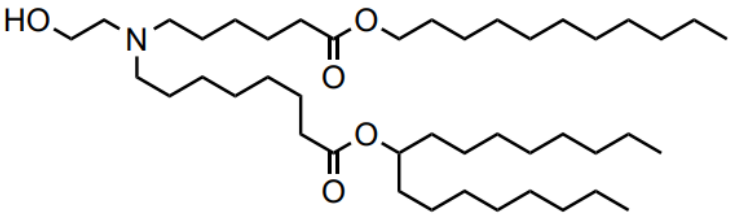
YK-401



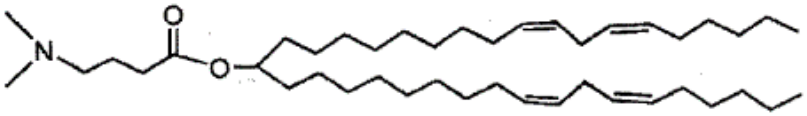
YK-305



ALC0315



SM102



DLIN-MC3 .

18. The composition according to claim 16, wherein the cationic lipid and the neutral lipid are at a molar ratio of (1-10):1; or,

the cationic lipid and the structural lipid are at a molar ratio of (1-5):1.

19. The composition according to claim 16, wherein the cationic lipid, the neutral lipid, the structural lipid, and the polymer-conjugated lipid are at a molar ratio of (25-75):(5-25):(15-65):(0.5-10); or

the cationic lipid, the neutral lipid, the structural lipid, and the polymer-conjugated lipid are at a molar ratio of (35-49):(7.5-15):(35-55):(1-5).

20. The composition according to claim 16, wherein the neutral lipid is selected from one or more of phosphatidylcholine, phosphatidylethanolamine, sphingomyelin, ceramide, sterol, and derivatives thereof; or

the neutral lipid is selected from one or more of the following: 1,2-dilinoleoyl-sn-glycero-3-phosphocholine (DLPC), 1,2-dimyristoyl-sn-glycero-phosphocholine (DMPC), 1,2-dioleoyl-sn-glycero-3-phosphocholine (DOPC), 1,2-dipalmitoyl-sn-glycero-3-phosphocholine (DPPC), 1,2-distearoyl-sn-glycero-3-phosphocholine (DSPC), 1,2-diundecanoyl-sn-glycero-phosphorylcholine (DUPC), 1-palmitoyl-2-oleoyl-sn-glycero-3-phosphocholine (POPC), 1,2-di-O-octadecadienyl-sn-glycero-3-phosphocholine (18:0 Diether PC), 1-oleoyl-2-cholesterolhemisuccinyl-sn-glycero-3-phosphocholine (OChemsPC), 1-hexadecyl-sn-glycero-3-phosphocholine (C16 Lyso PC), 1,2-dilinolenoyl-sn-glycero-3-phosphocholine, 1,2-diarachidonyl-sn-glycero-3-phosphorylcholine, 1,2-didocosahexaenoyl-sn-glycero-3-phosphocholine, 1,2-

dioleoyl-sn-glycero-3-phosphoethanolamine (DOPE), 1,2-diphyanoyl-sn-glycero-3-phosphoethanolamine (ME 16:0 PE), 1,2-distearoyl-sn-glycero-3-phosphoethanolamine, 1,2-dilinoleoyl-sn-glycero-3-phosphoethanolamine, 1,2-dilinolenoyl-sn-glycero-3-phosphoethanolamine, 1,2-diarachidonyl-sn-glycero-3-phosphoethanolamine, 1,2-didocosahexaenoyl-sn-glycero-3-phosphoethanolamine, 1,2-dioleoyl-sn-glycero-3-phospho-rac-(1-glycerol) sodium salt (DOPG), dipalmitoyl phosphatidylglycerol (DPPG), palmitoyl oleoyl phosphatidylethanolamine (POPE), distearoyl-phosphatidyl-ethanolamine (DSPE), dipalmitoyl phosphatidylethanolamine (DPPE), dimyristoyl phosphatidylethanolamine (DMPE), 1-stearyl-2-oleoyl-stearoylethanolamine (SOPE), 1-stearoyl-2-oleoyl-phosphatidylcholine (SOPC), sphingomyelin, phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine, phosphatidylinositol, phosphatidic acid, palmitoyl oleoyl phosphatidylcholine, lysophosphatidylcholine, and lysophosphatidylethanolamine (LPE); or

the neutral lipid is DOPE and/or DSPC; or

the structural lipid is selected from one or more of the following: cholesterol, nonsterol, sitosterol, ergosterol, campesterol, stigmasterol, brassicasterol, tomatidine, ursolic acid, α-tocopherol and corticosteroid.

21. The composition according to claim 16, wherein the polymer-conjugated lipid is selected from one or more of the following: PEG-modified phosphatidylethanolamine, PEG-modified phosphatidic acid, PEG-modified ceramide, PEG-modified dialkylamine, PEG-modified diacylglycerol, PEG-modified dialkylglycerol.

22. The composition according to claim 21, wherein the polymer-conjugated lipid is selected from one or more of the following: distearoyl phosphatidylethanolamine polyethylene glycol 2000 (DSPE-PEG2000), dimyristoylglycerol-3-methoxy polyethylene glycol 2000 (DMG-PEG2000), and methoxypoly(ethylene glycol) ditetradecylacetamide (ALC-0159).

23. The composition according to any one of claims 13 to 22, wherein the vaccine is in a form of an injection.

24. A method for preparing the composition according to any one of claims 13 to 23, comprising: mixing the RNA of the RSV with the pharmaceutically acceptable excipient.

25. A use of the composition according to any one of claims 1 to 23 in the preparation of a vaccine for inducing a protective immune response to RSV in a subject.

26. A use of the composition according to any one of claims 1 to 23 in the preparation of a vaccine for inducing a humoral immune response to RSV in a subject.

27. A use of the composition according to any one of claims 1 to 23 in the preparation of a vaccine for preventing an RSV infection.