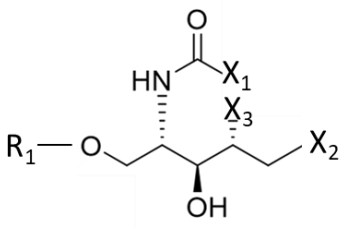
Claims

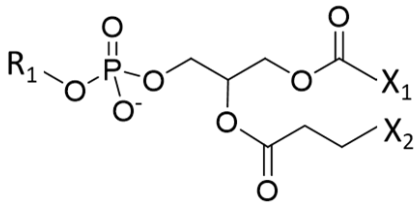
1. A nucleic acid, configured to encode a recombinant spike protein, wherein the recombinant spike protein has an N-linked glycosylation site in an S1 domain or an S2 domain thereof, provided that a stem region thereof is devoid of an N-linked glycosylation site, and wherein the nucleic acid comprises the nucleotide sequence of SEQ ID NO: 11 or SEQ ID NO: 22.

2. A vector, comprising the nucleic acid of claim 1.

3. The vector of claim 2, wherein the expression vector is a lipid nanoparticle, and the lipid nanoparticle comprises a membrane defining an inner space, and wherein the membrane encompasses the nucleic acid, and the membrane is formed with a plurality of lipid components comprising a bi-functional compound, and the bi-functional compound comprises:



Formula 1; or



Formula 2;

wherein R_1 comprises a substituted or non-substituted glycosyl group;

wherein X_1 and X_2 are each independently hydrogen, C_{1-30} alkyl, C_{1-30} alkenyl, C_{1-30} alkynyl, aryl, aryloxy, or a substituted version thereof, or

$–(CH_2)nX_4$, n is 0 to 30, and X_4 is hydrogen, aryl, aryloxy, heterocyclic group, cycloalkyl, or heterocycloalkyl, or a substituted version thereof, provided that when X_4 is a heterocyclic group, the heterocyclic group comprises 1 to 3 heteroatoms, selected from the group consisting of O, S, and N, or a combination thereof; and

wherein X_3 is hydrogen, C_{1-6} alkyl, or hydroxyl.

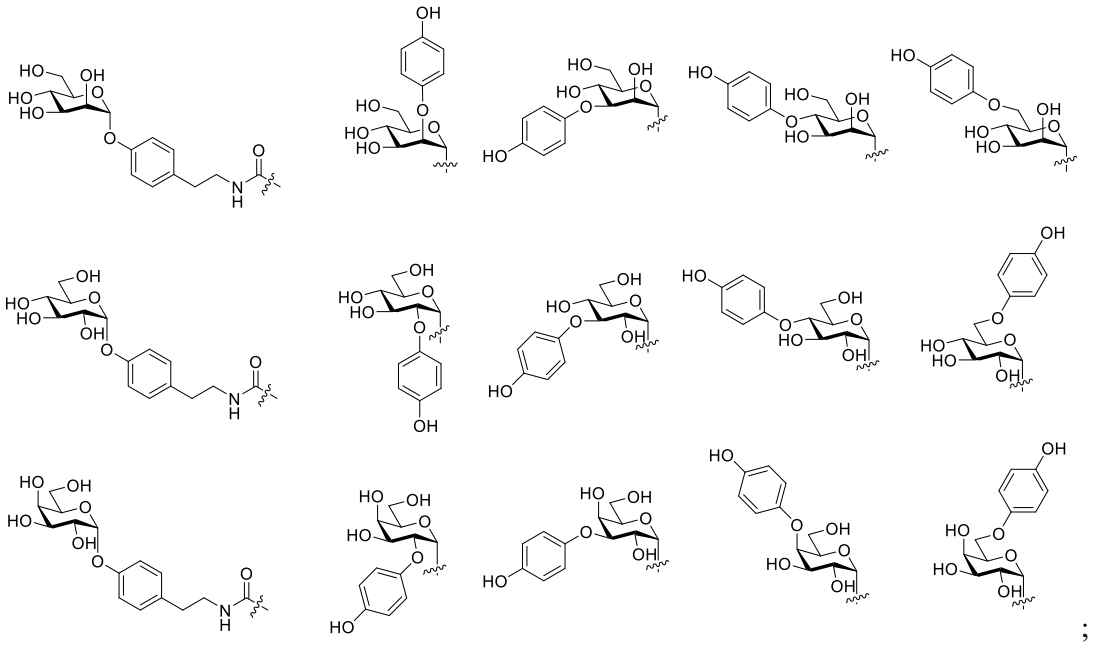
4. The vector of claim 3, wherein R_1 comprises a formula of R_2-R_A-, wherein R_A is an attachment group and R_2 is the substituted or non-substituted glycosyl group, and wherein the attachment group comprises an aryl, an alkyl, an amide, an alkylamide, a substituted version thereof, a combination thereof, or a covalent bond.

5. The vector of claim 4, wherein R_A comprises the aryl having 0 to 3 substituents, wherein the substituent is C_{1-6} alkyl, halide, or C_{1-6} alkyl halide.

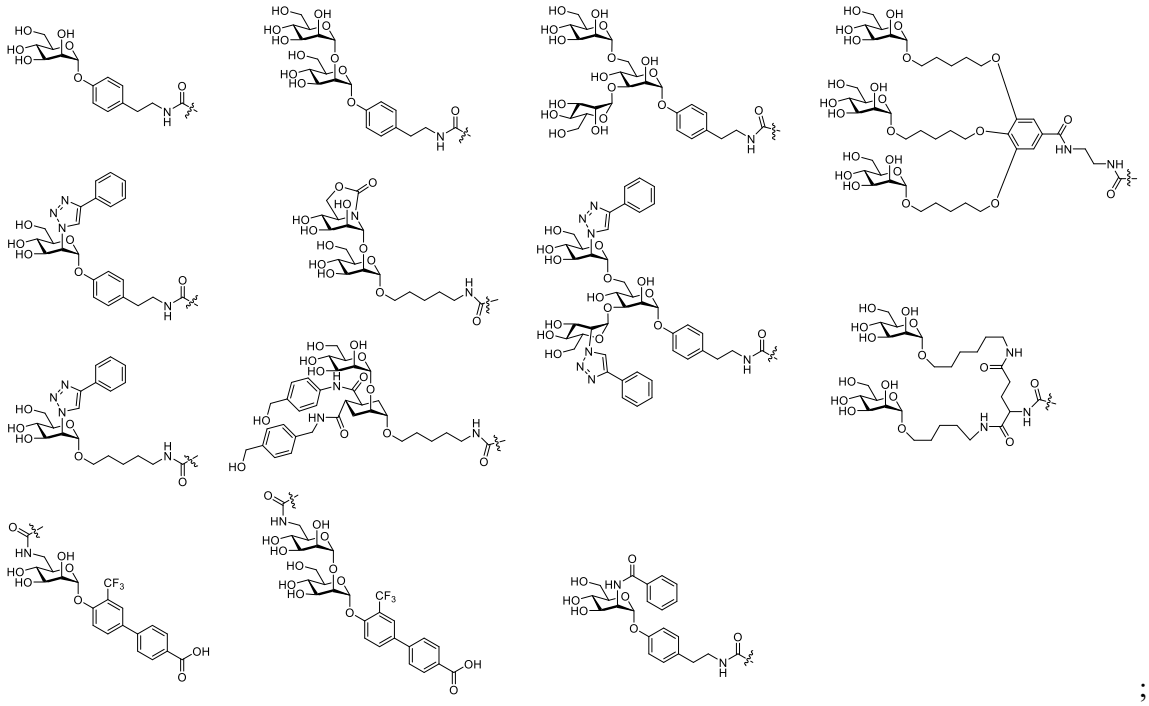
6. The vector of any one of claims 3 to 5, wherein the glycosyl group comprises a mono-mannoside, a di-mannoside, or a tri-mannoside.

7. The vector of any one of claims 3 to 6, wherein R_1 is a substituted glycosyl group, and the substituted glycosyl group comprises 1 to 6 substituents, wherein the substituent is C_{1-6} alkyl, C_{1-6} alkenyl, halogen, C_{1-6} alkyl halide, C_{1-6} alkoxy, amine, nitro, C_{1-6} alkyl amine, amide, azido, aryl, cycloalkyl, heterocycloalkyl, sulfite, or a substituted version thereof, or a combination thereof.

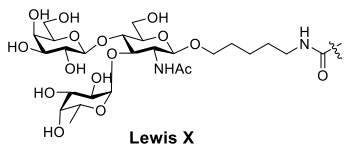
8. The vector of any one of claims 3 to 7, wherein R_1 is selected from the group consisting of:



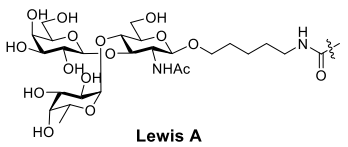
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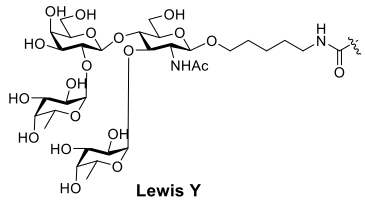
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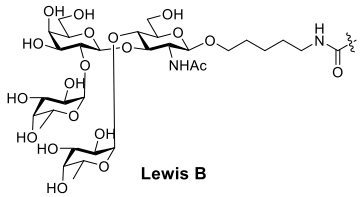
Lewis X



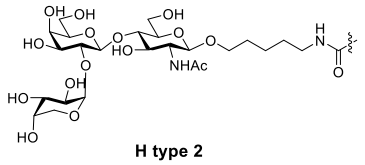
Lewis A



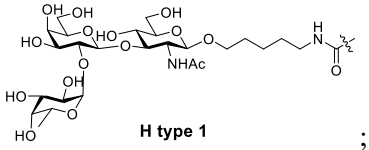
Lewis Y



Lewis B

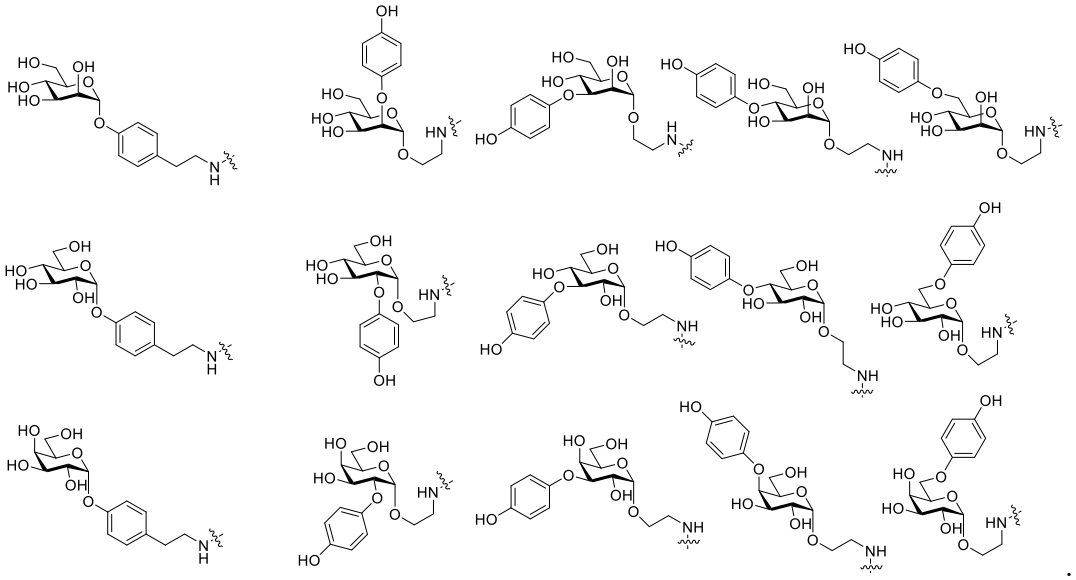


H type 2



H type 1

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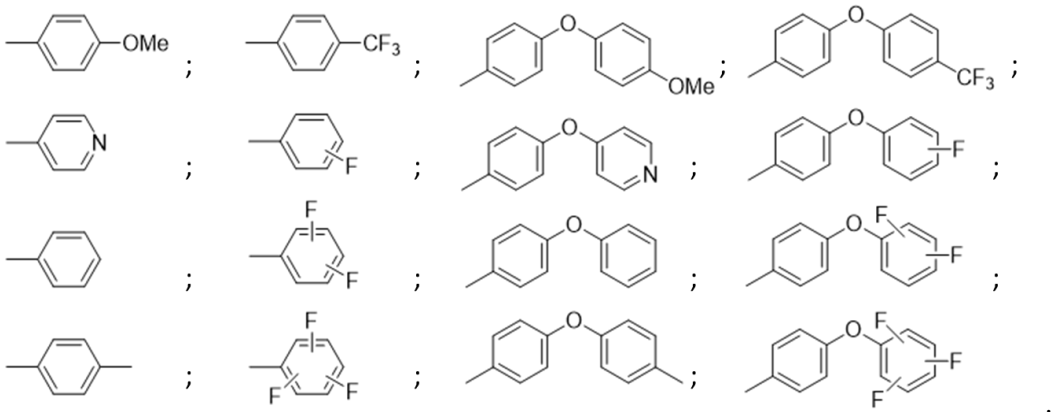


9. The vector of any one of claims 3 to 8, wherein at least one of X_1 and X_2 comprises a saturated hydrocarbon chain, comprising at least 8 carbons.

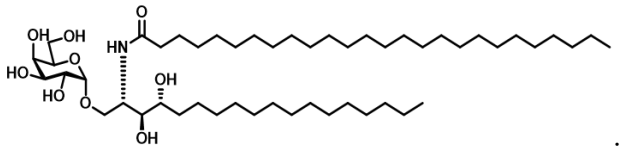
10. The vector of any one of claims 3 to 9, wherein X_1 and X_2 are each independently hydrogen, C_{8-30} alkyl, C_{8-30} alkenyl, C_{8-30} alkynyl, aryl, aryloxy, or $-(CH_2)nX_4$, n is 8 to 30.

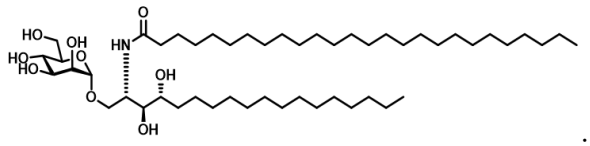
11. The vector of any one of claims 3 to 10, wherein X_4 is $-R_3-O-R_4$, wherein R_3 and R_4 are each independently aryl, heterocyclic group, cycloalkyl, heterocycloalkyl, each comprising 0 to 6 substituents selected from the group consisting of C_{1-6} alkyl, halogen, C_{1-6} alkyl halogen, and C_{1-6} alkoxy.

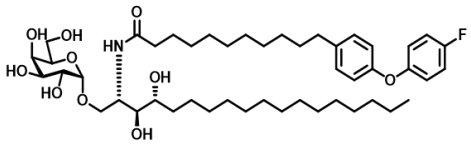
12. The vector of any one of claims 3 to 11, wherein X_4 is selected from the group consisting of:

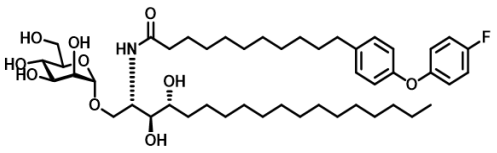


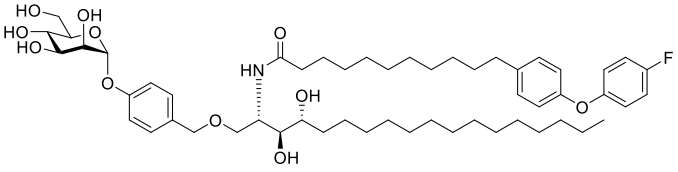
13. The vector of any one of claims 3 to 12, wherein the compound is selected from the group consisting of:

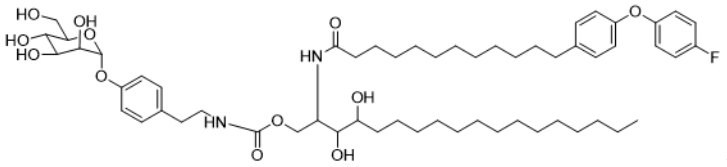

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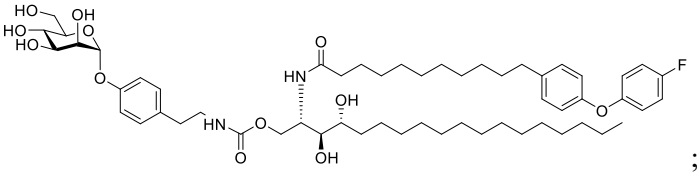

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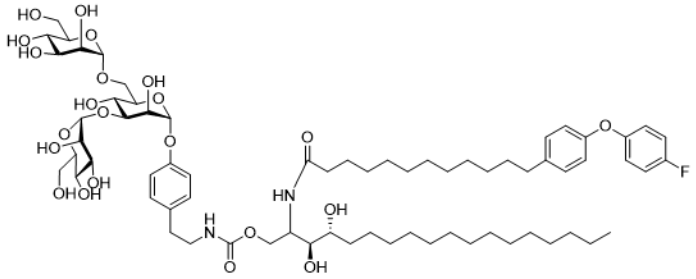

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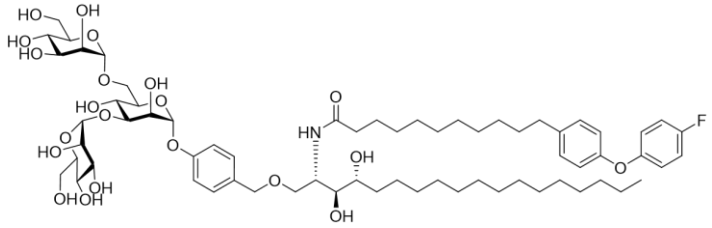

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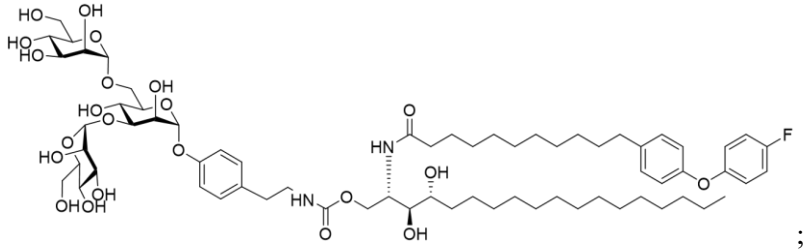

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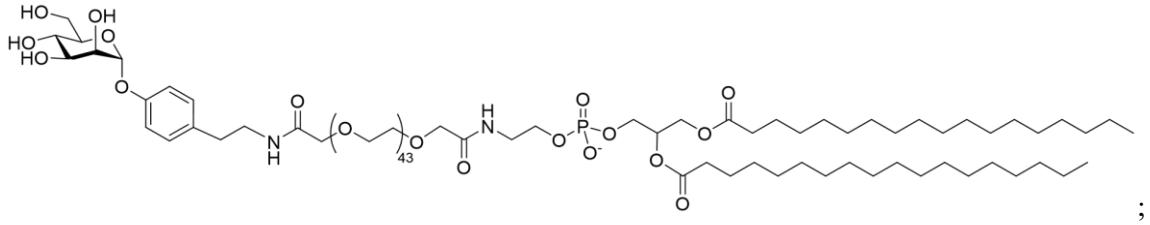

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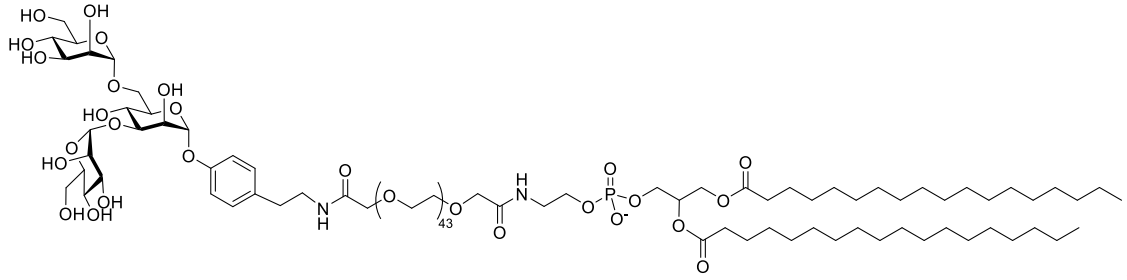

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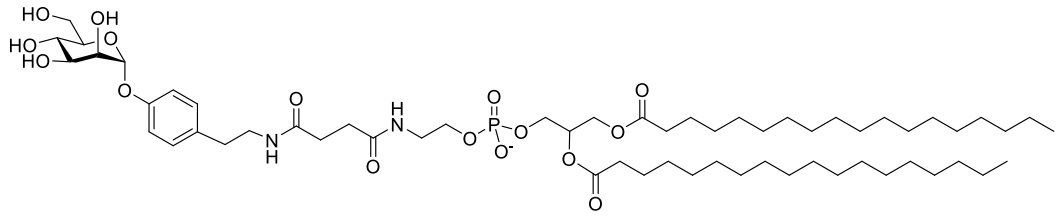

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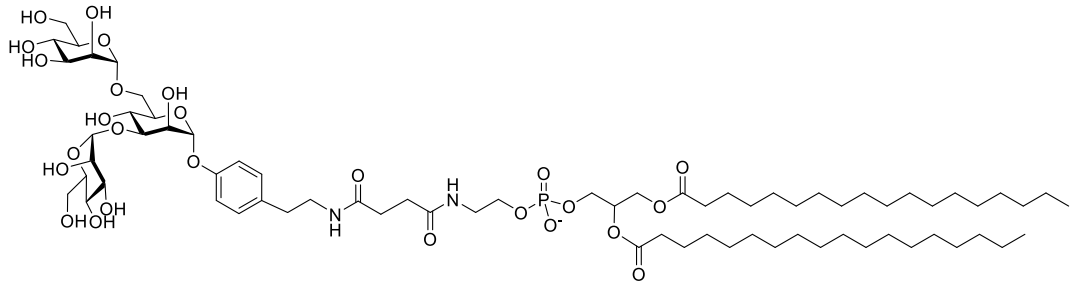

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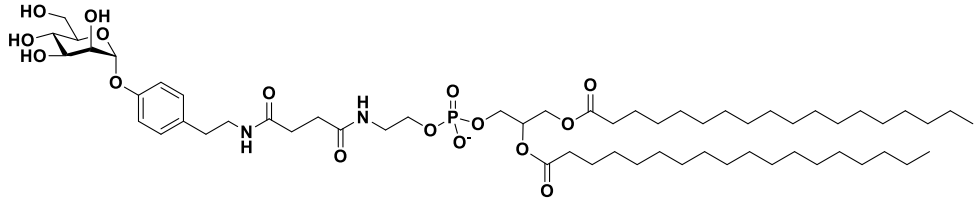


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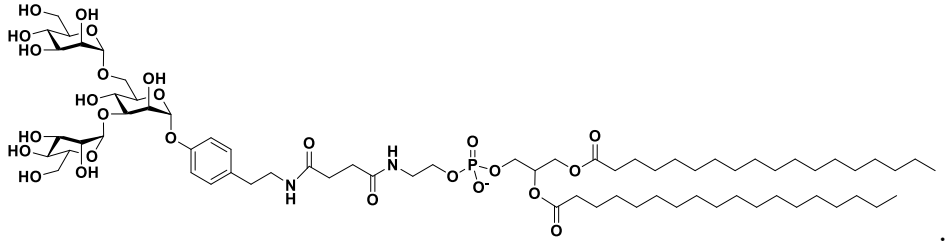


.

14. The vector of any one of claims 3 to 13, wherein the compound is selected from the group consisting of



and



.

15. A composition for use in preventing coronavirus infection, comprising the vector of any one of claims 2 to 14 and a pharmaceutically acceptable excipient, adjuvant, or a combination thereof.

16. A recombinant protein, encoded by the nucleic acid of claim 1.