CLAIMS

1. A modified nucleic acid molecule encoding a modified spike protein derived from a SARS-CoV-2 spike protein comprising one or more amino acid substitutions of asparagine (N) to glutamine (Q) at N-linked glycosylation sequons (N-X-S/T), wherein X is any amino acid residue except proline, and S/T denotes a serine or threonine residue, wherein the spike protein further comprises: one or more amino acid deletions or additions at N-linked glycosylation sequons (N-X-S/T) to eliminate N-linked glycan sequons, or one or more amino acid substitutions of S/T to alanine (A) at O-linked glycosylation sites to eliminate O-linked glycosylation sites, wherein the modified nucleic acid molecule is an mRNA or a double-strand or single-strand DNA.

2. The modified nucleic acid molecule of claim 1, wherein the spike protein comprises an amino acid sequence of SEQ ID NO: 2, 16, 18 or 20, or amino acid sequence having at least about 99%, 98%, 97%, 96%, 95%, 90%, 85%, or 80% identity to the amino acid sequence of SEQ ID NO: 2, 16, 18 or 20.

3. The modified nucleic acid molecule of claim 2, wherein the nucleic acid molecule encoding the amino acid sequence of SEQ ID NO: 2, 16, 18 or 20 is an mRNA comprising the nucleotide sequence of SEQ ID NO: 1, 15, 17 or 19 respectively, or a nucleotide sequence having at least about 99%, 98%, 97%, 96%, 95%, 90%, 85%, or 80% identity to the nucleotide sequence of SEQ ID NO: 1, 15, 17 or 19 respectively.

4. The modified nucleic acid molecule of claim 1, wherein the modified spike protein comprises an amino acid sequence of SEQ ID NO: 4, 22, 24 or 26, wherein the modified spike protein comprises a receptor binding domain (RBD) lacking glycosylation sites.

5. The modified nucleic acid molecule of claim 4, wherein the modified nucleic acid molecule encoding the amino acid sequence of SEQ ID NO: 4, 22, 24 or 26 comprises the nucleotide sequence of SEQ ID NO: 3, 21, 23 or 25 respectively, or a nucleotide sequence having at least about 99%, 98%, 97%, 96%, 95%, 90%, 85%, or 80% identity to the nucleotide sequence of SEQ ID NO: 3, 21, 23 or 25 respectively.

6. The modified nucleic acid molecule of claim 1, wherein the modified spike protein comprises an amino acid sequence of SEQ ID NO: 6, 28, 30 or 32, wherein the modified spike protein comprises a S2 subunit lacking glycosylation sites.

7. The modified nucleic acid molecule of claim 6, wherein the modified nucleic acid molecule encoding the amino acid sequence of SEQ ID NO: 6, 28, 30 or 32 comprises the nucleotide sequence of SEQ ID NO: 5, 27, 29 or 31 respectively, or a nucleotide sequence having at least about 99%, 98%, 97%, 96%, 95%, 90%, 85%, or 80% identity to the nucleotide sequence of SEQ ID NO: 527, 29 or 31 respectively.

8. The modified nucleic acid molecule of claim 1, wherein the modified spike protein described herein comprises an amino acid sequence of SEQ ID NO: 8 or 34, wherein the modified spike protein comprises a S2 subunit that consists of a single glycosylation site, wherein the single glycosylation site is at the position N1194.

9. The modified nucleic acid molecule of claim 8, wherein the modified nucleic acid molecule encoding the amino acid sequence of SEQ ID NO: 8 or 34 comprises the nucleotide sequence of SEQ ID NO: 7 or 33 respectively, or a nucleotide sequence having at least about 99%, 98%, 97%, 96%, 95%, 90%, 85%, or 80% identity to the nucleotide sequence of SEQ ID NO: 7 or 33 respectively.

10. The modified nucleic acid molecule of claim 1, wherein the modified spike protein comprises an amino acid sequence of SEQ ID NO: 10 or 36, wherein the modified spike protein comprises a receptor binding domain (RBD) lacking glycosylation sites, and an amino acid substitution of N801 to Q801.

11. The modified nucleic acid molecule of claim 10, wherein the modified nucleic acid molecule encoding the amino acid sequence of SEQ ID NO: 10 or 36 comprises the nucleotide sequence of SEQ ID NO: 9 or 35 respectively, or a nucleotide sequence having at least about 99%, 98%, 97%, 96%, 95%, 90%, 85%, or 80% identity to the nucleotide sequence of SEQ ID NO: 9 or 35 respectively.

12. The modified nucleic acid molecule of claim 1, wherein the modified spike protein comprises an amino acid sequence of SEQ ID NO: 12 or 38, wherein the modified spike protein comprises a receptor binding domain (RBD) lacking glycosylation sites, and an amino acid substitution of N1194 to Q1194.

13. The modified nucleic acid molecule of claim 12, wherein the modified nucleic acid molecule encoding the amino acid sequence of SEQ ID NO: 12 or 38 comprises the nucleotide sequence of SEQ ID NO: 11 or 37 respectively, or a nucleotide sequence having at least about 99%, 98%, 97%, 96%, 95%, 90%, 85%, or 80% identity to the nucleotide sequence of SEQ ID NO: 11 or 37 respectively.

14. The modified nucleic acid molecule of claim 1, wherein the modified spike protein described herein comprises an amino acid sequence of SEQ ID NO: 14 or 40, wherein the modified spike protein comprises a modified receptor binding domain (RBD) lacking glycosylation sites, and amino acid substitutions of N122 to Q122, N165 to Q165, and N234 to Q234.

15. The modified nucleic acid molecule of claim 14, wherein the modified nucleic acid molecule encoding the amino acid sequence of SEQ ID NO: 14 or 40 comprises the nucleotide sequence of SEQ ID NO: 13 or 39 respectively, or a nucleotide sequence having at least about 99%, 98%, 97%, 96%, 95%, 90%, 85%, or 80% identity to the nucleotide sequence of SEQ ID NO: 13 or 39 respectively.

16. The modified nucleic acid molecule of claim 1, wherein the mRNA for S-(deg-RBD) has the sequence of SEQ ID NO: 3, 21, 23 or 25, the mRNA or DNA for S-(deg-S2) has the sequence of SEQ ID NO: 5, 27, 29 or 31, the mRNA or DNA for S-(deg-S2-1194) has the sequence of SEQ ID NO: 7 or 33, the mRNA or DNA for S-(deg-RBD-801) has the sequence of SEQ ID NO: 9 or 35, the mRNA or DNA for S-(deg-RBD-1194) has the sequence of SEQ ID NO: 11 or 37, the mRNA or DNA for S-(deg-RBD-122-165-234) has the sequence of SEQ ID NO: 13 or 39.

17. The modified nucleic acid molecule of any of claims 1 to 16, which can be used as a coronavirus mRNA vaccine.

18. A combo vaccine, comprising the mRNA vaccine of claim 17 and one or more additional vaccines selected from the group consisting of one or more COVID-19 vaccine, influenza (flu) vaccine, advenovirus vaccine, anthrax vaccine, cholera vaccine, diphtheria vaccine, hepatitis A or B vaccine, HPV vaccine, measle vaccine, mumps vaccine, smallpox vaccine, rotavirus vaccine, tuberculosis vaccine, pneumoccal vaccine and Haemophilus influenzae type b vaccine and any combination thereof.

19. Use of the modified nucleic acid molecule according to any one of claims 1-17 in the manufacture of a composition for preventing or treating a coronavirus infection in a subject infected with, or at risk of being infected with, a coronavirus.

20. The use of claim 19, wherein the composition is formulated as a combination comprising one or more additional vaccines, wherein each member of the combination comprising an effective amount of the modified nucleic acid molecule ranging from about 5 μg to about 50 μg.