

CLAIMS

1. A fusion protein comprising:
 - (a)
 - (i) a spike protein from 2019-nCoV having at least 90% identity with SEQ ID NO: 1;
 - or
 - (ii) a polypeptide having at least 90% identity to an immunogenic fragment of SEQ ID NO: 1, wherein said fragment comprises or consists of receptor-binding domain (RBD) of the 2019-nCoV spike protein, preferably having at least 90% identity with SEQ ID NO: 15; and
 - (b)
 - (i) the Hepatitis B surface antigen;
 - (ii) the HPV 18 L1 protein;
 - (iii) the Hepatitis E P239 protein; and/or
 - (iv) the HPV 16 L1 protein.

2. The fusion protein of claim 1, wherein:
 - (a) the fusion protein is encoded by a polynucleotide which comprises or consists of a nucleic acid sequence having at least 90% identity with any one of SEQ ID NO: 3, 5, 6, 8, 26, 27, 29, 30, or 32; and/or
 - (b) the fusion protein comprises or consists of an amino acid sequence having at least 90% identity with any one of SEQ ID NO: 9, 10, 11, 12, 28, 31, or 33.

3. A virus-like particle (VLP) comprising:
 - (a) a spike protein from 2019-nCoV having at least 90% identity with SEQ ID NO: 1;
 - (b) a polypeptide having at least 90% identity to an immunogenic fragment of SEQ ID NO: 1, wherein said fragment comprises or consists of receptor-binding domain (RBD) of the 2019-nCoV spike protein, optionally having at least 90% identity with SEQ ID NO: 15;
 wherein optionally said VLP comprises or consists of a fusion protein as defined in claim 1 or 2.

4. An isolated polynucleotide encoding:
 - (a) a spike protein from 2019-nCoV having at least 90% identity with SEQ ID NO: 1; or
 - (b) a polypeptide having at least 90% identity to an immunogenic fragment of SEQ ID NO: 1, wherein said fragment comprises or consists of receptor-binding domain (RBD) of the 2019-nCoV spike protein, optionally having at least 90% identity with SEQ ID NO: 15; and

wherein said polynucleotide is optimised for recombinant expression.

5. The polynucleotide of claim 4, which:

(a) is optimised for expression in a host cell selected from:

(i) *Escherichia coli*;

(ii) yeast, preferably *Komagataella* or *Saccharomyces*; and/or

(iii) mammalian cells, preferably human cells; and/or

(b) has a codon adaptation index (CAI) of at least about 0.80, preferably at least about 0.9, more preferably at least about 0.93.

6. The polynucleotide of claim 4 or 5, wherein one or more cis-acting sequence motif is omitted, said one or more cis-acting sequence motif being independently selected from:

(a) an internal TATA-box;

(b) a chi-site;

(c) a ribosomal entry site;

(d) an AT-rich and/or GC-rich stretch of sequence;

(e) an RNA instability motif;

(f) a repeat sequence and/or an RNA secondary structure;

(g) a cryptic splice donor site;

(h) a cryptic splice acceptance site; and/or

(i) any combination of (a) to (i).

7. The polynucleotide of any one of claims 4 to 6, wherein the polynucleotide integrates into the host cell genome.

8. The polynucleotide of any one of claims 4 to 7, which comprises or consists of a nucleic acid sequence having:

(a) at least 90% identity to SEQ ID NO: 2;

(b) at least 90% identity to SEQ ID NO: 3;

(c) at least 90% identity to SEQ ID NO: 4;

(d) at least 90% identity to SEQ ID NO: 5;

(e) at least 90% identity to SEQ ID NO: 6;

(f) at least 90% identity to SEQ ID NO: 7;

(g) at least 90% identity to SEQ ID NO: 8

- (h) at least 90% identity to SEQ ID NO: 13
- (i) at least 90% identity to SEQ ID NO: 14
- (j) at least 90% identity to SEQ ID NO: 26
- (k) at least 90% identity to SEQ ID NO: 27
- (l) at least 90% identity to SEQ ID NO: 29;
- (m) at least 90% identity to SEQ ID NO: 30; or
- (n) at least 90% identity to SEQ ID NO: 32.

9. The polynucleotide of any one of claims 4 to 8, wherein the encoded spike protein, or fragment thereof:

- (a) retains the conformational epitopes present in the native 2019-nCoV spike protein; and/or
- (b) results in the production of neutralising antibodies specific for the spike protein or fragment thereof when the nucleic acid or the encoded spike protein or fragment thereof is administered to a subject.

10. An expression construct comprising polynucleotide of any one of claims 4 to 9, operably linked to a promoter.

11. A vaccine composition comprising:

- (a) a spike protein from 2019-nCoV having at least 90% identity with SEQ ID NO: 1; or
- (b) a polypeptide having at least 90% identity to an immunogenic fragment of SEQ ID NO: 1, wherein said fragment comprises or consists of receptor-binding domain (RBD) of the 2019-nCoV spike protein, optionally having at least 90% identity with SEQ ID NO: 15; optionally wherein the composition results in the production of neutralising antibodies specific for the spike protein or fragment thereof when administered to a subject.

12. A viral vector, RNA vaccine or DNA plasmid that:

- (a) expresses a spike protein from 2019-nCoV having at least 90% identity with SEQ ID NO: 1; or
- (b) expresses a polypeptide having at least 90% identity to an immunogenic fragment thereof of SEQ ID NO: 1, wherein said fragment comprises or consists of receptor-binding domain (RBD) of the 2019-nCoV spike protein, preferably having at least 90% identity with SEQ ID NO: 15.

13. The viral vector, RNA vaccine or DNA plasmid of claim 12, which expresses the spike protein or fragment thereof, further comprising a signal peptide; optionally wherein the signal peptide directs secretion from human cells.

14. The viral vector, RNA vaccine or DNA plasmid of claim 12 or 13, wherein the viral vector, RNA vaccine or DNA plasmid further expresses one or more additional antigen or a fragment thereof, preferably one or more additional antigen from 2019-nCoV, or a fragment thereof; optionally wherein the spike protein or fragment thereof and the one or more additional antigen or fragment thereof are expressed:

- (a) as a fusion protein; or
- (b) in separate viral vectors, RNA vaccines or DNA plasmids for use in combination.

15. The viral vector, RNA vaccine or DNA plasmid of any one of claims 12 to 14, which comprises one or more polynucleotide as defined in any one of claims 4 to 9 or an expression construct of claim 10.

16. A vaccine composition comprising the viral vector, and/or RNA vaccine and/or DNA plasmid of any one of claims 12 to 15.

17. The polynucleotide of any one of claims 4 to 9, and/or the expression construct of claim 10, and/or vaccine composition of any one of claims 11 and/or 16, and/or the viral vector and/or RNA vaccine and/or DNA plasmid of any one of claims 12 to 15, and/or the virus-like particle of claim 3, and/or the fusion protein of claim 1 or 2 for use in the treatment and/or prevention of 2019-nCoV infection.

18. Use of the polynucleotide of any one of claims 4 to 9, and/or the expression construct of claim 10, and/or vaccine composition of any one of claims 11 and/or 16, and/or the viral vector and/or RNA vaccine and/or DNA plasmid of any one of claims 12 to 15, and/or the virus-like particle of claim 3, and/or the fusion protein of claim 1 or 2 in the manufacture of a medicament for the prevention and/or treatment of 2019-nCoV infection.

19. A method of producing a spike protein from 2019-nCoV having at least 90% identity with SEQ ID NO: 1, or a fragment thereof, comprising expressing a polynucleotide as defined in any one of claims 4 to 9 in a host cell, and optionally purifying the spike protein or fragment.
20. The method of claim 19, which further comprises formulating said spike protein or fragment thereof with a pharmaceutically acceptable carrier or diluent.