

## **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;

wherein:

- 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

- 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.

2. 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 said VLP comprises or consists of a fusion protein as defined in claim 1.

3. 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 immunogenic fragment thereof.

4. The vaccine composition of claim 3, wherein the spike protein or immunogenic fragment thereof is comprised in a fusion protein which further comprises:

- (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.

5. The vaccine composition of claim 4, wherein the fusion protein:

- (a) 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.

6. The vaccine composition of claim 3, wherein the spike protein or immunogenic fragment thereof is comprised in a virus-like particle (VLP); wherein optionally said VLP comprises or consists of a fusion protein as defined in claim 4 or 5.

7. A vaccine composition comprising 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.

8. The vaccine composition of claim 7, wherein the viral vector, RNA vaccine or DNA plasmid expresses the spike protein or immunogenic fragment thereof, further comprising a signal peptide; optionally wherein the signal peptide directs secretion from human cells.

9. The vaccine composition of claim 7 or 8, 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 immunogenic fragment thereof and the one or more additional antigen or immunogenic fragment thereof are expressed:

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

10. The vaccine composition of any one of claims 7 to 9, wherein the viral vector, RNA vaccine or DNA plasmid which comprises one or more polynucleotide encoding the spike protein or immunogenic fragment thereof, or an expression construct comprising the polynucleotide operably linked to a promoter, wherein said polynucleotide is optimised for recombinant expression with:

(a) a codon adaptation index (CAI) of at least about 0.80, preferably at least about 0.9, more preferably at least about 0.93; and/or

(b) one or more cis-acting sequence motif is omitted from said polynucleotide, said one or more cis-acting sequence motif being independently selected from

- (i) an internal TATA-box;
- (ii) a chi-site;
- (iii) a ribosomal entry site;
- (iv) an AT-rich and/or GC-rich stretch of sequence;
- (v) an RNA instability motif;
- (vi) a repeat sequence and/or an RNA secondary structure;
- (vii) a cryptic splice donor site;
- (viii) a cryptic splice acceptance site; and/or
- (ix) any combination of (i) to (viii).

11. The vaccine composition of claim 10, wherein the polynucleotide is optimised for expression in a host cell selected from:

- (a) *Escherichia coli*;
- (b) yeast, preferably *Komagataella* or *Saccharomyces*; and/or
- (c) mammalian cells, preferably human cells.

12. The vaccine composition of claim 11, wherein the polynucleotide integrates into the host cell genome.

13. The vaccine composition of any one of claims 10 to 12, wherein the polynucleotide 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.

14. The vaccine composition of any one of claims 1 to 13, wherein the spike protein, or immunogenic 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 immunogenic fragment thereof when the nucleic acid or the encoded spike protein or immunogenic fragment thereof is administered to a subject.