

association of ZIKV with the autoimmune disease, Guillain-Barré Syndrome (GBS), and congenital malformations resulting in Microcephaly [4, 11].

[0006] To date, no prophylactic or therapeutic treatment is commercially available and licensed for ZIKV, despite intensive efforts in this direction.

SUMMARY

[0007] The present disclosure includes a novel ZIKV virus like particle (VLP) and materials and methods for making and using such particles, including formulations and uses as a vaccine, a prophylactic, therapeutic, and diagnostic.

[0008] The development of a safe and effective vaccine to protect against ZIKV infection is a high priority objective to reduce the incidence and spread of the severe forms of the disease. An urgent need for the vaccine is also underlined by the impact of the infection on pregnant women and the still unknown implications to men who may become infected.

[0009] An ideal vaccine candidate, in addition to having a high safety profile, should also be cost effective and economically viable with ease of large scale manufacture. Live virus vaccines and inactivated virus vaccines are expensive to manufacture due the requirement of highly stringent processes and containment facilities (BSL2 or BSL3), using sophisticated biological production systems (e.g., mammalian cells, eggs). An important caveat with an attenuated vaccine is the safety profile, particularly due to the potential for reversions that may reduce/eliminate attenuation. In the context of a virus like ZIKV, especially if required to be administered to pregnant women, this will be a critical concern.

[0010] In the case of inactivated whole virus vaccines, often the inactivation methodologies render epitopes ineffective. Epitope stability is important to the production of completely neutralizing antibodies or protective antibodies.

[0011] With the unresolved issue of the role of non-neutralizing and cross-reacting Dengue antibodies enhancing ZIKV infection, similar phenomena may be anticipated in the case of non-neutralizing or partially neutralizing cross-reacting ZIKV antibodies. With the prevalence of diverse strains of ZIKV, and pending information on effective cross-protection between diverse strains, a VLP strategy engineered using highly conserved regions of ZIKV surface glycoproteins, as provided herein, provides significant advantages. This approach will maintain the ZIKV epitope architecture while increasing the possibility of cross-protection across multiple ZIKV strains and cost-effective scale-up. During the last decade, advances in VLP production, purification, and adjuvant optimization led to several licensed vaccines for viral diseases [12]

such as human papilloma virus (HPV), hepatitis B virus (HBV), hepatitis E virus (HEV), and influenza. VLPs are more efficient for stimulating the immune system with respect to the subunit proteins because they have the ability to mimic the native morphology of the target virion and they display a repetitive array of epitopes in high concentration. In addition, VLPs are safe due to the absence of replicating viral genetic material [12].

[0012] In some examples, the VLPs disclosed herein are able to cross-protect across different strains of ZIKV. Contrary to other vaccination strategies such as live attenuated vaccines, a VLP strategy as disclosed herein possesses a higher safety profile, particularly for high risk populations such as immunocompromised individuals and pregnant women. In contrast to purified protein vaccines, VLPs of the disclosure express the immunological entity in higher concentration, in an appropriate conformation (folding) that expresses the epitopes effectively, and with a higher stability profile. From a product development perspective, the technology disclosed herein will also lend itself to facilitated scale-up with defined quality control strategies for large scale production.

[0013] Accordingly, in some examples the disclosure includes isolated peptides suitable for making Zika vaccines or Zika antibodies or for detecting Zika antibodies. For example, the disclosure includes an isolated peptide or protein comprising or consisting of an amino acid sequence that is at least 80% identical to a sequence as set out in any one or more of SEQ ID NOs: 2-11, 22-33, 46-47, or 50-51. Genera of peptides with higher minimum percent identity, including 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% minimum identity to a reference sequence also are contemplated. In some examples, the isolated peptide or protein comprises or consists of an amino acid sequence that is 100% identical to a sequence as set out in any one or more of SEQ ID NOs: 2-11, 22-33, 46-47, or 50-51, or an immunogenic fragment thereof. In some examples, the disclosure provides an isolated peptide comprising or consisting of an amino acid sequence that is at least 80% identical to a sequence as set out in any one or more of SEQ ID NOs: 2-11. In some examples, the isolated peptide comprises or consists of an amino acid sequence that is 100% identical to a sequence as set out in any one or more of SEQ ID NOs: 2-11. In some examples, the disclosure provides an isolated peptide comprising or consisting of an amino acid sequence that is at least 80% identical to a sequence as set out in any one or more of SEQ ID NOs: 22-33. In some examples, the isolated peptide comprises or consists of an amino acid sequence that is 100% identical to a sequence as set out in any one or more of SEQ ID NOs: 22-33. In some examples, the disclosure provides an isolated peptide comprising or consisting of an amino acid sequence that is at least 80% identical to a sequence as set out in any one or

more of SEQ ID NOs: 46-47. In some examples, the isolated peptide comprises or consists of an amino acid sequence that is 100% identical to a sequence as set out in any one or more of SEQ ID NOs: 46-47. In some examples, an isolated peptide is provided comprising or consisting of an amino acid sequence that is at least 80% identical to a sequence as set out in any one or more of SEQ ID NOs: 50-51. In some examples, the isolated peptide comprises or consists of an amino acid sequence that is 100% identical to a sequence as set out in any one or more of SEQ ID NOs: 50-51.

[0014] In related examples, the disclosure includes a chimeric peptide comprising a peptide derived from Zika as described herein, including those of the preceding paragraph, linked to a heterologous peptide or protein having an amino acid sequence that is at least 90% identical to a Woodchuck Hepatitis core Antigen protein (WHcAg) comprising or consisting of an amino acid sequence as set out in SEQ ID NO: 1, or comprising or consisting of at least one fragment of SEQ ID NO: 1. In some variations, the Zika-derived peptide portion of the chimeric peptide is inserted within the WHcAg-derived portion. Higher minimum percent identities also are contemplated, as described in the preceding paragraph. In some examples, the chimeric peptide further includes at least one peptide linker of 1-10 amino acids linking the sequence that is at least 80% identical to any one or more of SEQ ID NOs: 2-11 or 22-33 or 46-47 or 50-51 to the sequence that is at least 90% identical to a WHcAg protein. In some examples, the chimeric peptide comprises or consists of an amino acid sequence at least 90% or at least 95% identical to any one of SEQ ID NOs: 12-21, 34-45, 48-49, and 52-53.

[0014a] In an aspect, the present disclosure refers to a chimeric peptide comprising a first peptide selected from SEQ ID NOS: 2-11, 22-33, 46, 47, 50 and 51 operably linked to a second heterologous peptide having an amino acid sequence that is at least 80% identical to a Woodchuck Hepatitis core Antigen protein (WHcAg) comprising an amino acid sequence of SEQ ID NO: 1 or a functional fragment thereof.

[0015] For example, the disclosure includes a chimeric peptide comprising a Zika-derived peptide as described herein linked to a heterologous peptide having an amino acid sequence that is at least 90% identical to a Woodchuck Hepatitis core Antigen protein (WHcAg) comprising or consisting of an amino acid sequence as set out in SEQ ID NO: 1, wherein the Zika-derived peptide is inserted into the WHcAg-derived peptide at a position between amino acids 77 and 82 of SEQ ID NO: 1.

[0016] In related examples, the disclosure includes a polynucleotide comprising a nucleotide sequence encoding any of the polypeptides described herein. In one aspect, the present disclosure refers to a polynucleotide comprising a nucleotide sequence encoding the chimeric peptide described herein. Polynucleotides that are DNA, RNA, and that comprises synthetic or modified nucleotides are contemplated. In some examples, the polynucleotide comprises a nucleotide sequence at least 90% identical to or at least 95% identical to any one of SEQ ID NOs: 65-74, 87-98, 101-102, and 105-106.

[0017] The disclosure further includes, in some examples, a vector comprising a polynucleotide as disclosed herein. In some variations, the vector comprises an expression vector comprising a polynucleotide of the disclosure operably linked to an expression control sequence. Vectors suitable for expression in all varieties of host cells are contemplated, including prokaryotic expression vectors and eukaryotic expression vectors. Exemplary eukaryotic expression vectors include vectors for expression in mammalian cells, insect cells, plant cells, avian cells, amphibian cells, and fungal cells, including yeast cells.

[0017a] In one aspect, the present disclosure refers to an expression vector comprising the polynucleotide as described herein operably linked to an expression control sequence.

[0018] In further examples, the invention includes a recombinant host cell comprising a vector or expression vector as disclosed herein. In some examples, the host cell is (a) a eukaryotic cell selected from the group consisting of mammalian, fungal (*e.g.* yeast), insect, plant, amphibian and avian cells; or (b) a prokaryotic cell.

[0018a] In one aspect, the present disclosure refers to a recombinant host cell comprising the expression vector as disclosed herein.

[0019] In one aspect, the present disclosure also refers to a composition comprising a vector as described herein in a pharmaceutically acceptable carrier, diluent, stabilizer, preservative, or adjuvant.

[0020] In some examples, the disclosure includes a virus-like particle (VLP) comprising or consisting essentially of one or more chimeric peptides or proteins described herein. In further examples, the disclosure includes an article comprising a chimeric peptide or protein as described herein or a VLP as described herein attached to a solid support. In some examples, the solid support is a microbead, an assay plate, a test strip, or a filter. In some variations, the article further includes a distinct peptide attached to the article, optimally at a spatially distinct location, that can serve as a positive or negative control in assays described herein. In still other variations, the article is packaged as part of a kit with at least one assay reagent, such as an immunoassay reagent.

[0020a] In one aspect, the present disclosure refers to a virus like particle (VLP) comprising the chimeric peptide as disclosed herein.

[0021] The disclosure also includes a composition comprising a peptide or protein described herein, or a chimeric peptide or protein described herein, and a

pharmaceutically acceptable diluent, adjuvant, excipient, stabilizer, preservative, or carrier. In some variations, the disclosure provides an antigenic composition comprising a VLP as disclosed herein, wherein the VLP is present in the composition at a concentration of about 0.1-2000 µg/ml of core antigen, in a pharmaceutically acceptable carrier, diluent, stabilizer, preservative, or adjuvant.

[0022] In additional variations, the disclosure includes an antigenic composition comprising two or more different polypeptides, chimeric polypeptides, or VLP's described herein. For instance, the disclosure includes first and second VLP described herein, wherein the first and second VLP comprise different sequences independently selected from amino acid sequences at least 80% identical to SEQ ID NOs: 2-11, 22-33, 46-47, and 50-51. For

examples of this nature, ordinals such as "first" or "second" are intended simply to differentiate one from another, and are not intended to imply an order. Such compositions optionally further includes a pharmaceutically acceptable diluent, adjuvant, excipient, stabilizer, preservative, or carrier.

[0022a] In one aspect, the present disclosure refers to an antigenic composition comprising the VLP as disclosed herein, wherein the VLP is present in the composition at a concentration of about 0.1-2000 µg/ml, in a pharmaceutically acceptable carrier, diluent, stabilizer, preservative, or adjuvant, said composition inducing one or more of a protective immune response, production of anti-Zika neutralizing antibody, and production of anti-Zika protective antibody.

[0022b] In another aspect, the present disclosure refers to an antigenic composition comprising the VLP as disclosed herein in a pharmaceutically acceptable carrier, diluent, stabilizer, preservative, or adjuvant, said composition comprising SEQ ID NO: 15.

[0023] In a related example, the disclosure is an antigenic composition comprising first, second, and third VLP as described herein. For instance, the first, second, and third VLP comprise different sequences independently selected from amino acid sequences at least 80% identical to SEQ ID NOs: 2-11, 22-33, 46-47, and 50-51.

[0024] In another related example, the disclosure is an antigenic composition comprising first, second, third, fourth, fifth, sixth, and seventh VLP as described herein. For example, the first, second, third, fourth, fifth, sixth, and seventh VLP comprise different sequences independently selected from SEQ ID NOs: 2-11, 22-33, 46-47, and 50-51.

[0025] The disclosure also includes a kit comprising a VLP as described herein, or comprises an article of manufacture as described herein, packaged with at least one reagent useful for performing an immunoassay. Exemplary suitable reagents include an enzyme substrate, a detection antibody, positive and negative control reagents, substrate/s detection solution, and washing, blocking, and diluent buffer. In some examples, the kit includes a specific apparatus used for the execution of the protocol and for the detection.

[0025a] In one aspect, the present disclosure refers to a kit comprising the VLP as disclosed herein packaged with at least one reagent selected from an enzyme substrate, a detection antibody, and a blocking buffer.

[0026] The disclosure further includes an antigenic composition comprising a peptide, a chimeric peptide or chimeric protein, or a VLP as described herein in a

pharmaceutically acceptable carrier, diluent, stabilizer, preservative, or adjuvant, wherein the composition is capable of generating an immune response to a Zika virus. An exemplary immune response includes antibody generation or a protective immune response in a mammalian subject. Desirably, the antibody response generated by the composition is improved relative to or compared to an immune response achieved with live Zika virus or Zika Envelope (E) recombinant protein. In some variations, the antibody response is a protective and functional against Zika virus by neutralizing activity, and/or antibody dependent cell-mediated cytotoxicity (ADCC), and/or antibody dependent cell-mediated phagocytosis (ADCP), and/or complement-dependent cytotoxicity (CDC), and/or T cell response (e.g. CD4+ and CD8+) and/or other protective immune mechanisms.

[0027] In still additional examples, the disclosure includes a vaccine comprising a peptide, chimeric peptide, chimeric protein, VLP, or antigenic composition as described herein and an adjuvant. In some examples, the adjuvant is a polymeric particle, cholera toxin, or

imidazoquinoline. In further examples, the adjuvant formulations include the classical aluminum-based adjuvants, and novel classes of adjuvants such as liposomes (e.g., CAF01), agonists of pathogen recognition receptors (e.g. Immune stimulating complexes (ISCOMs), Lipid A analogs (MPL, RC-529, and GLA), double stranded RNA analogs (e.g. Poly I:C and Poly ICLC), cytidine monophosphate guanosine oligodeoxynucleotide (e.g. CpG, CpG ODN), flagellin, imidazoquinoline (Imiquimod and Resiquimod), polymeric particles (e.g. Chitosan), emulsions (e.g. squalene oil-based), cytokines (e.g. Interleukin-12), bacterial toxins (e.g. Cholera Toxin (CT) or Escherichia coli enterotoxin (LT)), Quil A and other saponins known in the art, and the plant polysaccharide inulin [12].

[0027a] In one aspect, the present disclosure refers to a vaccine comprising the antigenic composition as disclosed herein, and an adjuvant.

[0028] The disclosure also includes methods of making and methods of using any of the foregoing compounds, compositions, articles of manufacture, apparatuses, and/or materials. Furthermore, it should be understood that examples of the disclosures that are described herein as methods can alternatively be described as “uses” of the compounds, compositions, articles, apparatuses and/or materials. All equivalent “uses” are also contemplated as examples of the disclosure.

[0029] In some variations, the disclosure includes a method of producing an immune response to a Zika virus in a subject, the method comprising administering to the subject an effective amount of an antigenic composition or a vaccine as described herein, thereby producing (causing the subject's immune system to generate) an immune response to a Zika virus in the subject. In related variations, the disclosure provides an antigenic composition or vaccine for use in producing an immune response to a Zika virus in a subject characterized in that producing the immune response comprises administering to the subject an effective amount of an antigenic composition or a vaccine as described herein, thereby producing (causing the subject's immune system to generate) an immune response to a Zika virus in the subject.

[0029a] In one aspect, the present disclosure refers to use of an effective amount of the antigenic composition as disclosed herein in the manufacture of a medicament for producing an immune response to a Zika virus in a subject.

[0030] In some variations, the disclosure includes a method of treating a Zika virus infection in a subject in need thereof, the method comprising administering to the subject an effective amount of an antigenic composition described herein, thereby treating a Zika virus infection in the subject. In related variations, the disclosure provides an antigenic composition for use in treating a subject in need thereof, characterized in that the treating comprises administering to the subject an effective amount of an antigenic composition described herein, thereby treating a Zika virus infection in the subject.

[0031] In still additional variations, the disclosure includes a method of preventing a disease or disorder caused by a Zika virus infection in a subject, the method comprising

administering to the subject an effective amount of an antigenic composition or a vaccine as described herein, in an amount effective to prevent a disease or disorder caused by a Zika virus infection in the subject. In related variations, the disclosure provides an antigenic composition or a vaccine for use in preventing a disease or disorder caused by a Zika virus infection in a subject, characterized in that the use comprises administering to the subject an effective amount of an antigenic composition or a vaccine as described herein, in an amount effective to prevent a disease or disorder caused by a Zika virus infection in the subject.

[0031a] In one aspect, the present disclosure refers to use of the vaccine as disclosed herein in the manufacture of a medicament for inhibiting Zika virus infection in a subject, wherein the subject is to be administered with an effective amount of the medicament, thereby preventing a disease or disorder caused by a Zika virus infection in the subject.

[0032] The disclosure also includes a method of protecting a subject from developing one or more symptoms of Zika virus infection, the method comprising administering to the subject a vaccine composition as described herein, in an amount effective to protect the subject from developing one or more symptoms of Zika virus infection. In related variations, the method is effective to reduce the number, severity, or duration of symptoms of a Zika virus infection. In some examples, the reduction in symptoms is measured as a reduction in viral load or viral copy number in the subject. In further examples, the disclosure provides a vaccine composition for use in protecting a subject from developing symptoms of Zika virus infection, characterized in that the protecting comprises administering to the subject a vaccine composition as described herein, in an amount effective to protect the subject from developing symptoms of Zika virus infection.

[0033] In still another related example, the disclosure includes a method of immunizing a mammalian subject against a Zika virus infection comprising administering to the subject an effective amount of an antigenic composition described herein or a vaccine described herein. In some examples, the disclosure provides an antigenic composition or a vaccine of the disclosure for use in immunizing a mammalian subject against a Zika virus infection, characterized in that the immunizing comprises administering to the subject an effective amount of an antigenic composition described herein or a vaccine described herein.

[0034] In some examples, the disclosure provides a method of protecting a subject from sexual transmission of Zika virus, comprising administering to the subject an effective amount of an antigenic composition or vaccine of the disclosure, thereby protecting the subject from sexual transmission of Zika virus. In some examples, the disclosure provides an antigenic composition or a vaccine for use in protecting a subject from sexual transmission of Zika virus, characterized in that the protecting comprises administering to the subject an effective amount of an antigenic composition or vaccine of the disclosure, thereby protecting the subject from sexual transmission of Zika virus. In some examples, the administering is mucosal

administration. In further examples, the mucosal administration is nasal, vaginal, rectal, or oral.

[0035] The materials and methods described herein also are useful for quantifying or detecting a Zika immune response after infection and/or vaccination. In one aspect, the present disclosure refers to a method of detecting or measuring antibodies to Zika virus in a biological sample comprising:

a) contacting a VLP as described herein with a biological sample under conditions suitable for the formation of an antigen-antibody complex; and

b) measuring or detecting antibodies to Zika virus by detecting or measuring an antigen-antibody complex formed between antibodies in the biological sample and the VLP.

[0036] The disclosure further includes a method of detecting a Zika virus infection comprising steps of:

a) contacting the VLP as described herein with a biological sample from a mammalian subject under conditions suitable for the formation of an antigen-antibody complex; and

b) detecting the antigen-antibody complex formed between the VLP and antibodies in the biological sample, thereby detecting the Zika virus infection.

[0037] In some variations, the foregoing method further comprises a step of detecting the Zika virus in the biological sample, wherein presence of the Zika virus indicates a current Zika virus infection.

[0038] The disclosure also includes a method for screening antibodies comprising steps of:

a) measuring binding of an antibody or fragment thereof to a VLP as described herein;

b) measuring binding of the antibody or fragment thereof to a Woodchuck Hepatitis core Antigen protein (WHcAg) VLP or protein; and

c) determining that the antibody or fragment thereof is an anti-Zika antibody when the antibody or fragment thereof binds to the VLP but not the WHcAg.

Such a method is particularly useful for evaluating antibodies produced following an immunization with VLP described herein and/or Zika virus infection.

[0039] In any of the foregoing methods, some variations involving using the VLP in solution or suspension. In other variations, the VLP is attached to a solid support, such as any of a microbead, an assay plate, a test strip, or a filter.

[0040] The disclosure also includes methods of making the VLP described herein. For instance, the disclosure includes a method of producing a VLP comprising introducing into a host cell the vector of claim 6 under conditions such that the cell produces the VLP. In some variations, the host cell is a eukaryotic cell, such as a mammalian cell, a fungal or yeast cell, an insect cell, a plant cell, an amphibian cell, or an avian cell. In still other variations, the cell is a prokaryotic cell, such as a bacterial cell. An exemplary yeast host cell is a *Pichia pastoris* cell (e.g., *Komagataella phaffii* Kurtzman (ATCC® 76273™)). In some variations, the vector is introduced into the host cell via transformation, transfection, transduction, or electroporation. In some variations, the cells are cultured at temperatures ranging from 25°C to 37°C in an incubator or fermenter or shaker, in continuous agitation and oxygenation. Optionally, the VLP produced according to such a method is purified from the host cell or a culture media of the host cell. Exemplary suitable procedures for VLP purification include precipitation, ultracentrifugation, density gradient ultracentrifugation, ultrafiltration such as tangential flow filtration (TFF) and other methods, chromatography, or a combination thereof.

[0041] The disclosure also includes a VLP produced by any of the foregoing methods.

[0042] Reference throughout this specification to "one embodiment", "some embodiments" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the example is included in at least one example of the present disclosure. The particular features, structures, or characteristics described herein may be combined in any suitable manner, and all such combinations are contemplated as examples of the disclosure.

[0043] Unless otherwise specified the use of the ordinal adjectives "first", "second", "third", etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0044] The headings herein are for the convenience of the reader and not intended to be limiting. Additional aspects, examples, and variations of the disclosure will be apparent from the Detailed Description and/or Drawing and/or claims.

[0045] Although the Applicant invented the full scope of the disclosure described herein, the Applicant does not intend to claim subject matter described in the prior art work of others. Therefore, in the event that statutory prior art within the scope of a claim is brought to the attention of the Applicant by a Patent Office or other entity or individual, the Applicant reserves the right to exercise amendment rights under applicable patent laws to redefine the subject matter of such a claim to specifically exclude such statutory prior art or obvious variations of statutory prior art from the scope of such a claim. Variations of the disclosure defined by such amended claims also are intended as aspects of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046] **Figure 1** depicts elements of the WHcAg VLP system as disclosed herein for epitope delivery. The depictions on the left show a WHcAg core antigen peptide and VLP comprised of such peptides. The images on the right show a chimeric peptide of the invention and a VLP comprised of such peptides. The dark black portions depict the displayed ZIKV epitope.

[0047] **Figure 2** depicts an example of a DNA construct for WHcAg chimeric VLP expression in a yeast system.

[0048] **Figures 3A and 3B** depict the structural vaccinology strategy that was applied for developing WHcAg-ZIKV chimeric VLPs using the Envelope protein Domain III (EDIII). In Figure 3B the EDIII sub-structural domain CD Loop is included for composition of the WHcAg-ZIKV chimeric VLP.

[0049] **Figure 4** shows a flow chart for production, purification, and quality testing of WHcAg-ZIKV chimerics.

[0050] **Figure 5** shows a WHcAg VLP analyzed by electron microscopy. Scale bar = 50 nanometers (nm).

[0051] **Figure 6** illustrates dot blot and Western blot analysis showing WHcAg-ZIKV chimeric VLP production and antigenicity. Figure 6A demonstrates WHcAg production and purification from Pichia culture, WHcAg VLPs are detected using the commercially available monoclonal antibody HepBcAg. Figures 6B and 6C show WHcAg-ZIKV chimeric VLPs

WHAT IS CLAIMED IS:

1. A chimeric peptide comprising a first peptide selected from SEQ ID NOS: 2-11, 22-33, 46, 47, 50 and 51 operably linked to a second heterologous peptide having an amino acid sequence that is at least 80% identical to a Woodchuck Hepatitis core Antigen protein (WHcAg) comprising an amino acid sequence of SEQ ID NO: 1 or a functional fragment thereof.
2. The chimeric peptide of claim 9, wherein the first peptide replaces amino acids from positions 77 to 82 of SEQ ID NO: 1 or functional fragments thereof.
3. The chimeric peptide according to claim 1, further including at least one peptide linker of 1-10 amino acids linking the first peptide to the sequence that is at least 90% identical to a WHcAg protein.
4. A polynucleotide comprising a nucleotide sequence encoding the chimeric peptide of claim 1.
5. An expression vector comprising the polynucleotide of claim 4 operably linked to an expression control sequence.
6. A recombinant host cell comprising the expression vector of claim 5.
7. The recombinant host cell of claim 6, wherein the host cell is:
 - (i) a eukaryotic cell selected from the group consisting of mammalian, yeast, insect, plant, amphibian and avian cells; or
 - (ii) a prokaryotic cell.
8. A virus like particle (VLP) comprising the chimeric peptide of claim 1.
9. The VLP according to claim 8, attached to a solid support microbead, an assay plate, a test strip, or a filter.

10. An antigenic composition comprising the VLP of claim 8, wherein the VLP is present in the composition at a concentration of about 0.1-2000 µg/ml, in a pharmaceutically acceptable carrier, diluent, stabilizer, preservative, or adjuvant, said composition inducing one or more of a protective immune response, production of anti-Zika neutralizing antibody, and production of anti-Zika protective antibody.
11. An antigenic composition comprising the VLP of claim 8 in a pharmaceutically acceptable carrier, diluent, stabilizer, preservative, or adjuvant, said composition comprising SEQ ID NO: 15.
12. The antigenic composition of claim 11 comprising a VLP according to claim 8, and one or more VLP comprising different sequences independently selected from amino acid sequences at least 80% identical to SEQ ID NOs: 2-4, 6-11, 22-33, 46-47, or 50-51.
13. A composition comprising the vector of claim 5 in a pharmaceutically acceptable carrier, diluent, stabilizer, preservative, or adjuvant.
14. The composition of claim 13, comprising an adjuvant.
15. A kit comprising the VLP of claim 8 packaged with at least one reagent selected from an enzyme substrate, a detection antibody, and a blocking buffer.
16. A vaccine comprising the antigenic composition of claim 11, and an adjuvant.
17. Use of an effective amount of the antigenic composition of claim 11 in the manufacture of a medicament for producing an immune response to a Zika virus in a subject.
18. Use of the vaccine of claim 16 in the manufacture of a medicament for inhibiting Zika virus infection in a subject, wherein the subject is to be administered with an effective amount of

the medicament, thereby preventing a disease or disorder caused by a Zika virus infection in the subject.

19. The use of claim 18, wherein administration of the medicament is vaginal or nasal mucosal administration.

20. A method of detecting or measuring antibodies to Zika virus in a biological sample comprising:

a) contacting the VLP of claim 8 with a biological sample under conditions suitable for the formation of an antigen-antibody complex; and

b) measuring or detecting antibodies to Zika virus by detecting or measuring an antigen-antibody complex formed between antibodies in the biological sample and the VLP.