

CLAIMS

WHAT IS CLAIMED:

- 5 1. A pharmaceutical composition comprising:
virus-like particles (VLPs) of at least one type of human papillomavirus (HPV) selected
from the group consisting of HPV types: 6, 11, 16, 18, 26, 31, 33, 35, 39, 45, 51, 52, 53, 55, 56,
58, 59, 66, 68, 73, and 82,
a lipid nanoparticle (LNP) adjuvant, and
10 a pharmaceutically acceptable carrier.
2. The pharmaceutical composition of claim 1, wherein the pharmaceutical composition
comprises VLPs of at least HPV types 16 and 18.
- 15 3. The pharmaceutical composition of claim 1, wherein the pharmaceutical composition
comprises VLPs of at least HPV types 6, 11, 16, and 18.
4. The pharmaceutical composition of claim 1, wherein the pharmaceutical composition
comprises VLPs of at least HPV types 31, 45, 52, and 58.
- 20 5. The pharmaceutical composition of claim 1, wherein the pharmaceutical composition
comprises VLPs of at least HPV types 6, 11, 16, 18, 31, 33, 45, 52, and 58.
6. The pharmaceutical composition of any of claims 1-5, wherein the LNP adjuvant
25 comprises a cationic lipid, a phospholipid, cholesterol, and a PEG-lipid.
7. The pharmaceutical composition of any of claims 1-6, wherein the LNP adjuvant
comprises 30-65 mole% cationic lipid, 5-30 mole% phospholipid, 10-40 mole% cholesterol, and
0.5-4 mole% PEG-lipid.
- 30 8. The pharmaceutical composition of any of claims 1-7, wherein the LNP adjuvant
comprises 55-65 mole% cationic lipid, 5-15 mole% phospholipid, 25-35 mole% cholesterol, and
1-2.5 mole% PEG-lipid.

9. The pharmaceutical composition of any of claims 1-8, wherein the LNP adjuvant comprises DSPC, cholesterol, ePEG2000-DMG, and (13Z, 16Z) – N, N-dimethyl-3-nonyldocosa 13, 16-dien-1-amine.
- 5 10. The pharmaceutical composition of any of claims 1-9, wherein the LNP adjuvant comprises 5-15 mole% DSPC, 25-35 mole% cholesterol, 1-2.5 mole% ePEG2000-DMG, and 55-65 mole% (13Z, 16Z) – N, N-dimethyl-3-nonyldocosa 13, 16-dien-1-amine.
11. The pharmaceutical composition of any of claims 1-10, further comprising an aluminum
10 adjuvant.
12. A pharmaceutical composition comprising:
(a) virus like particles (VLPs) of at least one type of human papillomavirus (HPV),
wherein the at least one type of HPV is selected from the group consisting of HPV types: 6, 11,
15 16, 18, 26, 31, 33, 35, 39, 45, 51, 52, 53, 55, 56, 58, 59, 66, 68, 73, and 82;
(b) about 100 µg to about 900 µg of an aluminum adjuvant; and
(c) about 10 µg to about 200 mg of a lipid nanoparticle (LNP) adjuvant,
wherein each of the HPV VLPs comprise recombinant L1 or recombinant L1 + L2 protein;
wherein each of the HPV VLPs are present in a concentration of about 10 µg to about
20 100 µg per 0.5 mL of the pharmaceutical composition;
wherein the total HPV VLP concentration is between 10 µg and 2000 µg per 0.5 mL of
the pharmaceutical composition; and
wherein the HPV VLPs are adsorbed onto the aluminum adjuvant.
- 25 13. The pharmaceutical composition of claim 12, wherein the pharmaceutical composition comprises HPV VLPs of at least HPV types 16 and 18.
14. The pharmaceutical composition of claims 12, wherein the pharmaceutical composition comprises HPV VLPs of at least HPV types 6, 11, 16, and 18.
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15. The pharmaceutical composition of claims 12, wherein the pharmaceutical composition comprises HPV VLPs of at least HPV types 31, 45, 52, and 58.

16. The pharmaceutical composition of claim 12, wherein the pharmaceutical composition comprises HPV VLPs of at least HPV types 6, 11, 16, 18, 31, 33, 45, 52, and 58.
17. The pharmaceutical composition of any of claims 12-16, wherein the LNP adjuvant
5 comprises a cationic lipid, a phospholipid, cholesterol, and a PEG-lipid.
18. The pharmaceutical composition of claim 17, wherein the LNP adjuvant comprises 30-65 mole% cationic lipid, 5-30 mole% phospholipid, 10-40 mole% cholesterol, and 0.5-4 mole% PEG-lipid.
- 10 19. The pharmaceutical composition of claim 18, wherein the LNP adjuvant comprises DSPC, cholesterol, ePEG2000-DMG, and (13Z, 16Z) – N, N-dimethyl-3-nonyldocosa 13, 16-dien-1-amine.
- 15 20. The pharmaceutical composition of claim 19, wherein the LNP adjuvant comprises 5-15 mole% DSPC, 25-35 mole% cholesterol, 1-2.5 mole% ePEG2000-DMG, and 55-65 mole% (13Z, 16Z) – N, N-dimethyl-3-nonyldocosa 13, 16-dien-1-amine.
21. The pharmaceutical composition of any of claims 1-20, wherein the HPV VLPs comprise
20 HPV L1 protein and do not comprise HPV L2 protein.
22. The pharmaceutical composition of any of claims 1-20, wherein the HPV VLPs consists of HPV L1 protein.
- 25 23. A single-dose vaccine composition comprising:
a lipid nanoparticle (LNP) adjuvant, wherein the adjuvant comprises 30-65 mole% cationic lipid, 5-30 mole% phospholipid, 10-40 mole% cholesterol, and 0.5-4 mole% PEG-lipid,
virus-like particles (VLPs) of at least one type of human papillomavirus (HPV) selected
from the group consisting of HPV types: 6, 11, 16, 18, 26, 31, 33, 35, 39, 45, 51, 52, 53, 55, 56,
30 58, 59, 66, 68, 73, and 82,
wherein the single-dose vaccine composition provides an elevated or comparable anti-HPV immune response relative to multiple doses of the same composition formulated without an LNP adjuvant.

24. The single-dose vaccine composition of claim 23, wherein the vaccine further comprises an aluminum adjuvant.
- 5 25. The single-dose vaccine composition of claim 24, wherein the HPV VLPs are adsorbed onto the aluminum adjuvant.
26. The single-dose vaccine composition of any of claims 23-25, wherein each of the HPV VLPs are present in a concentration of about 10 μ g to about 100 μ g per 0.5 mL of the
10 pharmaceutical composition and wherein the total HPV VLP concentration is between 10 μ g and 2000 μ g per 0.5 mL of the pharmaceutical composition.
27. A method of inducing an immune response to a human papillomavirus (HPV) in a human patient comprising administering to the patient the pharmaceutical composition of any of claims
15 1-22 or the single-dose vaccine composition of any of claims 23-26.
28. A method of inducing an immune response to a human papillomavirus (HPV) in a human patient comprising co-administering to the patient (a) a pharmaceutical composition comprising virus-like particles (VLPs) of at least one type of human papillomavirus (HPV) selected from the
20 group consisting of HPV types: 6, 11, 16, 18, 26, 31, 33, 35, 39, 45, 51, 52, 53, 55, 56, 58, 59, 66, 68, 73, and 82 and (b) an LNP adjuvant.
29. A method of preventing infection of a human patient by a human papillomavirus (HPV) comprising administration to the patient the pharmaceutical composition of any of claims 1-22 or
25 the single-dose vaccine composition of any of claims 23-26.
30. A method of preventing infection of a human patient by a human papillomavirus (HPV) comprising co-administering to the patient (a) a pharmaceutical composition comprising virus-like particles (VLPs) of at least one type of human papillomavirus (HPV) selected from the
30 group consisting of HPV types: 6, 11, 16, 18, 26, 31, 33, 35, 39, 45, 51, 52, 53, 55, 56, 58, 59, 66, 68, 73, and 82 and (b) an LNP adjuvant.
31. A kit comprising:

- (a) a human papilloma virus (HPV) vaccine; and
- (b) an LNP adjuvant.

32. The kit of claim 31, further comprising instructions for administering to a human patient
5 the HPV vaccine and the LNP adjuvant.

33. The kit of any of claims 25 and 26, wherein the HPV vaccine comprises virus-like
particles (VLPs) of at least one type of human papillomavirus (HPV) selected from the group
consisting of HPV types: 6, 11, 16, 18, 26, 31, 33, 35, 39, 45, 51, 52, 53, 55, 56, 58, 59, 66, 68,
10 73, and 82.

34. A method of delivering a pharmaceutical composition that induces a neutralizing titer
against an HPV antigen in a host comprising:

- (a) administering a pharmaceutical composition comprising:
15 a lipid nanoparticle (LNP) adjuvant, and
virus-like particles (VLPs) of at least one type of human papillomavirus (HPV) selected
from the group consisting of HPV types: 6, 11, 16, 18, 26, 31, 33, 35, 39, 45, 51, 52, 53, 55, 56,
58, 59, 66, 68, 73, and 82,
and
20 (b) inducing a neutralizing titer against the HPV antigen in the host,
where a single dose of the pharmaceutical composition provides enhanced or comparable
neutralizing titers when compared to multiple doses of the same pharmaceutical
composition when the anti-HPV composition is formulated without an adjuvant.

25 35. The method of claim 34, further comprising an aluminum adjuvant.