

What is claimed is:

1. A composition comprising:

an aluminum-containing wet gel suspension selected from aluminum hydroxide wet gel
5 suspension and aluminum phosphate wet gel suspension;

a vaccine in an amount effective to stimulate an immune response in a mammal;

a sugar, sugar alcohol, or combinations thereof; and

a thickener;

wherein the composition has a viscosity of 500 to 30,000 cps when measured at 100s^{-1} and
10 temperature of 25 °C.

2. The composition of claim 1, comprising a sugar, wherein the sugar is selected from
raffinose, stachyose, sucrose, trehalose, apiose, arabinose, digitoxose, fucose, fructose, galactose,
15 glucose, gulose, hamamelose, idose, lyxose, mannose, ribose, tagatose, xylose, cellobiose,
gentiobiose, lactose, lactulose, maltose, melibiose, primeverose, rutinose, scillabiose, sophorose,
turanose, and vicianose.

3. The composition of claim 2, wherein the sugar is a non-reducing sugar.

4. The composition of claim 3, wherein the sugar is selected from raffinose, stachyose,
sucrose, and trehalose.

5. The composition of claim 1, comprising a sugar alcohol, wherein the sugar alcohol is
25 selected from sorbitol, mannitol, xylitol, erythritol, ribitol, and inositol.

6. The composition of any one of the preceding claims, wherein the thickener is selected
from hydroxyethyl cellulose, methyl cellulose, microcrystalline cellulose, hydroxypropyl methyl
cellulose, hydroxyethylmethyl cellulose, hydroxypropyl cellulose, dextran, polyvinylpyrrolidone,
30 and mixtures thereof.

7. The composition of any one of the preceding claims, wherein the vaccine is present in an amount of from 0.5 wt.-% to 50 wt.-% of the coating formulation.

8. The composition of any one of the preceding claims, wherein the aluminum-containing wet gel suspension is present in an amount of from 10 wt.-% to 70 wt.-% of the coating formulation.

9. The composition of any one of the preceding claims, wherein the sugar, sugar alcohol, or combinations thereof is present in an amount of from 0.01 wt.-% to 60 wt.-% of the coating formulation.

10. The composition of any one of the preceding claims, wherein the thickener is present in an amount of from 0.01 wt.-% to 60 wt.-% of the coating formulation.

11. The composition of any one of the preceding claims, further comprising at least one buffer, wherein the buffer is present in an amount of from 1 wt.-% to 20 wt.-% of the coating formulation.

12. The composition of claim 11, wherein the at least one buffer is selected from histidine, phosphate buffers, acetate buffers, citrate buffers, glycine buffers, ammonium acetate buffers, succinate buffers, pyrophosphate buffers, Tris acetate buffers, Tris buffers, phosphate buffered saline, Tris buffered saline, saline-sodium acetate buffer, and saline-sodium citrate buffer.

13. The composition of claim 12, wherein the at least one buffer is phosphate buffered saline.

14. The composition of any one of the preceding claims, wherein the aluminum-containing wet gel suspension comprises 0.1 wt.-% to 2 wt.-% aluminum.

15. The composition of any one of the preceding claims, comprising 0.5% to 3% by weight of aluminum.

16. A device comprising:
a microneedle array comprising a substrate and a plurality of microneedles; and
the composition of any one of claims 1-14 coated on at least a portion of one or more of the microneedles.

17. The device of claim 16, wherein the device has a surface area and comprises at least 0.03 micrograms of aluminum per cm^2 of the surface area.

18. The device of claim 16, wherein the device has a surface area and comprises from 0.03 to 18 micrograms of aluminum per cm^2 of the surface area.

19. A method of forming an aluminum-adjuvanted vaccine formulation comprising:
providing a first aluminum-containing wet gel suspension selected from aluminum hydroxide
wet gel suspension and aluminum phosphate wet gel suspension;
concentrating the aluminum-containing wet gel suspension to produce a second aluminum-
5 containing wet gel suspension;
mixing at least one vaccine into the second aluminum-containing wet gel suspension in an
amount effective to stimulate an immune response in a mammal to form the aluminum-
adjuvanted vaccine formulation.

10 20. The method of claim 19, wherein the first aluminum-containing wet gel suspension has a
first aluminum concentration and the second aluminum-containing wet gel suspension has a
second aluminum concentration, and the second aluminum concentration is at least 1.2 times
greater than first aluminum concentration.

15 21. The method of claim 19, wherein the first aluminum-containing wet gel suspension has a
first aluminum concentration and the second aluminum-containing wet gel suspension has a
second aluminum concentration, and the second aluminum concentration is from 1.2 to 2 times
greater than first aluminum concentration.

20 22. The method of claim 20, wherein the first aluminum-containing wet gel suspension has a
first aluminum concentration and the second aluminum-containing wet gel suspension has a
second aluminum concentration, and the second aluminum concentration is from 1.5 to 2 times
greater than first aluminum concentration.

25 23. The method of claim 19, wherein the first aluminum-containing wet gel suspension has a
first volume and concentrating the aluminum-containing wet gel suspension to produce a second
aluminum-containing wet gel suspension reduces the first volume such that the second
aluminum-containing wet gel suspension has a second volume that is less than the first volume.

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24. The method of claim 23, wherein the second volume is from 20% to 80% less than the first volume.

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25. A method for maximizing the aluminum content of a vaccine-coated microneedle array comprising:

providing a microneedle array comprising a microneedle substrate and a plurality of microneedles;

10 forming aluminum-adjuvanted vaccine formulation by

providing a first aluminum-containing wet gel suspension selected from aluminum hydroxide wet gel suspension and aluminum phosphate wet gel suspension;

concentrating the aluminum-containing wet gel suspension to produce a second aluminum-containing wet gel suspension;

15 mixing at least one vaccine into the second aluminum-containing wet gel suspension in an amount effective to stimulate an immune response in a mammal to form the aluminum-adjuvanted vaccine formulation; and

bringing at least a portion of the plurality of microneedles into contact with the aluminum-adjuvanted vaccine formulation, thereby transferring at least a portion of the aluminum-

20 adjuvanted vaccine formulation to the microneedle array to form a wet-coated microneedle array.