Claims

1. A method for forming noble metal nanoparticles on a support, comprising:

mixing a support ink with one or more noble metal precursor solution, wherein the support ink comprises a solution of a first polyhydric alcohol and the support, wherein the one or more noble metal precursor solution comprises a solution of a second polyhydric alcohol and the one or more noble metal precursor;

feeding the mixture of the support ink and the one or more noble metal precursor solution to a spiral glass tube reactor;

heating the spiral glass tube reactor containing the mixture of the support ink and the one or more noble metal precursor solution to reduce the noble metal precursor to form noble metal nanoparticles on the support.

2. Method according to claim 1, wherein heating comprises exposing the spiral glass tube reactor to microwave heat or millimeter waves.

3. Method according to claim 2, wherein heating comprises exposing the spiral glass tube reactor to microwave heat at 100 °C to 200 °C.

4. Method according to claim 3, wherein heating comprises exposing the spiral glass tube reactor to microwave heat at 150 °C.

5. Method according to any one of claims 1-4, wherein the one or more noble metal precursor solution further comprises a polybasic carboxylic acid.

6. Method according to claim 5, wherein the polybasic carboxylic acid comprises citric acid, tartaric acid, malic acid, oxalic acid, or their salts.

7. Method according to claim 6, wherein the polybasic carboxylic acid comprises citric acid or a citrate of sodium or potassium.

8. Method according to any one of claims 1-7, wherein the solution of the first polyhydric alcohol and the solution of the second polyhydric alcohol are the same.

9. Method according to claim 8, wherein the first polyhydric alcohol and the second polyhydric alcohol each comprises ethylene glycol.

10. Method according to any one of claims 1-9, further comprises adding a base solution to the mixture of the support ink and the one or more noble metal precursor solution prior to feeding the mixture to the spiral glass tube reactor.

11. Method according to claim 10, wherein the base solution comprises a hydroxide of sodium or potassium.

12. Method according to any one of claims 1-11, wherein the noble metal nanoparticles comprise nanoparticles of platinum, ruthenium, palladium, gold, silver, rhenium, rhodium, iridium, osmium, or a combination thereof.

13. Method according to claim 12, wherein the one or more noble metal precursor comprises an oxide, a halide, a nitrite, a sulphate, or a complex of platinum, ruthenium, palladium, gold, silver, rhenium, rhodium, iridium, osmium, or a combination thereof.

14. Method according to any one of claims 1-13, wherein the support comprises one or more carbon material selected from the group consisting of carbon black, carbon nanotube, carbon fibre, graphene, graphite, and carbon mesosphere.

15. Method according to any one of claims 1-14, further comprising filtering and drying the thus-formed supported noble metal nanoparticles.

16. Noble metal nanoparticles supported on a support, wherein the average noble metal nanoparticle size is 2.0 nm or below.

17. Supported noble metal nanoparticles of claim 16, wherein the noble metal loading based on the total mass of the noble metal nanoparticles and the support is 40 wt% or more.

18. Supported noble metal nanoparticles of claim 17, wherein the noble metal loading based on the total mass of the noble metal nanoparticles and the support is 60 wt% or more.

19. Supported noble metal nanoparticles of any one of claims 16-18, wherein the average noble metal nanoparticle size is 1.8 nm and the noble metal loading based on the total mass of the noble metal nanoparticles and the support is 75 wt%.

~~20. Use of the supported noble metal nanoparticles of any one of claims 16-19 as a catalyst layer in an electrode for fuel cell applications.~~

Claims

1. Noble metal nanoparticles supported on a support, wherein an average noble metal nanoparticle size is 2.0 nm or below, wherein a noble metal loading based on the total mass of the noble metal nanoparticles and the support is 60 wt% or more, and wherein the support comprises graphene.

2. The supported noble metal nanoparticles of claim 1, wherein the average size of the noble metal nanoparticles is greater than 1.7 nm and up to 2.0 nm.

3. The supported noble metal nanoparticles of claim 2, wherein the average size of the noble metal nanoparticles is greater than 1.8 nm and up to 2.0 nm.

4. The supported noble metal nanoparticles of claim 1, wherein the noble metal loading is 75 wt% or more.

5. The supported noble metal nanoparticles of claim 1, wherein the noble metal nanoparticles comprise nanoparticles of platinum, ruthenium, palladium, gold, silver, rhenium, rhodium, iridium, osmium, or a combination thereof.

6. The supported noble metal nanoparticles of claim 1, wherein the noble metal loading is more than 60 wt%.

7. The supported noble metal nanoparticles of claim 5, wherein the noble metal nanoparticles comprise platinum.

8. The supported noble metal nanoparticles of claim 1, wherein the average size of the noble metal nanoparticles is between 1.62 nm and 1.98 nm.

9. The supported noble metal nanoparticles of claim 8, wherein the noble metal nanoparticles comprise platinum.