Summary

The present disclosure relates to a cathode material comprising a layer of sulfur species dispersed within or thereon a porous matrix comprising a first conducting carbon material, a second conducting carbon material and a binder, wherein the second conducting carbon material is carbon fiber or carbon nanotube.

The present disclosure also relates to a cathode material comprising a layer of sulfur species dispersed within or thereon a porous matrix comprising a first conducting carbon material, a second conducting carbon material and a binder, wherein said porous matrix is interconnected with uniform pores.

In one aspect, the present disclosure relates to a cathode material comprising a layer of sulfur species dispersed within or thereon a porous matrix comprising reduced graphene oxide, carbon fiber and a binder, wherein the binder is a copolymer of acrylamide, lithium carboxylate and cyano group, wherein said porous matrix is interconnected with uniform pores.

Advantageously, due to the way the cathode material is made, the cathode material may be interconnected with pores that are uniform in size and volume, large surface area and/or small ohmic resistance. The cathode material as described herein can be used in a lithium-sulfur battery and due to the large surface area, availability of electrochemically active sites for sulfur species, such as sulfur (S), lithium sulfide (Li_2S) and polysulfide (PS), can be increased, allowing both nucleation and binding to occur on the cathode surface, leading to higher specific capacities of the cathode material.

Further advantageously, the large surface area of the cathode material as described herein may lead to a decrease in the concentration of dissolved PS in bulk, reducing the undesired PS shuttling effect. Therefore, the capacity fading of the capacity fading of the electrode material may be inhibited.

The present disclosure also relates to a method for preparing a cathode material comprising the steps of:

a) coating a support with a slurry formed by mixing a mixture of a first conducting carbon material, a second conducting carbon material and a binder, wherein the second conducting carbon material is carbon fiber or carbon nanotube; and

b) adding a sulfur source in fluid state to the coated support to thereby obtain the cathode material.

The present disclosure also relates to a method for preparing a cathode material comprising the steps of:

a) coating a support with a slurry formed by mixing a mixture of a first conducting carbon material, a second conducting carbon material and a binder;

b) adding a sulfur source in fluid state to the coated support to thereby obtain the cathode material.

In another aspect, the present disclosure relates to a method for preparing a cathode material comprising the steps of:

a) coating a support with a slurry formed by mixing a mixture of reduced graphene oxide, carbon fiber and a binder, wherein the binder is a copolymer of acrylamide, lithium carboxylate and cyano group; and

Claims

1. A cathode material comprising a layer of sulfur species dispersed within or thereon a porous matrix comprising reduced graphene oxide, carbon fiber and a binder,
wherein the binder is a copolymer of acrylamide, lithium carboxylate and cyano group, and
wherein said porous matrix is interconnected with uniform pores.

2. The cathode material according to claim 1, wherein the sulfur species is a polysulfide or elemental sulfur.

3. The cathode material according to claim 2, where the polysulfide has a formula of Li_2S_n, wherein $2<n\leq8$.

4. The cathode material according to any one of the preceding claims, wherein the cathode material has a sulfur content in the range of 30 wt% to 80 wt% based on the total weight of the cathode material.

5. The cathode material according to any one of the preceding claims, wherein the reduced graphene oxide is doped with nitrogen, oxygen, sulfur, boron, phosphorus or their mixtures thereof.

6. The cathode material according to any one of the preceding claims, wherein the amount of the reduced graphene oxide is in the range of 20 wt% to 60 wt% based on the total weight of the cathode material.

7. The cathode material according to any one of the preceding claims, wherein the amount of the binder is in the range of 5 wt% to 15 wt% based on the total weight of the cathode material.

8. The cathode material according to any one of the preceding claims, wherein the carbon fiber has a diameter in the range of 0.1 nm to 100 μm.

9. The cathode material according to any one of the preceding claims, wherein the carbon fiber is vapor grown carbon fiber (VGCF).

10. The cathode material according to any one of the preceding claims, wherein the amount of the carbon fiber is in the range of 5 wt% to 35 wt% based on the total weight of the cathode material.

11. The cathode material according to any one of the preceding claims, wherein the cathode material has a sulfur loading density in the range of 1.3 mg cm^{-2} to 15 mg cm^{-2}.

12. The cathode material according to any one of the preceding claims, wherein the cathode material has a surface area in the range of 200 m^2/g to 900 m^2/g.

13. The cathode material according to any one of the preceding claims, wherein the cathode material has a pore volume in the range of 0.25 cm^3/g to 3 cm^3/g.

14. The cathode material according to any one of the preceding claims, wherein the cathode material has a pore size distrbution of mesopore size in the range of 2.0 nm to 50 nm and macropore size larger than 50 nm.

15. A method for preparing a cathode material comprising the steps of:

a) coating a support with a slurry formed by mixing a mixture of reduced graphene oxide, carbon fiber and a binder, wherein the binder is a copolymer of acrylamide, lithium carboxylate and cyano group; and

b) adding a sulfur source in fluid state to the coated support to thereby obtain the cathode material.

16. The method according to claim 15, further comprising, before said coating step (a), the step of (a1) stirring said mixture in a solvent overnight with a solid content in the range of 3 wt% to 10 wt%.

17. The method according to claim 16, wherein the solvent is water or water mixture with polar organic solvents.

18. The method according to any one of claims 15 to 17, wherein the reduced graphene oxide has a concentration in the range of 20 wt% to 60 wt% based on the total weight of solid content.

19. The method according to any one of claims 15 to 18, wherein the carbon fiber has a concentration in the range of 5 wt% to 35 wt% based on the total weight of solid content.

20. The method according to any one of claims 15 to 19, wherein the binder has a concentration in the range of 5 wt% to 15 wt% based on the total weight of solid content.

21. The method according to any one of claims 15 to 20, further comprising, after said coating step (a), the step of (a2) drying the coated support at a temperature in the range of 40 ºC to 80 ºC for more than 2 hours.

22. The method according to any one of claims 15 to 21, comprising the step of preparing a polysulfide (PS) solution as the sulfur source in fluid state by stirring a mixture of sulfur (S) and lithium sulfide (Li_2S).

23. The method according to claim 22, wherein the mixture is stirred at a temperature in the range of 40 °C to 60 °C overnight in a glovebox.

24. The method according to claim 22 or 23, wherein the mixture has a S/Li_2S mass ratio in the range of 2:1 to 5:1.

25. The method according to any one of claims 15 to 21, comprising the step of obtaining said sulfur source in fluid state by heating elemental sulfur solid at a temperature in the range of 160ºC to 190ºC.

26. The method according to claim 25, wherein duration of the heating step is in the range of 5 minutes to 40 minutes.

27. An electrochemical cell comprising a cathode material according to any one of claims 1 to 14 and a liquid electrolyte.

28. A lithium-sulfur battery comprising one or more electrochemical cells according to claim 27.