

Claims

1. 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.
2. 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.
3. The cathode material according to claim 1 or 2, wherein the sulfur species is a polysulfide or elemental sulfur.
4. The cathode material according to claim 3, where the polysulfide has a formula of Li_2S_n , wherein $2 < n \leq 8$.
5. The cathode material according to any one of the preceding claims, wherein the cathode material has a sulfur content in the range of about 30 wt% to about 80 wt% based on the total weight of the cathode material.
6. The cathode material according to any one of the preceding claims, wherein the first conducting carbon material is selected from the group consisting of reduced graphene oxide, graphene, graphite, carbon nanotube, carbon fiber, acetylene black, and ketjenblack.
7. The cathode material according to any one of the preceding claims, wherein the first conducting carbon material is different from the second conducting carbon material.
8. The cathode material according to any one of the preceding claims, wherein the first conducting carbon material is reduced graphene oxide.
9. The cathode material according to any one of the preceding claims, wherein the first conducting carbon material is doped with nitrogen, oxygen, sulfur, boron, phosphorus or their mixtures thereof.
10. The cathode material according to any one of the preceding claims, wherein the amount of the first conducting carbon agent is in the range of 20 wt% to 60 wt% based on the total weight of the cathode material.
11. The cathode material according to any one of the preceding claims, wherein the binder is a copolymer of acrylamide, lithium carboxylate and cyano group, polyvinylidene fluoride (PVDF), styrene/butadiene copolymer (SBR), carboxymethyl cellulose (CMC), polysaccharides, or a polymer having a monomer selected from the group consisting of olefin, butadiene, carboxylate, carboxylate salt of Li and Na, styrene, amide, ester, acrylate, methacrylate, urethane and mixtures thereof.
12. The cathode material according to any one of the preceding claims, wherein the binder is a copolymer of acrylamide, lithium carboxylate and cyano group.
13. The cathode material according to any one of the preceding claims, wherein the binder is water soluble.
14. 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.

15. The cathode material according to any one of the preceding claims, wherein the second conducting carbon material has a diameter in the range of about 0.1 nm to about 100 μm .
- 5 16. The cathode material according to any one of the preceding claims, wherein the second conducting carbon material is vapor grown carbon fiber (VGCF).
17. The cathode material according to any one of the preceding claims, wherein the amount of the second conducting carbon material is in the range of 5 wt% to 35 wt% based on the total weight of the cathode material.
- 10 18. 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} .
- 15 19. 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 .
- 20 20. 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 .
21. The cathode material according to any one of the preceding claims, wherein the cathode material has a pore size distribution of mesopore size in the range of 2.0 nm to 50 nm and macropore size larger than 50 nm.
22. A method for preparing a cathode material comprising the steps of:
- 25 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.
- 30 23. 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; and
- 35 b) adding a sulfur source in fluid state to the coated support to thereby obtain the cathode material.
24. The method according to claim 22 or 23, 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%.
- 40 25. The method according to claim 24, wherein the solvent is water or water mixture with polar organic solvents.
26. The method according to any one of claims 22 to 25, wherein the first conducting carbon material has a concentration in the range of 60 wt% to 90 wt% based on the total weight of solid content in the slurry.
- 45 27. The method according to any one of claims 22 to 26, wherein the first conducting carbon material is reduced graphene oxide.
- 50 28. The method according to any one of claims 22 to 27, wherein the second conducting carbon material has a concentration in the range of 5 wt% to 50 wt% based on the total weight of solid content.

29. The method according to any one of claims 22 to 28, wherein the binder has a concentration in the range of 5 wt% to 20 wt% based on the total weight of solid content.
- 5 30. The method according to any one of claims 22 to 29, further comprising, after said coating step (a), the step of (a2) drying the coated support at a temperature in the range of 40 °C to 80 °C for more than 2 hours.
- 10 31. The method according to any one of claims 22 to 30, 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).
32. The method according to claim 31, wherein the mixture is stirred at a temperature in the range of 40 °C to 60 °C overnight in a glovebox.
- 15 33. The method according to claim 31 or 32, wherein the mixture has a S/ Li_2S mass ratio in the range of 2:1 to 5:1.
- 20 34. The method according to any one of claims 22 to 30, comprising the step of obtaining said sulfur source in fluid state by heating elemental sulfur solid at a temperature in the range of 160°C to 190°C.
35. The method according to claim 34, wherein duration of the heating step is in the range of 5 minutes to 40 minutes.
- 25 36. A cathode material prepared by the method according to any one of claims 22 to 35.
37. An electrochemical cell comprising a cathode material according to any one of claims 1 to 21 or 36 and a liquid electrolyte.
- 30 38. A lithium-sulfur battery comprising one or more electrochemical cells according to claim 37.