

Claims

1. A method of synthesizing a porous carbon-sulfur composite, comprising the steps of:
 - (a) carbonizing a carbon material having a metal-organic framework at a temperature in the range of 800 °C to 1000 °C to produce a porous carbon;
 - (b) mixing and heating the porous carbon with sulfur to infuse said sulfur into the pores of said porous carbon; and
 - (c) removing excess sulfur not infused into the pores or present on the surface of said porous carbon.
2. The method of claim 1, wherein the temperature for the carbonizing step (a) is at least 900 °C to less than 1000 °C.
3. The method of claim 1 or 2, wherein the metal-organic framework of the carbon material is selected from the group consisting of zeolite-type metal-organic frameworks, micro-porous metal-organic framework (MMOFs), porous coordination networks (PCNs) and porous coordination polymers (PCPs).
4. The method of claim 3, wherein the zeolite-type metal-organic framework is selected from the group consisting of zeolitic imidazolate framework-3 (ZIF-3), zeolitic imidazolate framework-6 (ZIF-6), zeolitic imidazolate framework-8 (ZIF-8), zeolitic imidazolate framework-11 (ZIF-11), zeolitic imidazolate framework-14 (ZIF-14), zeolitic imidazolate framework-20 (ZIF-20), zeolitic imidazolate framework-60 (ZIF-60), zeolitic imidazolate framework-68 (ZIF-68) and zeolitic imidazolate framework-95 (ZIF-95).
5. The method of any one of claims 1 to 4, wherein the method does not comprise a washing step after the carbonizing step (a).
6. The method of any one of claims 1 to 5, wherein the sulfur infused into the pores of said porous carbon in step (b) is short-chain sulfur allotropes S₂, S₃ or S₄ and the excess sulfur not infused into the pores or present on the surface of said porous carbon in step (c) is elemental sulfur S₈.
7. The method of any one of claims 1 to 6, wherein in the mixing and heating step (b), the sulfur and porous carbon are provided in a weight ratio in the range of 5:1 to 1:1.
8. The method of any one of claims 1 to 7, wherein the removing step (c) comprises evaporating the excess sulfur under an inert gas flow in an open system.
9. A porous carbon-sulfur composite synthesized by the method of claim 1.
10. The porous carbon-sulfur composite of claim 9, wherein the composite has a weight percentage of sulfur in the range of 30 weight % to 40 weight % based on the porous carbon-sulfur composite.
11. The porous carbon-sulfur composite of claim 9 or 10, wherein the composite has a weight ratio of carbon and nitrogen in the range of 20:1 to 3:1.

12. The porous carbon-sulfur composite of any one of claims 9 to 11, wherein the composite has a sulfur content consisting essentially of S₂, S₃, S₄ and combinations thereof.
- 5 13. A cathode comprising the porous carbon-sulfur composite of any one of claims 9 to 12.
14. A method of preparing the cathode of claim 13, comprising the steps of:
- 10 (a) mechanically treating a mixture comprising the porous carbon-sulfur composite of any one of claims 9 to 12, a conductive carbon, and a polymer binder;
- (b) adding an organic solvent into the mixture to yield a slurry; and
- (c) coating the slurry onto a carbon-coated aluminium foil.
- 15 15. The method of claim 14, wherein the mechanically treating step (a) comprises mixing the porous carbon-sulfur composite, the conductive carbon and the polymer binder at a weight ratio of about 7:2:1.
16. The method of claim 14 or 15, wherein the adding step (b) further comprises
- 20 stirring the slurry overnight.
17. The method of any one of claims 14 to 16, further comprising a drying step after the coating step (c); wherein the drying step is performed under a temperature in the range of 40 °C to 80 °C.
- 25 18. An electrochemical cell comprising:
- (a) the cathode of claim 13;
- (b) an anode; and
- (c) an electrolyte in fluid communication with both said cathode and said anode.
- 30 19. The electrochemical cell of claim 18, further comprising a separator.
20. The electrochemical cell of claim 18 or 19, wherein the anode is a sodium anode or a lithium anode.
- 35 21. The electrochemical cell of any one of claims 18 to 20, wherein the electrolyte is NaClO₄ in tetraglyme, NaCF₃SO₃ in tetraglyme or a combination thereof.
- 40 22. The electrochemical cell of any one of claims 18 to 21, wherein the electrolyte has a concentration in the range of 0.1 M to 2 M.