

Claims

1. A composite comprising: a) short chain sulfur; and b) a carbon-supported conductive polymer, wherein sulfur atoms of said short chain sulfur are covalently linked to the conductive polymer of said carbon-supported conductive polymer via a C-S bond.
2. The composite according to claim 1, wherein said composite is a two-component composite.
3. The composite according to claim 1 or 2, wherein said conductive polymer is a carbonized polymer.
4. The composite according to any one of the preceding claims, wherein said conductive polymer comprises a plurality of monomers and said carbon-supported conductive polymer comprises a polymerized form of said plurality of monomers on or within a carbon support.
5. The composite according to claim 4, wherein said conductive polymer is selected from the group consisting of carbonized polyacrylonitrile (PAN), polyaniline, polypyrrole, polyacetylene, polyphenylene, polyphenylene sulfide, polythiophene, poly(fluorene)s, polypyrenes, polyazulenes, polynaphthalenes, polycarbazoles, polyindoles, polyazepines, poly(3,4-ethylenedioxythiophene) (PEDOT), poly(p-phenylene sulfide) (PPS), poly(p-phenylene vinylene) (PPV), and co-polymers mixtures thereof.
6. The composite according to claim 5, wherein the monomers of said conductive polymer is selected from the group consisting of acrylonitrile, aniline, pyrrole, acetylene, phenylene, phenylene sulfide, thiophene, (fluorene)s, pyrenes, azulenes, naphthalenes, carbazoles, indoles, azepines, 3,4-ethylenedioxythiophene, p-phenylene sulfide, p-phenylene vinylene, and mixtures thereof.
7. The composite according to any one of claims 4 to 6, wherein said carbon support comprises a particulate porous carbon or a fibrous carbon.
8. The composite according to claim 7, wherein said particulate porous carbon has a surface area in the range of 100 m²/g to 2000 m²/g and an average pore size or average pore distribution size in the range of 2 nm to 500 nm.
9. The composite according to claim 7, wherein said fibrous carbon is a carbon cloth comprising fibers having a diameter in the range of 3 μm to 20 μm and having a cloth thickness in the range of 200 μm to 500 μm.
10. The composite according to any one of the preceding claims, wherein said short-chain sulfur is selected from S₂, S₃, S₄ or mixtures thereof.
11. The composite according to any one of the preceding claims, wherein said short-chain sulfur is present in said composite in a concentration in the range of 20 wt% to 50 wt%, based on the total weight of said composite.

12. The composite according to any one of the preceding claims, wherein said short-chain sulfur and said conductive polymer is present in said composite at a ratio in the range of 2:1 to 6:1.
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13. A method of preparing a composite comprising: a) short-chain sulfur; and b) a carbon-supported conductive polymer, wherein sulfur atoms of the short-chain sulfur are covalently linked to the conductive polymer of the carbon-supported conductive polymer via a C-S bond, comprising the steps of:
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- (a) polymerizing, in the presence of a carbon scaffold, a plurality of monomers making up the conductive polymer or a plurality of monomers making up a precursor of the conductive polymer;
- (b) mixing elemental sulfur with said carbon-supported conductive polymer or the carbon-supported conductive polymer precursor obtained in step (a); and
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- (c) heating the mixture of the elemental sulfur with the carbon-supported conductive polymer precursor obtained in step (b).
14. The method according to claim 13, further comprising, before step (a), the steps of:
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- (a1') adding a polymerization initiator to a mixture of said plurality of monomers and said carbon scaffold in a solvent; or
- (a1'') adding said plurality of monomers to a mixture of a polymerization initiator and said carbon scaffold in a solvent; and
- (a2) heating said mixture from step (a1') or step (a1'') to initiate polymerization.
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15. The method according to claim 13 or 14, wherein said heating step (c) is undertaken at a temperature in the range of 400°C to 600°C.
16. A cathode material comprising a composite according to any one of claims 1 to 13.
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17. Use of the cathode material according to claim 16 in a sodium-sulfur electrochemical cell.
18. An electrochemical cell comprising the cathode material according to claim 16, a pure sodium anode and a liquid electrolyte.
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19. The electrochemical cell according to claim 18, wherein said liquid electrolyte comprises sodium trifluoromethanesulfonate dissolved in a mixture of solvents.