

CLAIMS

1. A method of synthesizing a transition metal sulfide-based carbon material for use as an electrode in lithium-sulfur battery, the method comprising:
 - 5 providing a solution containing group VI transition metal sulfide precursor and a solvent;
immersing a carbon fiber material into the solution to form a mixture;
subjecting the mixture to a temperature between 200°C to 300°C to allow loading of transition metal sulfide onto the carbon fiber material; and
 - 10 drying the loaded carbon fiber material to obtain a transition metal sulfide-based loaded carbon material.
2. The method according to claim 1, wherein the transition metal sulfide precursor is selected from the group consisting of ammonium tetrathiomolybdate and ammonium
15 tetrathiotungstate.
3. The method according to claim 2, wherein the transition metal sulfide is selected from the group consisting of molybdenum disulfide and tungsten disulfide.
- 20 4. The method according to claim 1, wherein the carbon fiber material is a woven material having a multiplicity of interwoven carbon fibers.
5. The method according to claim 1, wherein the carbon fiber material is a porous carbon cloth.
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6. The method according to claim 1, wherein the solvent is selected from the group consisting of dimethylformamide, deionised water and a combination thereof.
7. The method according to claim 1, wherein the carbon fiber material is
30 immersed in the solvent contained in the solution prior to the step of providing the solution containing group VI transition metal sulfide precursor and the solvent.
8. The method according to claim 7, wherein the solvent comprises cetyltrimethylammonium bromide dissolved in deionised water.
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9. The method according to claim 3, wherein the transition metal sulfide is molybdenum disulfide and the transition metal sulfide-based loaded carbon material is loaded with edge-oriented molybdenum disulfide.

5 10. The method according to claim 8, wherein the transition metal sulfide is molybdenum disulfide and the transition metal sulfide-based loaded carbon material is loaded with basal plane-oriented molybdenum disulfide.

10 11. The method according to claim 3, wherein the transition metal sulfide is tungsten disulfide and the transition metal sulfide-based loaded carbon material is loaded with edge-oriented tungsten disulfide or basal plane-oriented tungsten disulfide.

12. The method according to claim 1, further comprising:
annealing the transition metal sulfide-based loaded carbon material to form a
15 semiconducting transition metal sulfide-based loaded carbon material.

13. The method according to claim 1, further comprising:
preparing an electrode for lithium-sulfur battery using the transition metal
sulfide-based loaded carbon fiber material, wherein the preparation comprises:
20 mixing and heating sulfur with carbon black to obtain a sulfur-carbon
black mixture;
mixing the sulfur-carbon black mixture with a binder and a solvent to
obtain a sulfur-containing slurry;
depositing the sulfur-containing slurry onto the transition metal sulfide-
25 based loaded carbon material; and
drying the transition metal sulfide-based loaded carbon material to
obtain a sulfur-loaded transition metal sulfide-based carbon electrode.

14. The method according to claim 13, wherein the electrode is a cathode.
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15. The method according to claim 13, further comprising:
repeating the steps of deposition and drying to obtain an areal sulfur loading
between $1.5 \text{ mg} \cdot \text{cm}^{-2}$ and $5.5 \text{ mg} \cdot \text{cm}^{-2}$.

35 16. The method according to claim 13, further comprising:

heating the sulfur-carbon black mixture to remove excess surface sulfur from the sulfur-carbon black mixture prior to mixing the sulfur-carbon black mixture with the binder and the solvent.

- 5 17. A transition metal sulfide-based carbon material comprising a carbon fiber material and a group VI transition metal sulfide selected from the group consisting of molybdenum disulfide and tungsten disulfide, wherein the transition metal sulfide is loaded onto the carbon fiber material.
- 10 18. The transition metal sulfide-based carbon material according to claim 17, wherein the transition metal sulfide is loaded onto the carbon fiber material by forming nanocrystals on the surface of the carbon fiber material.
- 15 19. The transition metal sulfide-based carbon material according to claim 17, wherein the carbon fiber material is a woven material having a multiplicity of interwoven carbon fibers.
- 20 20. The transition metal sulfide-based carbon material according to claim 17, wherein the carbon fiber material is a porous carbon cloth.
- 20 21. The transition metal sulfide-based carbon material according to claim 17, wherein the transition metal sulfide is molybdenum disulfide.
- 25 22. The transition metal sulfide-based carbon material according to claim 21, wherein the molybdenum disulfide is an edge-oriented molybdenum disulfide or a basal plane-oriented molybdenum disulfide.
- 30 23. The transition metal sulfide-based carbon material according to claim 17, wherein the transition metal sulfide is tungsten disulfide.
24. The transition metal sulfide-based carbon material according to claim 23, wherein the tungsten disulfide is an edge-oriented tungsten disulfide or a basal plane-oriented tungsten disulfide.

25. A transition metal sulfide-based carbon electrode comprising a transition metal sulfide-based carbon material according to any of the preceding claims 17-24 loaded with sulfur.
- 5 26. A lithium-sulfur battery comprising an anode and a cathode, wherein the cathode comprises a transition metal sulfide-based carbon material according to any of the preceding claims 17-24 loaded with sulfur.