

Claims

1. A coral-like composite material comprising highly dispersed conductive metal nitride, metal carbide or metal carbonitride nanoparticles on mesoporous carbon nanosheets.
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2. The coral-like composite material of claim 1, wherein the size of the metal nitride, metal carbide or metal carbonitride nanoparticles is in the range of about 2 nm to about 20 nm.
3. The coral-like composite material of claim 1 or 2, wherein the metal element from the metal nitride, metal carbide or metal carbonitride nanoparticles is scandium, titanium, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, yttrium, zirconium, niobium, molybdenum, technetium, ruthenium, rhodium, palladium, silver, cadmium, hafnium, tantalum, tungsten, rhenium, osmium, iridium, platinum, or their combinations thereof.
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4. The coral-like composite material of any one of the preceding claims, wherein the metal carbide is niobium carbide, titanium carbide, tungsten carbide, molybdenum carbide, vanadium carbide, hafnium carbide, niobium titanium carbide, niobium tungsten carbide, niobium molybdenum carbide, niobium vanadium carbide, niobium hafnium carbide, titanium tungsten carbide, titanium molybdenum carbide, titanium vanadium carbide, titanium hafnium carbide, tungsten molybdenum carbide, tungsten vanadium carbide, tungsten hafnium carbide, molybdenum vanadium carbide, molybdenum hafnium carbide, vanadium hafnium carbide or their mixtures thereof.
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5. The coral-like composite material of any one of the preceding claims, wherein the metal nitride is titanium nitride, tungsten nitride, molybdenum nitride, vanadium nitride, niobium nitride, zirconium nitride, hafnium nitride, titanium tungsten nitride, titanium molybdenum nitride, titanium vanadium nitride, titanium niobium nitride, titanium zirconium nitride, titanium hafnium nitride, tungsten molybdenum nitride, tungsten vanadium nitride, tungsten niobium nitride, tungsten zirconium nitride, tungsten hafnium nitride, molybdenum vanadium nitride, molybdenum niobium nitride, molybdenum zirconium nitride, molybdenum hafnium nitride, vanadium niobium nitride, vanadium zirconium nitride, vanadium hafnium nitride, niobium zirconium nitride, niobium hafnium nitride, zirconium hafnium nitride or their mixtures thereof.
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6. The coral-like composite material of any one of the preceding claims, wherein the metal carbonitride is vanadium carbonitride, titanium carbonitride, tungsten carbonitride, molybdenum carbonitride, niobium carbonitride, zirconium carbonitride, vanadium titanium carbonitride, vanadium tungsten carbonitride, vanadium molybdenum carbonitride, vanadium niobium carbonitride, vanadium zirconium carbonitride, titanium tungsten carbonitride, titanium molybdenum carbonitride, titanium niobium carbonitride, titanium zirconium carbonitride, tungsten molybdenum carbonitride, tungsten niobium carbonitride, tungsten zirconium carbonitride, molybdenum niobium carbonitride, molybdenum zirconium carbonitride, niobium zirconium carbonitride or their mixtures thereof.
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7. The coral-like composite material of any one of the preceding claims, wherein the metal carbide, metal nitride or metal carbonitride nanoparticles further comprises surface metal oxides.
8. The coral-like composite material of any one of the preceding claims, wherein the coral-like composite material has a surface area larger than 100 m²/g.
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9. The coral-like composite material of any one of the preceding claims, wherein the coral-like composite material has a pore volume in the range of about 0.5 cm³/g to about 2 cm³/g.
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10. The coral-like composite material of any one of the preceding claims, wherein the coral-like composite material has a pore size in the range of about 2 nm to about 50 nm.
11. A method for preparing a coral-like composite material comprising the steps of

- 5 a) mixing a mixture of a precursor of metal nitride, metal carbide or metal carbonitride material and a graphitic carbon nitride material; and
 b) drying the mixture and heating solids obtained from dried mixture at a first elevated temperature for a first time period and at a second elevated temperature for a second time period in an inert atmosphere.
12. The method of claim 11, wherein the precursor of the metal nitride metal carbide or metal carbonitride material is metal alkoxide.
- 10 13. The method of claim 11 or 12, wherein the first elevated temperature of step b) is in the range of about 400°C to about 700°C and the first time period of step b) is more than 3 hours.
14. The method of any one of claims 11 to 13, wherein the second elevated temperature of step b) is in the range of about 750°C to about 1000°C and the second time period of step b) is more than 2 hours.
- 15 15. A coating material for a modified separator of a lithium-sulfur battery comprising the coral-like composite material of any one of claims 1 to 10, a conducting carbon material and a binder.
- 20 16. The coating material of claim 15, wherein the conducting carbon material is selected from the group consisting of reduced graphene oxide, graphene, graphite, carbon nanotube, carbon fiber, acetylene black, and ketjenblack.
17. The coating material of claim 15 or 16, wherein the conducting carbon material has a diameter in the range of about 0.1 nm to about 100 μm.
- 25 18. The coating material of any one of claims 15 to 17, wherein the coating material has a thickness in the range of about 5 μm to about 70 μm.
- 30 19. The coating material of any one of claims 15 to 18, wherein the coating material has a mass density in the range of about 0.5 mg cm⁻² to about 3 mg cm⁻².
20. A method for preparing a modified separator for lithium-sulfur battery comprising the steps of
 a) mixing a mixture of the coral-like composite material of any one of claims 1 to 10, a conducting carbon material and a binder; and
35 b) coating the mixture on a porous and non-electrically-conductive membrane.
21. The method of claim 20, wherein the conducting carbon material is selected from the group consisting of reduced graphene oxide, graphene, graphite, carbon nanotube, carbon fiber, acetylene black, and ketjenblack.
- 40 22. The method of claim 20 or 21, wherein the porous and non-electrically-conductive membrane is a glass fiber membrane, a polypropylene and/or a polyethylene electrolytic membrane.
- 45 23. A lithium-sulfur battery comprising the coating material of any one of claims 15 to 19.