Summary

According to a first aspect, there is provided a method of forming a porous particle comprising an electrically conductive shell encapsulating a core, said core comprising an elemental compound that reversibly reduces in the presence of a cation and oxidizes in the absence of said cation, said method comprising the steps of:

a) encapsulating an elemental compound precursor with said electrically conductive shell;

b) reacting said elemental compound precursor with an oxidation agent to oxidise said elemental compound precursor to form said elemental compound, thereby forming said electrically conductive shell encapsulating said core comprising said elemental compound.

Advantageously, this method may allow for the encapsulation of an elemental compound that would normally be destroyed by currently available methods of forming a lithium-sulfur battery.

The encapsulation of the elemental compound may also ensure that the elemental compound is not lost during discharge of the battery as the elemental compound is confined by the electrically conductive shell.

Further advantageously, this method may allow for the core to possess a smaller volume than the inner volume of the encapsulating shell therefore creating a void inside the shell, in which the void is disposed between the core and the shell. Due to the presence of the void, the core may increase in volume without damaging or destroying the encapsulating shell. The void may be formed during the reacting step (b).

The method may result in a plurality of porous particles being formed in which the electrically conductive shells are in close proximity with each other. Due to the interconnected shells, this may ensure that good electrical contact is maintained from one particle to the other, ensuring that the plurality of porous particles (which may form a matrix) has good electrical conductivity as a whole. The encapsulated elemental compound within each porous particle then encounters lesser electrical resistance as compared to a bulk elemental compound (that is, one that is not encapsulated by an electrically conductive shell).

According to the disclosure, there is provided a porous particle comprising an electrically conductive shell encapsulating a core, said core comprising an elemental compound precursor that oxidizes in the presence of an oxidation agent to form an elemental compound.

According to a second aspect, there is provided a yolk-shell porous particle comprising an electrically conductive carbon shell encapsulating a core, said core comprising an elemental compound precursor that oxidizes in the presence of an oxidation agent to form an elemental compound.

According to the disclosure, there is provided a cathode comprising a plurality of porous particles, each porous particle made according to the method as defined above, wherein each porous particle comprises an electrically conductive shell encapsulating a core, said core comprising an elemental compound that reversibly reduces in the presence of a cation and oxidizes in the absence of said cation.

According to a third aspect, there is provided a cathode comprising a plurality of yolk-shell porous particles, each yolk-shell porous particle comprising an electrically conductive carbon shell encapsulating a core, said core comprising an elemental compound that reversibly reduces in the presence of a cation and oxidizes in the absence of said cation.

Advantageously, choosing the elemental compound so that it may reversibly be reduced in the presence of a cation and oxidized in the absence of that cation may allow the porous particle to be used in a battery such as a rechargeable battery.

poly halide, polyester, polycarbonate, polyimide, phenol formaldehyde resin, epoxy, polyalkylene glycol and polysaccharide.

15. The method of claim 13, comprising the step of selecting said polymer from the group consisting of polyethylene, polypropylene, polymethylmethacrylate, polyvinyl chloride, polyethylene terephthalate, polyethylene glycol, polypropylene glycol, starch, glycogen, cellulose and chitin.

16. A yolk-shell porous particle comprising an electrically conductive carbon shell encapsulating a core, said core comprising an elemental compound precursor that oxidizes in the presence of an oxidation agent to form an elemental compound.

17. The porous particle according to claim 16, wherein said elemental compound reversibly reduces in the presence of a cation and oxidizes in the absence of said cation.

18. The porous particle according to claim 16 or 17, wherein a void is present between said shell and said elemental compound.

19. A cathode comprising a plurality of yolk-shell porous particles, each yolk-shell porous particle comprising an electrically conductive carbon shell encapsulating a core, said core comprising an elemental compound that reversibly reduces in the presence of a cation and oxidizes in the absence of said cation.

20. A battery comprising:
    a) an anode;
    b) the cathode of claim 19; and
    b) an electrolyte comprising said cation.

21. The battery of claim 20, wherein said cation is dissociated from said anode.

22. The battery of claim 20 or 21, wherein said cation is chosen from the group consisting of lithium, sodium, potassium, rubidium, beryllium, magnesium, calcium, strontium and barium.