CLAIMS

1. A method for forming quasi-spherical particles of a sulfur-host composite material comprising the steps:

(i) providing a particulate host material and elemental sulfur to a screw extruder;

(ii) mixing the particulate host material and elemental sulfur in the screw extruder at a temperature of from 115 to 450°C to create a stream comprising molten sulfur and a solid particulate host material;

(iii) passing the stream comprising molten sulfur and solid particulate host material through an atomiser to form an atomised stream comprising a plurality of particles formed from solid particulate host material surrounded by molten sulfur; and

(iv) cooling the atomised stream to form solid particles comprising a particulate host material core and a shell formed from elemental sulfur, which particles have a quasi-spherical shape.

2. The method according to Claim 1, wherein the particles comprising a particulate host material core and a shell formed from elemental sulfur are microparticles or nanoparticles.

3. The method according to Claim 1 or 2, wherein step (ii) is performed at a temperature of from 130 to 250°C, preferably from 150 to 180°C.

4. The method according to any one of Claims 1 to 3, comprising:

(a) a preliminary step of mixing the particulate host material and the elemental sulfur to form a homogeneous mixture; and/or

(b) a post-processing step of processing the solid particles into a composite material comprising crystalline sulfur and homogeneously dispersed host material,

optionally wherein at least 45 wt. % of the elemental sulfur is in the form of α-sulfur.

5. The method according to any one of Claims 1 to 4, wherein the particulate host material is selected from one or more of the group consisting of Fe, Zn, Mn, Ti, W, Mo, Cr, Cu, Sn, Te, Gd, Ge, Lu, Co, Tb, Ru, Nb, V, Zr, Si, P, C, B, Al, Mg, Ca, an oxide thereof, and a conductive polymer,

optionally wherein:

the carbon is selected from one or more carbon nanomaterials; and/or

the oxide is selected from one or more of the group consisting of RuO_2, Ti_4O_7, and MnO_2, and/or

the conductive polymer is polyaniline (PANI).

6. The method according to any one of Claims 1 to 5, wherein the ratio of host material to elemental sulfur provided to the screw extruder is from 3:7 to 1:99, optionally from 1:4 to 3:97, such as from 3:17 to 1:19.

7. The method according to any one of Claims 1 to 6, wherein step (iv) is performed in a solidification chamber, and where the screw extruder, atomiser and solidification chamber are part of an apparatus comprising:

a screw extruder comprising one or more heating zones, each comprising a heating element;

a means or apparatus for providing an inert atmosphere or vacuum to the screw extruder;

an atomiser configured to receive a molten stream from the screw extruder and atomise the molten stream into an atomised stream;

a solidification chamber configured to receive the atomised stream produced by the atomiser;

a gas inlet for providing a cooling gas stream to the solidification chamber to solidify the atomised stream; and

a first solid-gas separator for isolating the solidified atomised stream,

wherein the screw extruder is configured to generate a molten stream comprising molten sulfur and a solid particulate host material when in use.

8. A method for forming an electrode comprising the steps:

(i) providing a particulate host material and elemental sulfur to a screw extruder;

(ii) mixing the particulate host material and elemental sulfur in the screw extruder at a temperature of from 115 to 450°C to create a stream comprising molten sulfur and solid particulate host material;

(iii) cooling the stream comprising molten sulfur and solid particulate host material to a temperature of from 115 to 135°C; and

(iv) extruding the cooled stream from step (iii) to form a self-standing electrode.

9. The method according to Claim 8, wherein step (ii) is performed at a temperature of from 130 to 250°C, optionally from 150 to 180°C.

10. The method according to Claim 8 or 9, comprising a preliminary step of mixing the particulate host material and the elemental sulfur to form a homogeneous mixture.

11. The method according to any one of Claims 8 to 10, wherein the particulate host material is selected from one or more of the group consisting of Fe, Zn, Mn, Ti, W, Mo, Cr, Cu, Sn, Te, Gd, Ge, Lu, Co, Tb, Ru, Nb, V, Zr, Si, P, C, B, Al, Mg, Ca, an oxide thereof, and a conductive polymer,

optionally wherein:

the carbon is selected from one or more carbon nanomaterials; or

the oxide is selected from the group consisting of RuO_2, Ti_4O_7, and MnO_2; or

the conductive polymer is PANI.

12. The method according to any one of Claims 8 to 11, wherein the ratio of host material to elemental sulfur provided to the screw extruder is from 3:7 to 1:99, optionally from 1:4 to 3:97, such as from 3:17 to 1:19.