CLAIMS

1. A nanoparticulate material, comprising:

a carbon nanomaterial having a plurality of active sites; and

sulfur attached to the plurality of active sites of the carbon nanomaterial, wherein

the sulfur forms from 50 wt.% to 99 wt.% of the composition when measured using one or both of CHNS elemental analysis and thermogravimetric analysis,

wherein the nanoparticulate material further comprises halogen atoms attached to a first portion of the plurality of active sites.

2. The nanoparticulate material according to Claim 1, wherein the carbon nanomaterial is selected from one or more of the group consisting of carbon nanotubes, carbon nanofibers, fullerenes, graphenes, graphene oxides, nanographites, carbon blacks, acetylene blacks, thermal blacks, mesoporous carbons, carbon quantum dots, and graphene quantum dots.

3. The nanoparticulate material according to Claim 2, wherein the carbon nanomaterial is a graphene and/or a carbon black

4. The nanoparticulate material according to Claim 3, wherein the graphene is in the form of graphene nanoplatelets and the carbon black is in the form of Ketjen black.

5. The nanoparticulate material according to any one of the preceding claims, wherein the halogen atoms are selected from one or more of the group consisting of F, Cl, Br, and I, optionally wherein the halogen atoms are selected from one or more of the group consisting of F, Cl and Br (e.g. the halogen atoms are F).

6. The nanoparticulate material according to any one of the preceding claims, wherein the sulfur forms from 50 to 97 wt.% of the composition when measured using one or both of CHNS elemental analysis or thermogravimetric analysis.

7. The nanoparticulate material according to Claim 6, wherein the sulfur content is from 70 to 96 wt% of the composition when measured using one or both of CHNS elemental analysis or thermogravimetric analysis.

8. The nanoparticulate material according to Claim 7, wherein the sulfur content is from 85 to 95 wt%, such as from 88 to 94 wt% of the composition when measured using one or both of CHNS elemental analysis or thermogravimetric analysis.

9. The nanoparticulate material according to any one of the preceding claims, wherein at least part of the sulfur is covalently bonded to a second portion of the plurality of active sites of the carbon nanomaterial.

10. The nanoparticulate material according to any one of the preceding claims, wherein the plurality of active sites are one or more active sites selected from the group consisting of a surface, an edge, a defect (e.g. a pore), and an interlayer.

11. The nanoparticulate material according to any one of the preceding claims, wherein a first portion of the sulfur is electrostatically bonded (ionically/Van der Waals) to the carbon nanomaterial and a second portion of the sulfur is covalently bonded.

12. A sulfur battery comprising:

a cathode comprising a nanoparticulate material as described in any one of Claims 1 to 11;

an anode;

an electrolyte; and

a separator, optionally wherein the anode comprises an active material that has an electrochemical redox potential below 1.4 V versus Li.

13. The metal sulfur battery according to Claim 12, wherein the metal sulfur battery is selected from one or more of the group consisting of Si, Li, Na, Mg, Al, Ca, graphite.

14. A sulfur battery comprising:

an anode comprising a nanoparticulate material as described in any one of Claims 1 to 11;

a cathode;

an electrolyte; and

a separator, optionally wherein the cathode comprises an active material that has an electrochemical redox potential above 2.6 V versus Li.

15. The sulfur battery according to Claim 14, wherein the sulfur cathode is selected from one or more of the group selected from $LiMn_2O_4$, $LiNiMn_2O_4$, $LiNiMnCoO_2$, $LiCoO_2$ and $LiFePO_4$.

16. The sulfur battery according to any one of Claims 12 to 15, wherein a specific energy density of the metal-sulfur battery is from 600 Wh to 3,600 Wh per kilogram of sulphur, with a total sulfur mass loading of from 1 to 30 mg cm^{-2}, such as from 1 to 20 mg cm^{-2}.

17. The sulfur battery according to Claim 16, wherein the specific energy density of the sulfur battery is from 2,210 Wh to 2,883 Wh per kilogram of sulfur at a current rate of 0.05C with a sulfur mass loading of from 3.5 to 7 mg over an electrode area of 2 cm^2, optionally wherein the specific energy density of the sulfur battery is 2,257 Wh per kilogram of sulphur with a sulfur mass loading of 3.5 mg over an electrode area of 2 cm^2.

18. A method of making a nanoparticulate material according to any one of Claims 1 to 11, wherein the method comprises the steps of:
(a) providing carbon nanomaterials and dispersing them into a solution comprising water, a non-ionic surfactant and a metal thiosulfate to form a precursor solution, wherein the carbon nanomaterials are halogenated; and
(b) adding an aqueous sulfuric acid solution to the precursor solution and allowing reaction for a period of time to form the nanoparticulate material.

19. The method according to Claim 18, wherein the aqueous sulfuric acid solution has a concentration of from 0.1 to 1.0M, such as 0.3M.

20. The method according to Claim 18 or Claim 19, wherein the aqueous sulfuric acid solution is provided in a volume to volume ratio compared to the precursor solution of from 1:1 to 1:10, such as from 1:2 to 1:5, such as from 3:4 to 3:5.

21. The method according to any one of Claims 18 to 20, wherein the halogenation is with one or more of F, Br, Cl or I, such as one or more of F, Br or Cl, such as F.

22. The method according to Claim 21, wherein the halogenated carbon nanomaterials are formed by the steps of:
(a) sonicating a dispersion of carbon nanomaterials in water to form a carbon nanomaterial suspension; and

(b) reacting the dispersed carbon nanomaterials suspension with a solution of a hydrophilic acid to form halogenated carbon nanomaterials.