alternative oxygen scavenger that overcomes or at least ameliorates one or more disadvantages as mentioned above.

Summary

There is provided a composite material comprising a mixture of at least one metal particle and a carbon material.

The carbon material may be derived from a biomass material. Advantageously, due to the use of biomass as a source for the carbon material, the resultant carbon material would have a layer of saccharides that is able to absorb the metal particles. This may lead to the carbon material having a high affinity to the metal particles. This may also lead to a uniform dispersion of the metal particles on or within the carbon material.

Advantageously, the composite material may be used as an oxygen scavenging material. The composite material, when used as an oxygen scavenging material, may be safe (that is, non toxic to the packaging material), may have a longer lifetime as compared to conventional oxygen scavengers, may have good stability during storage at ambient conditions, may be of low cost and easier to prepare or operate.

According to a first aspect, there is provided an oxygen scavenging nanostructured composite material comprising at least one metal particle and a carbon material, wherein said carbon material is derived from a biomass material selected from a saccharide, wherein the saccharide is selected from a monosaccharide, disaccharide, oligosaccharide or a polysaccharide; wherein the monosaccharide is selected from the group consisting of glucose, fructose and galactose; wherein the oligosaccharide is selected from the group consisting of a sugar or an amino sugar, or wherein the polysaccharide is selected from the group consisting of a cyclodextrin, a cellulose, a starch, a glycogen, a chitin and a hemicellulose; wherein said carbon material is a carbon particle or a sheet-like material having a porous structure with a pore size in the range of 10 to 700 nm; wherein said carbon material acts as a support for said at least one metal particle; wherein said at least one metal particle is uniformly distributed on or within said carbon material; and wherein said metal particle is a zero-valent transition metal particle.

There is provided a composition comprising a composite material comprising a mixture of at least one metal particle and a carbon material, an inorganic salt and optionally an aqueous medium.

According to another aspect, there is provided an oxygen scavenging composition comprising i. an oxygen scavenging nanostructured composite material comprising at least one metal particle and a carbon material; ii. an inorganic salt; and iii. optionally an aqueous medium, wherein said carbon material is derived from a biomass material selected from a saccharide, wherein the saccharide is selected from a monosaccharide, disaccharide, oligosaccharide or a polysaccharide; wherein the monosaccharide is selected from the group consisting of glucose, fructose and galactose; wherein the oligosaccharide is selected from the group consisting of a sugar or an amino sugar, or wherein the polysaccharide is selected from the group consisting of a cyclodextrin, a cellulose, a starch, a glycogen, a chitin and a hemicellulose; wherein said carbon material is a carbon particle or a sheet-like material having a porous structure with a pore size in the range of 10 to 700 nm; wherein said carbon material acts as a support for said at least one metal particle; wherein said at least one metal particle is uniformly distributed on or within said carbon material; and wherein said metal particle is a zero-valent transition metal particle.

There is provided a method of synthesizing a composite material comprising a mixture of at least one metal particle and a carbon material, comprising the steps of:

i. immersing at least one carbon particle that has a porous structure into a solution of metal ions to allow said metal ions to impregnate into the pores of the carbon particle;
ii. drying the impregnated carbon particle; and
iii. subjecting the impregnated carbon particle to a carbothermal reduction process at conditions to thereby synthesize the composite material.

According to another aspect, there is provided a method of synthesizing an oxygen scavenging nanostructured composite material, the method comprising: i. subjecting a dissolved biomass material to a one-step hydrothermal treatment process to form a porous carbon particle having a layer of saccharides containing hydroxyl and/or carboxylic acid groups thereon; ii. immersing said porous carbon particle of step (i) into a solution of metal ions to allow said metal ions to impregnate into the pores of the carbon particle; iii. drying the impregnated carbon particle; and iv. subjecting the impregnated carbon particle to a carbothermal reduction process at conditions to thereby synthesize said composite material, wherein said oxygen scavenging nanostructured composite material comprises at least one metal particle and a carbon material; wherein said biomass material is selected from a saccharide, wherein the saccharide is selected from a monosaccharide, disaccharide, oligosaccharide or a polysaccharide; wherein the monosaccharide is selected from the group consisting of glucose, fructose and galactose; wherein the oligosaccharide is selected from the group consisting of a sugar or an amino sugar, or wherein the polysaccharide is selected from the group consisting of a cyclodextrin, a cellulose, a starch, a glycogen, a chitin and a hemicellulose; wherein said carbon material is a carbon particle or a sheet-like material having a porous structure with a pore size in the range of 10 to 700 nm; wherein said carbon material acts as a support for said at least one metal particle; wherein said at least one metal particle is uniformly distributed on or within said carbon material; and wherein said metal particle is a zero-valent transition metal particle.

There is provided a multilayer film comprising an oxygen barrier layer that retards the permeation of oxygen from an external environment into the multilayer film and an oxygen scavenging layer comprising a composite material having a mixture of at least one metal particle and a carbon material.

According to another aspect, there is provided an oxygen scavenging multilayer film comprising i. an oxygen barrier layer that retards the permeation of oxygen from an external environment into the multilayer film; and ii. an oxygen scavenging layer comprising an oxygen scavenging nanostructured composite material comprising at least one metal particle and a carbon material, wherein said carbon material is derived from a biomass material selected from a saccharide, wherein the saccharide is selected from a monosaccharide, disaccharide, oligosaccharide or a polysaccharide; wherein the monosaccharide is selected from the group consisting of glucose, fructose and galactose; wherein the oligosaccharide is selected from the group consisting of a sugar or an amino sugar, or wherein the polysaccharide is selected from the group consisting of a cyclodextrin, a cellulose, a starch, a glycogen, a chitin and a hemicellulose; wherein said carbon material is a carbon particle or a sheet-like material having a porous structure with a pore size in the range of 10 to 700 nm; wherein said carbon material acts as a support for said at least one metal particle; wherein said at least one metal particle is uniformly distributed on or within said carbon material; and wherein said metal particle is a zero-valent transition metal particle.

Definitions

The following words and terms used herein shall have the meaning indicated:

The term ‘biomass material’ is to be interpreted broadly to include biological material derived from living, or living organisms. This is often used to mean plant based material but can equally apply to both animal and vegetable derived material when biomass is used for energy. Herein, biomass is carbon based and is composed of a mixture of organic molecules containing hydrogen, usually including atoms of oxygen, often nitrogen, and also small quantities of other atoms, including alkali, alkaline earth and heavy metals.

The term “composite material” as used herein represents a material made from two or more constituent materials with significantly different physical or chemical properties that, when

Claims

1. An oxygen scavenging nanostructured composite material comprising at least one metal particle and a carbon material,

wherein said carbon material is derived from a biomass material selected from a saccharide,

wherein the saccharide is selected from a monosaccharide, disaccharide, oligosaccharide or a polysaccharide;

wherein the monosaccharide is selected from the group consisting of glucose, fructose and galactose;

wherein the oligosaccharide is selected from the group consisting of a sugar or an amino sugar, or

wherein the polysaccharide is selected from the group consisting of a cyclodextrin, a cellulose, a starch, a glycogen, a chitin and a hemicellulose;

wherein said carbon material is a carbon particle or a sheet-like material having a porous structure with a pore size in the range of 10 to 700 nm;

wherein said carbon material acts as a support for said at least one metal particle;

wherein said at least one metal particle is uniformly distributed on or within said carbon material; and

wherein said metal particle is a zero-valent transition metal particle.

2. The oxygen scavenging nanostructured composite material according to claim 1, wherein said saccharide is selected from the group consisting of α-cyclodextrin, β-cyclodextrin, γ-cyclodextrin, D-glucosamine hydrochloride, L-glucosamine hydrochloride, α-D-glucose, β-D-glucose, α-L-glucose and β-L-glucose.

3. The oxygen scavenging nanostructured composite material according to claim 1 or 2, wherein said carbon material has a surface area in the range of 50 m^2/g to 1000 m^2/g.

4. The oxygen scavenging nanostructured composite material according to any of the preceding claims, wherein the transition metal of said zero-valent transition metal particle is selected from the group consisting of iron particles, ruthenium particles, osmium particles, cobalt particles, rhodium particles, iridium particles, manganese particles and combinations thereof.

5. The oxygen scavenging nanostructured composite material according to any one of the preceding claims, wherein said metal particle has a particle size of less than 500 nm.

6. The oxygen scavenging nanostructured composite material according to any one of the preceding claims, wherein the concentration of said metal particle in the composite material may be in the range of 1 to 80 wt%, based on the dry weight % of said carbon material.

7. An oxygen scavenging composition comprising

i. an oxygen scavenging nanostructured composite material comprising at least one metal particle and a carbon material;

ii. an inorganic salt; and

iii. optionally an aqueous medium,

wherein said carbon material is derived from a biomass material selected from a saccharide,

wherein the saccharide is selected from a monosaccharide, disaccharide, oligosaccharide or a polysaccharide;

wherein the monosaccharide is selected from the group consisting of glucose, fructose and galactose;

wherein the oligosaccharide is selected from the group consisting of a sugar or an amino sugar, or

wherein the polysaccharide is selected from the group consisting of a cyclodextrin, a cellulose, a starch, a glycogen, a chitin and a hemicellulose;

wherein said carbon material is a carbon particle or a sheet-like material having a porous structure with a pore size in the range of 10 to 700 nm;

wherein said carbon material acts as a support for said at least one metal particle;

wherein said at least one metal particle is uniformly distributed on or within said carbon material; and

wherein said metal particle is a zero-valent transition metal particle.

8. The oxygen scavenging composition according to claim 7, wherein the inorganic salt is an electrolyte or an acidifying agent.

9. The oxygen scavenging composition according to claim 8, wherein when the inorganic salt is an electrolyte, said electrolyte is a halide compound selected from the group consisting of an alkali metal halide, an alkaline earth metal halide and a metal halide.

10. The oxygen scavenging composition according to any one of claims 7 to 9, wherein the concentration of said inorganic salt is in the range of 0.1 to 20 wt%, based on the dry weight of said composite material.

11. The oxygen scavenging composition according to claim 8, wherein said acidifying agent is a polyacid selected from the group consisting of polyacrylic acid, polymethacrylic acid, polyethylacrylic acid and polymaleic acid.

12. A method of synthesizing an oxygen scavenging nanostructured composite material, the method comprising:

i. subjecting a dissolved biomass material to a one-step hydrothermal treatment process to form a porous carbon particle having a layer of saccharides containing hydroxyl and/or carboxylic acid groups thereon;

ii. immersing said porous carbon particle of step (i) into a solution of metal ions to allow said metal ions to impregnate into the pores of the carbon particle;

iii. drying the impregnated carbon particle; and

iv. subjecting the impregnated carbon particle to a carbothermal reduction process at conditions to thereby synthesize said composite material,

wherein said oxygen scavenging nanostructured composite material comprises at least one metal particle and a carbon material;

wherein said biomass material is selected from a saccharide,

wherein the saccharide is selected from a monosaccharide, disaccharide, oligosaccharide or a polysaccharide;

wherein the monosaccharide is selected from the group consisting of glucose, fructose and galactose;

wherein the oligosaccharide is selected from the group consisting of a sugar or an amino sugar, or

wherein the polysaccharide is selected from the group consisting of a cyclodextrin, a cellulose, a starch, a glycogen, a chitin and a hemicellulose;

wherein said carbon material is a carbon particle or a sheet-like material having a porous structure with a pore size in the range of 10 to 700 nm;

wherein said carbon material acts as a support for said at least one metal particle;

wherein said at least one metal particle is uniformly distributed on or within said carbon material; and

wherein said metal particle is a zero-valent transition metal particle.

13. The method of claim 12, wherein the solution of metal ions is derived from a metal salt selected from the group consisting of metal nitrate, metal chloride, metal sulfate, metal gluconate, metal citrate and metal oxalate.

14. The method of claim 12, wherein said immersing step is undertaken for a period of time in the range of 30 minutes to 24 hours.

15. The method of claim 12, wherein said subjecting step is undertaken at a temperature in the range of 700 to 1000 °C, or in an inert gas environment.

16. An oxygen scavenging multilayer film comprising

i. an oxygen barrier layer that retards the permeation of oxygen from an external environment into the multilayer film; and

ii. an oxygen scavenging layer comprising an oxygen scavenging nanostructured composite material comprising at least one metal particle and a carbon material,

wherein said carbon material is derived from a biomass material selected from a saccharide,

wherein the saccharide is selected from a monosaccharide, disaccharide, oligosaccharide or a polysaccharide;

wherein the monosaccharide is selected from the group consisting of glucose, fructose and galactose;

wherein the oligosaccharide is selected from the group consisting of a sugar or an amino sugar, or

wherein the polysaccharide is selected from the group consisting of a cyclodextrin, a cellulose, a starch, a glycogen, a chitin and a hemicellulose;

wherein said carbon material is a carbon particle or a sheet-like material having a porous structure with a pore size in the range of 10 to 700 nm;

wherein said carbon material acts as a support for said at least one metal particle;

wherein said at least one metal particle is uniformly distributed on or within said carbon material; and

wherein said metal particle is a zero-valent transition metal particle.