Summary

The present disclosure relates to a composite material comprising a porous silica particle, a plurality of metal particles disposed within the pores of said silica particle and a polymeric coating that at least partially encapsulates said silica particle.

In one aspect, the present disclosure relates to a composite material comprising a porous silica particle, a plurality of metal particles disposed within the pores of said silica particle and a polymeric coating that at least partially encapsulates said silica particle, wherein the thickness of the polymeric coating is in the range of 5 to 10 nm.

Advantageously, the polymeric coating acts as a protective layer that uniformly covers the metal/silica particles to avoid the oxidation of the metal particles in the porous silica particle during their preparation, leading to high oxygen scavenging of the metal particles and good dispersion in polymer matrix. Due to the nanoscale thickness of the polymeric coating, the metal particles can still be activated by moisture to scavenge oxygen.

Still advantageously, the silica particle may be functionalized with a silane which promotes the adsorption of the metal nanoparticle, leading to higher metal particle loading in the porous silica particle and therefore improves the oxygen scavenging capacity.

The present disclosure relates to a method of preparing a composite material, comprising the step of mixing a solution containing a plurality of activated metal and silica particles with a polymer solution to thereby form said composite material, wherein said composite material comprises a porous silica particle, a plurality of metal particles disposed within the pores of said silica particle and a polymeric coating that at least partially encapsulates said silica particle.

In another aspect, the present disclosure relates to a method of preparing a composite material, comprising the step of mixing a solution containing a plurality of activated metal and silica particles with a polymer solution to thereby form said composite material, wherein said composite material comprises a porous silica particle, a plurality of metal particles disposed within the pores of said silica particle and a polymeric coating that at least partially encapsulates said silica particle, wherein the thickness of the polymeric coating is in the range of 5 to 10 nm.

The method may further comprise a step of by annealing or chemical etching to enlarge the pore size of the silica particle.

Advantageously, through annealing or etching process, the porous silica particle possesses larger pore/channel for holding more metal particles in the composite material.

In another aspect, the present disclosure relates to use of the composite material as defined herein as an oxygen scavenger material.

In another aspect, the present disclosure relates to a method of forming an oxygen scavenging or oxygen barrier film comprising the step of compounding or coating a substrate with a composite material as defined herein.

Advantageously, the polymeric coating avoids oxidation and aggregation of metal/silica particles during compounding process with polymer resin, resulting in transparent oxygen scavenging composite films with high oxygen scavenging capability.

Definitions

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

The term “composite” as used herein represents material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce the material. The individual components remain separate and distinct within the finished material.

The term “oxygen scavenging” as used herein refers to an act of gathering or removing oxygen from an enclosed area or mixture.

Unless specified otherwise, the terms "comprising" and "comprise", and grammatical variants thereof, are intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, unrecited elements.

Claims

1. A composite material comprising a porous silica particle, a plurality of metal particles disposed within the pores of said silica particle and a polymeric coating that at least partially encapsulates said silica particle, wherein the thickness of the polymeric coating is in the range of 5 to 10 nm.

2. The composite material according to claim 1, wherein the silica particle is modified with a silane compound.

3. The composite material according to claim 2, wherein the silane compound is functionalised with an amino group or a carboxylic group.

4. The composite material according to any one of the preceding claims, wherein the metal of the metal particle is selected from Group 8 of the Periodic Table.

5. The composite material according to any one of the preceding claims, wherein the metal of the metal particle is iron.

6. The composite material according to any one of the preceding claims, wherein the size of the metal particle is less than 100 nm.

7. The composite material according to any one of the preceding claims, wherein the size of the porous silica particle is in the range of 20 nm to 1 μm.

8. The composite material according to any one of the preceding claims, wherein the pore size of the porous silica particle is in the range of 5 to 50 nm.

9. The composite material according to any one of the preceding claims, wherein the weight of the metal particles in the composite material is in the range of 1 to 80 wt% based on the dry weight of the porous silica particle.

10. The composite material according to any one of the preceding claims, further comprising an activator.

11. The composite material according to claim 10, wherein the activator is a halide salt.

12. The composite material according to any one of the preceding claims, wherein the polymeric coating comprises a polymer having a monomer selected from the group consisting of urethane, acrylate, methacrylate, epoxy, ethylene, vinyl alcohol and mixtures thereof.

13. The composite material according to any one of the preceding claims, wherein the composite material has an oxygen scavenging performance in the range of 210 to 230 cm^3/g of iron.

14. A method of preparing a composite material, comprising the step of mixing a solution containing a plurality of activated metal and silica particles with a polymer solution to thereby form said composite material, wherein said composite material comprises a porous silica particle, a plurality of metal particles disposed within the pores of said silica particle and a polymeric coating that at least partially encapsulates said silica particle, wherein the thickness of the polymeric coating is in the range of 5 to 10 nm.

15. The method according to claim 14, further comprising a step of annealing or chemical etching to enlarge the pore size of the silica particle.

16. The method according to claim 15, wherein the annealing step is undertaken at a temperature range of 100 to 700ºC.

17. The method according to claim 15, wherein the chemical etching step comprises the use of an alkali salt solution.

18. The method according to claim 15, wherein the amount of alkali salt in said solution is in the range of 0.01% to 5 wt% of the silica particle.

19. The method according to any one of claims 14 to 18, further comprising the step of modifying the silica particles with a silane compound.

20. The method according to claim 19, wherein the silane compound is functionalised with an amino group or a carboxylic group

21. The method according to any one of claims 14 to 20, wherein the polymer of the polymer solution is dissolved in a mixture of alcohol and water.

22. The method according to any one of claims 14 to 21, wherein the concentration of the polymer in the polymer solution is in the range of 0.01 to 10 wt%.

23. The method according to any one of claims 14 to 22, further comprising the step of activating a metal particle with a salt to form said activated metal.

24. Use of the composite material of any one of claims 1 to 13as an oxygen scavenger material.

25. A method of forming an oxygen scavenging or oxygen barrier film comprising the step of compounding or coating a substrate with a composite material as defined in any one of claims 1 to 13.