Description

Title of Invention : Fillers For Polymers

Technical Field

The present invention relates to a composite material comprising a core and a functionalized elastomeric polymer. The present invention also relates to a polymer comprising a resin and the composite material, and the method for making the composite material.

Background Art

Incorporation of composite materials such as nanofillers for the purposes of mechanical enhancement of a polymer matrix has been researched for decades. Incorporation of fillers can significantly increase some aspects of material strength, such as tensile properties. For instance, by adding a filler, a polymer may be able to withstand higher stress while being stretched or pulled before it breaks or fails, compared to when no filler is added.

However, addition of a filler has also been known to compromise material properties such as impact resistance, which results in the material being more brittle. This contradictory phenomenon has been a constant challenge for material researchers.

There is therefore a need to provide composite material such as a filler that overcomes or at least ameliorates, one or more of the disadvantages described above.

Summary of Invention

There is provided a composite material comprising a chalcogen core and a functionalized elastomeric polymer bonded onto the chalcogen core.

In an aspect, there is provided a composite material comprising a core comprising oxygen and a functionalized elastomeric polymer bonded onto the core comprising oxygen, wherein the core comprising oxygen comprises a composition selected from the group consisting of organosilica, silica, clay, graphene oxide, oxygen-functionalised carbon nanotubes, oxygen-functionalised carbon black, glass fibres and any mixture thereof, and wherein the elastomeric polymer is a thermoset elastomer.

Advantageously, the composite material may concomitantly enhance properties such as tensile strength, tensile modulus, elongation at break, storage modulus, impact resistance and fracture toughness of polymer matrices into which they are mixed with. Advantageously, this enhancement may be due to the structural design of the composite material at the molecular level and the synergism between each of the components of the composite material. That is, between the core, the elastomeric polymer and the functional group of the elastomeric polymer. Advantageously, the composite material may comprise of three important parts, including the chalcogen core which acts as the rigid inner core, the elastomeric polymer which acts as a soft ductile segment that is firmly bonded onto the inner core, and a reactive functional group that terminates the elastomeric polymer. More advantageously, the chalcogen core may provide a firm backbone to the polymer, the elastomeric polymer may provide resilience to the polymer matrix and the reactive functional group may provide bonding of the composite material to the

polymer matrix. Advantageously, the elastomeric polymer may confer not only enhancement in tensile properties to the polymer matrix but also enhancement in properties such as impact resistance. That is, the elastomeric polymer may reduce brittleness of the polymer matrix. Further advantageously, the composite material may have a uniform size and may be easily and uniformly dispersed in polymer matrices.

In another aspect, there is provided a polymer comprising a resin and the composite material as defined above. Advantageously, with as little as 1wt% of the composite material in the polymer matrix, the material strength and material resilience may improve significantly. That is, the material may be able to withstand a larger amount of stress before failing, while at the same time, be able to absorb more energy and deform without fracturing compared to conventional materials.

In comparison to epoxy resin that does not contain any fillers, a polymer comprising the composite material as defined above may have an 80% increase in impact resistance, 20% increase in fracture toughness (K_{ic}), more than 100% increase in elongation at break and almost 50 % increase in maximum tensile strength. Advantageously, the polymer may simultaneously have material strength and material resilience, unlike conventional polymer comprising a filler where material resilience may be compromised. In other words, a polymer material containing the disclosed composite material may exhibit tensile strength comparable or superior to other polymer materials containing conventional nanofillers, but without experiencing the brittleness that conventional nanofillers tend to cause.

Further advantageously, the composite material may be uniformly distributed within the polymer matrix. More advantageously, there may be a strong interaction between the composite material and the resin of the polymer.

There is provided a method of synthesizing the composite material as defined above, comprising the steps of: providing a chalcogen core; activating the core; contacting the activated core with an elastomeric polymer; and functionalizing the elastomeric polymer with a reactive functional group.

In another aspect, there is provided a method of synthesizing the composite material as defined above, comprising the steps of: providing a core comprising oxygen, wherein the core comprising oxygen comprises a composition selected from the group consisting of organosilica, silica, clay, graphene oxide, oxygen-functionalised carbon nanotubes, oxygen-functionalised carbon black, glass fibres and any mixture thereof; activating the core comprising oxygen; contacting the activated core comprising oxygen with an elastomeric polymer, wherein the elastomeric polymer is a thermoset elastomer; and functionalizing the elastomeric polymer with a reactive functional group.

Advantageously, the method may provide a time- and cost-effective way for manufacturing the composite material. More advantageously, the method may be easily up-scaled. Further advantageously, the simple preparation process may allow easy integration of the method as defined above with existing industrial processes.

Claims

1. A composite material comprising a core comprising oxygen and a functionalized elastomeric polymer bonded onto the core comprising oxygen, wherein the core comprising oxygen comprises a composition selected from the group consisting of organosilica, silica, clay, graphene oxide, oxygen-functionalised carbon nanotubes, oxygen-functionalised carbon black, glass fibres and any mixture thereof, and wherein the elastomeric polymer is a thermoset elastomer.
2. The composite material according to claim 1, wherein the core comprising oxygen comprises organosilica.
3. The composite material according to claim 2, wherein the organosilica is polyhedral oligomeric silsesquioxane (POSS).
4. The composite material according to claim 3, wherein the polyhedral oligomeric silsesquioxane (POSS) is an octahedral oligomeric silsesquioxane.
5. The composite material according to any one of the preceding claims, wherein the functionalized elastomeric polymer is covalently bonded onto the core comprising oxygen.
6. The composite material according to any one of the preceding claims, wherein the elastomeric polymer is selected from the group consisting of poly(n-butylacrylate), polysiloxane, polyisoprene, polychloroprene, polyisobutylene, polyacrylate, and any mixture thereof.
7. The composite material according to claim 6, wherein the elastomeric polymer is poly(n-butylacrylate).
8. The composite material according to any one of the preceding claims, wherein the elastomeric polymer is a polymer that has a glass transition temperature below -30 °C.
9. The composite material according to any one of the preceding claims, wherein the elastomeric polymer is functionalized with a functional group selected from the group consisting of amine, epoxy, ester, hydroxyl, vinyl, urethane, isocyanate and any mixture thereof.
10. The composite material according to claim 9, wherein the elastomeric polymer is functionalized with amine.
11. A polymer comprising a resin and the composite material according to claim 1.

14. The polymer according to any one of claims 11 to 13, wherein the resin comprises polymerizable groups selected from the group consisting of amine, epoxy, ester, hydroxyl, vinyl, urethane, isocyanate and any mixture thereof.

15. The polymer according to claim 14, wherein the resin comprises epoxy groups.

16. The polymer according to any one of claims 11 to 15, wherein the resin is bisphenol A diglycidylether.

17. A method of synthesizing the composite material according to claim 1, comprising the steps of:

providing a core comprising oxgen, wherein the core comprising oxygen comprises a composition selected from the group consisting of organosilica, silica, clay, graphene oxide, oxygen-functionalised carbon nanotubes, oxygen-functionalised carbon black, glass fibres and any mixture thereof;

activating the core comprising oxygen;

contacting the activated core comprising oxygen with an elastomeric polymer, wherein the elastomeric polymer is a thermoset elastomer; and

functionalizing the elastomeric polymer with a reactive functional group.

18. The method according to claim 17, wherein the core comprising oxygen comprises octahedral oligomeric silsesquioxane.

19. The method according to claim 18, wherein the octahedral silsesquioxane is octa(3-hydroxy-3-methylbutyldimethylsiloxy)-POSS.

20. The method according to any one of claims 17 to 19, wherein the activating step is performed by converting the hydroxyl group of octahydroxy polyoctahedral silsesquioxane to a bromo group.

21. The method according to any one of claims 17 to 20, wherein the activated core is octabromopropionyl polyoctahedral silsesquioxane.

22. The method according to any one of claims 17 to 21, wherein the elastomeric polymer is poly(n-butyl acrylate).

23. The method according to any one of claims 17 to 22, wherein the contacting step is performed in the presence of a base.

24. The method according to any one of claims 17 to 23, wherein the contacting step forms a covalent bond between the activated core and the elastomeric polymer.

25. The method according to any one of claims 17 to 24, wherein the functional group is amine.

26. The method according to any one of claims 17 to 25, wherein the functionalizing step is performed by contacting the elastomeric polymer with an amino-containing compound.