Claims

1. Use of a nanoparticle composition as a heat transfer fluid in battery or other electrical equipment systems, wherein the nanoparticle composition is obtainable by milling a mixture, the mixture comprising one or more nanoparticle compound (A) and one or more amorphous polymer compound (B),

(A) wherein the one or more nanoparticle compound (A) is selected from the group consisting of

- metal or metalloid nitride nanoparticle;
- multi or single walled carbon nanotubes;
- carbon black;
- a metal chalcogenide having a molecular formula MX_2, wherein M is a metallic element selected from the group consisting of titanium (Ti), vanadium (V), , manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), zirconium (Zr), niobium (Nb), molybdenum (Mo), tantalum (Ta), tungsten (W), osmium (Os), and combinations thereof, and X is a chalcogen element selected from the group consisting of sulfur (S), oxygen (O), and combinations thereof;
- or a mixture thereof, and

(B) wherein the one or more amorphous polymer compound (B) is obtainable by polymerizing a monomer composition comprising:

a) 1 to 30 % by weight, based on the total weight of the monomer composition, of one or more functional monomer selected from the list consisting of:

a1) aminoalkyl (meth)acrylates and aminoalkyl (meth)acrylamides;

a2) nitriles of alkyl (meth)acrylic acid and other nitrogen-containing alkyl (meth)acrylates;

a3) (meth)acrylates of ether alcohols;

a4) oxiranyl alkyl (meth)acrylate;

a5) phosphorus-, boron- and/or silicon-containing alkyl (meth)acrylates;

a6) heterocyclic alkyl (meth)acrylates;

a7) vinyl halides;

a8) vinyl esters;

a9) vinyl monomers containing aromatic groups;

a10) heterocyclic vinyl compounds;

a11) vinyl and isoprenyl ethers;

a12) methacrylic acid and acrylic acid, and

b) 30 to 80% by weight of one or more alkyl (meth)acrylate monomer, wherein each of the alkyl group of the one or more alkyl (meth)acrylate monomer is independently linear, cyclic or branched and comprises from 1 to 40 carbon atoms, based on the total weight of the monomer composition, and

c) 20 to 60 % by weight of the reaction product of one or more ester of (meth)acrylic acid and one or more hydroxylated hydrogenated polybutadiene having a number-average molecular weight (M_n) of 500 to 10,000 g/mol, based on the total weight of the monomer composition,

and wherein the weight ratio of the one or more nanoparticle compound (A) to the one or more amorphous polymer compound (B) is 9:1 to 1:5.

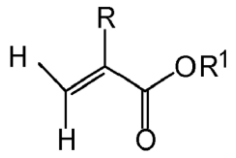
2. The use according to claim 1, wherein the one or more hydroxylated hydrogenated polybutadiene of component c) has a number-average molecular weight (Mn) of 1,500 to 2,100 g/mol, more preferably 1,800 to 2,100 g/mol, most preferably 1,900 to 2,100 g/mol determined by gel permeation chromatography using polybutadiene calibration standards according to DIN 55672-1 with tetrahydrofuran as eluent.

3. The use according to claim 1 or 2, wherein the one or more amorphous polymer compound (B) has a weight-average molecular weight (M_w) of 10,000 to 1,000,000 g/mol, more preferably 50,000 to 800,000 g/mol, even more preferably 100,000 to 500,000 g/mol, most preferably 150,000 to 350,000 g/mol determined by gel permeation chromatography using polymethylmethacrylate calibration standards and tetrahydrofuran as eluent.

4. The use according to any one of claims 1 to 3, wherein the one or more amorphous polymer compound (B) is obtainable by polymerizing a monomer composition comprising:

a) 1 to 30 % by weight, preferably 5 to 30 % by weight, more preferably 10 to 20 % by weight of the one or more functional monomer as component a), based on the total weight of the monomer composition; and

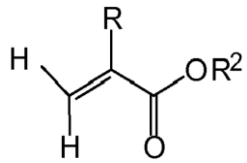
b1) 30 to 60 % by weight, preferably 30 to 50 % by weight, more preferably 35 to 50 % by weight of one or more alkyl (meth)acrylate of formula (I), as first component b):



(I)

wherein R is hydrogen or methyl, R^1 means a linear, branched or cyclic alkyl residue with 1 to 8 carbon atoms, preferably 1 to 5 carbon atoms, and more preferably 1 to 4 carbon atoms, based on the total weight of the monomer composition; and

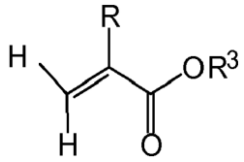
b2) 0 to 20 % by weight, preferably 1 to 15 % by weight, more preferably 1 to 10 % by weight of one or more alkyl (meth)acrylate of formula (II), as second component b):



(II)

wherein R is hydrogen or methyl, R^2 means a linear, branched or cyclic alkyl residue with 9 to 15 carbon atoms, preferably 12 to 15 carbon atoms, and more preferably 12 to 14 carbon atoms, based on the total weight of the monomer composition; and

b3) 0 to 20 % by weight, preferably 0 to 15 % by weight, more preferably 0 to 10 % by weight of one or more alkyl (meth)acrylate of formula (III), as third component b):



(III)

wherein R is hydrogen or methyl, R^3 means a linear, branched or cyclic alkyl residue with 16 to 40 carbon atoms, preferably 16 to 30 carbon atoms, and more preferably 6 to 20 carbon atoms, based on the total weight of the monomer composition; and

c) 20 to 60 % by weight, more preferably 25 to 55 % by weight, more preferably 30 to 50 % by weight of the reaction product of one or more ester of (meth)acrylic acid and one or more hydroxylated hydrogenated polybutadiene having a number-average molecular weight (M_n) of 500 to 10,000 g/mol, based on the total weight of the monomer composition.

5. The use according to any one of claims 1 to 4, wherein the weight ratio of the one or more nanoparticle compound (A) to the one or more amorphous polymer compound (B) is preferably 5:1 to 1:2, more preferably 3:1 to 1:2.

6. The use according to any one of claims 1 to 5, wherein the one or more amorphous polymer compound (B) is obtainable by polymerizing a monomer composition comprising:

a1) 0.5 to 5 % by weight of an aminoalkyl (meth)acrylamide, most preferably N-(3-dimethyl-aminopropyl)methacrylamide, as first component a), based on the total weight of the monomer composition;

a9) 5 to 15 % by weight of a vinyl monomer containing aromatic groups, most preferably styrene, as second component a), based on the total weight of the monomer composition;

b1) 35 to 50 % by weight of an alkyl (meth)acrylate monomer of formula (I), most preferably methyl methacrylate and/or butyl methacrylate, as first component b), based on the total weight of the monomer composition;

b2) 1 to 10 % by weight of an alkyl (meth)acrylate monomer of formula (II), most preferably lauryl methacrylate, as second component b), based on the total weight of the monomer composition;

c) 30 to 50 % by weight of an ester of a (meth)acrylic acid and a hydroxylated hydrogenated polybutadiene having a number-average molecular weight (M_n) of 500 to 10,000 g/mol, most preferably a macromonomer derived from the reaction of an ester of a (meth)acrylic acid and a hydroxylated hydrogenated

polybutadiene having a number-average molecular weight (M_n) of 1,500 to 5,000 g/mol, as component c), based on the total weight of the monomer composition.

7. The use according to any one of claims 1 to 6, wherein the weight contents of monomers a), b) and c) of the monomer composition sum up to 100 % by weight, based on the total weight of the monomer composition.

8. The use according to any one of claims 1 to 7, wherein the nanoparticle compound (A) is selected from hexagonal boron nitride (hBN) nanoparticle; carbon black, a metal chalcogenide having a molecular formula MX_2 wherein the metallic element M is molybdenum (Mo) or tungsten (W) and the chalcogen element X is sulfur (S); or a mixture thereof.

9. The use according to any one of claims 1 to 8, wherein the nanoparticle composition further comprises a base fluid (C), which has a kinematic viscosity at 40 °C from 3 cSt to 30 cSt, preferably from 3 cSt to 15 cSt, according to ASTM D-445 and a flash point of more than 110 °C according to ASTM D-93.

10. The use according to claim 9, wherein the base fluid is selected from the list consisting of an API Group I base oil, an API Group II base oil, an API Group III base oil, an API Group IV base oil, an API Group V base oil, or a mixture thereof.

11. The use according to claim 9 or 10, wherein the nanoparticle composition comprises 85 to 99.9 % by weight of a base fluid (C) and 0.1 to 15 % by weight of (A) and (B), more preferably 90 to 99.9 % by weight of a base fluid (C) and 0.1 to 10 % by weight of (A) and (B), most preferably 92 to 99.5 % by weight of a base fluid (C) and 0.5 to 8 % by weight of (A) and (B), based on the total weight of the nanoparticle composition.

12. The use according to any one of claims 9 to 11, wherein the amounts of (A), (B) and (C) sum up to 100 % by weight, based on the total weight of the nanoparticle composition.

13. The use according to any one of claims 1 to 12, wherein the nanoparticle composition comprising one or more nanoparticle (A), one or more amorphous polymer compound (B) and optionally the base fluid (C) is milled via a ball mill process.

14. The use according to any one of claims 1 to 13, wherein the nanoparticle composition further comprises one or more additive component (D) selected from the group consisting of antioxidants, anti-wear additives, pour point depressants, corrosion inhibitors, metal passivators, electrostatic discharge depressants, defoaming agents, seal fix or seal compatibility agents, rust inhibitors, demulsifiers, emulsifiers, friction modifiers, extreme pressure additives, dyes or a mixture thereof.

15. The use according to any one of claims 1 to 14, wherein the electrical equipment system is selected from the group consisting of electric batteries, electric motors, electric vehicle transmission, electric transformers, electric capacitors, fluid-filled transmission lines, fluid-filled power cables, computers and power electronics.