SUMMARY

In an aspect, there is provided a composite material comprising more than 2 wt/wt% nanotubes, wherein said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 mm.

In another aspect, there is provided a material comprising a filler and at least one byproduct, wherein the filler is selected from the group consisting of a nanotube, a carbon nanotube, a multi-wall nanotube, a multi-wall carbon nanotube, a single-wall nanotube, a single-wall carbon nanotube, graphene, a carbon fibre, a carbon nanofibre, a carbon nanothread, nanowire, a ceramic material, a fullerene, graphane, graphene oxide, graphite, graphyne, a COOH-functionalized carbon nanotube, a OH-functionalized carbon nanotube, an NH2-functionalized carbon nanotube, an SH-functionalized carbon nanotube, COOH-functionalized graphene, NH2-functionalized graphene, OH-functionalized graphene, thiol-functionalized graphene, a glass fibre, preferably selected from nanotube, a carbon nanotube, a single-wall carbon nanotube, graphene, and graphene oxide, and

wherein the byproduct is selected from H2O, HCl, NaCl, N2, CO2, biphenyl, NC-C(CH3)2-C(CH3)2-CN, NC-C(CH3)(CH2-CH3)-C(CH3)(CH2-CH3)-CN, NC-C(CH3)(CH2-C(CH3)2-O-CH3)-C(CH3)(CH2-C(CH3)2-O-CH3)-CN, preferably selected from H2O, HCl, NaCl, N2, CO2, biphenyl, and NC-C(CH3)2-C(CH3)2-CN.

In another aspect, there is provided a method for preparing a composite material, said method comprising:
a) Provide a nanotube;
b) Provide a precursor-ML, being a chemical entity that can be turned into a mechanical ligand (ML) by formation of a covalent bond between two different parts of said precursor-ML;
c) Optionally, provide a catalyst;
to generate a nanotube-ML structure;
wherein steps a) to c) may be performed in any order.

What is provided is a method for effectively dispersing nanotubes, in particular carbon nanotubes in solvents as well as in composites. It is shown how the method irreversibly improves the dispersion, but also, how dispersion may first be effectuated and then the nanotubes be left unmarked (pristine) from the method, yet with only rather small nanotube aggregates left in the composite.

What is thus provided is a general process for the production of a SE1-ML complex, comprising the following steps:

Step Y1. Provide a SE1, where the SE1 is a nanotube;

Step Y2. Provide a precursor-ML, where the precursor-ML is a Ushape comprising two chemical moieties with affinity for the nanotube;

to obtain a nanotube-Ushape complex;

where Steps Y1-Y2 may be performed in any order.

A composite material comprising nanotubes is also provided, wherein said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 1 mm.

What is further provided is a means for the efficient anchoring of nanotubes, in particular carbon nanotubes, in composite materials.

What is thus provided is a general process for the production of a SE1-ML-SE2 complex, comprising the following steps:

Step 1a. Provide a SE1;

Step 1b. Provide a precursor-ML;

Step 1c. Optionally, provide a catalyst;

Step 1d. Provide a SE2;

to generate a SE1-ML-SE2 structure.

What is further provided is a means for applying the disclosure to industrial production of products made from composite materials, including minimizing the presence of nanotube

PU, PUR, Polyamide, Nylon, Epoxy, Polyester, ABS, ASA, SAN, PBS, PBT, PET, PA, Polycarbonate, PU, PUR, UPR, Polymethylpentene (PMP), Polybutene-1 (PB-1), polyisobutylene (PIB), Ethylene propylene rubber (EPR), Vinyl ester, PMMA, Phenolic (PH), Polyphenylene sulfide (PPS), Polyetherimide (PEI), Polyetheretherketone (PEEK), Polyetherketoneketone (PEKK), CA, Cyanate ester (CE), Bismaleimide (BMI), Polyimide (PI), TPE, PBAT, PTT, PHA, PEF, EPDM, PLA, or Ethylene propylene diene monomer (M-class) rubber.

Further provided is a composite material, wherein at least one of said one or more mechanical ligands is bonded to a polymer chain, preferably a polymer chosen from: PE, LDPE, HDPE, Polypropylene, PVC, PS, EPS, PPS, PU, PUR, Polyamide, Nylon, Epoxy, Polyester, ABS, ASA, SAN, PBS, PBT, PET, PA, Polycarbonate, PU, PUR, UPR, Polymethylpentene (PMP), Polybutene-1 (PB-1), polyisobutylene (PIB), Ethylene propylene rubber (EPR), Vinyl ester, PMMA, Phenolic (PH), Polyphenylene sulfide (PPS), Polyetherimide (PEI), Polyetheretherketone (PEEK), Polyetherketoneketone (PEKK), CA, Cyanate ester (CE), Bismaleimide (BMI), Polyimide (PI), TPE, PBAT, PTT, PHA, PEF, EPDM, PLA, or Ethylene propylene diene monomer (M-class) rubber.

In one example of the composite material, the nanotubes are selected from carbon nanotube, multiwall, single-wall, or double-wall nanotubes, or mixtures thereof.

In a further example of the composite material, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 µm, wherein the nanotube concentration is 10-15 w/w%; and wherein the composite material has a volume of at least 1 μm^3.

Suitably, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 µm, wherein the nanotube concentration is 15-25 w/w%; and wherein the composite material has a volume of at least 1 μm^3.

In a further example, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 µm, wherein the nanotube concentration is 25-40 w/w%; and wherein the composite material has a volume of at least 1 μm^3.

In a further example, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 µm, wherein the nanotube concentration is 40-70 w/w%; and wherein the composite material has a volume of at least 1 μm^3.

In a further example, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 µm, wherein the nanotube concentration is 70-99,99 w/w%; and wherein the composite material has a volume of at least 1 μm^3.

In a further example, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 µm, wherein the nanotube concentration is 10-25 w/w%; and wherein the composite material has a volume of at least 1 μm^3.

In a further example, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 µm, wherein the nanotube concentration is 10-25 w/w%; and wherein the composite material has a volume of at least 10 μm^3.

In a further example, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.1 µm, wherein the nanotube concentration is 10-25 w/w%; and wherein the composite material has a volume of at least 100 μm^3.

In a further example, said composite material does not comprise any nanotube aggregates having a smallest dimension larger than 0.01 µm, wherein the nanotube concentration is 10-25 w/w%; and wherein the composite material has a volume of at least 10 μm^3.

The present technology also provides an ML-nanotube complex, comprising at least two mechanical ligands (ML) complexed to a single nanotube, and wherein said at least two mechanical ligands are covalently linked to one another. Further details of the mechanical ligand (ML) are provided in the following.

LEGENDS TO THE FIGURES

Figure 1. SE1-ML complexes. Various SE1-ML complexes are shown.

Figure 2. SE1-ML-SE2 complexes. Various SE1-ML-SE2 complexes are shown.

Figure 3. Formation of mechanical ligands (MLs). The formation of MLs from precursor-MLs is shown.