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Nanotechnologies — Magnetic nanomaterials —

Part 1: Specification of characteristics and measurements for magnetic nanosuspensions

Nanotechnologies — Nanomatériaux magnétiques —

Partie 1: Spécification des caractéristiques et des mesures pour les nanosuspensions magnétiques

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Contents

Page

Foreword

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Introduction

Nanomaterials offer the opportunity for new technologies at the interfaces between chemistry, physics and biology. The term nanomaterial is used to refer to a wide range of particles, thin films, self-assembling and lithographically produced structures in which at least one dimension is less than 100 nm. Magentic nanosuspensions are fluid nanodispersion, where the solid phase is formed by magnetic nanoparticles.Magnetic nanosuspensions and bulk materials react to applied magnetic fields in different ways. These unique properties enable the development of innovative technologies and products.

Magnetic nanosuspensions have important potential industrial and healthcare applications such as vacuum seals, lubricants, coolants, dampers, magnetic soaps, environmental remediation, medical imaging, drug delivery technologies, magnetic hyperthermia therapy, etc. To satisfy the demands of rapidly accelerating application markets, there is a strong need to provide universal definitions and measurement methods for the characteristics of these suspensions. There are three components of a magnetic nanosuspension: (1) magnetic nanoparticles (2) dispersing medium and (3) dispersant (Annex A).

Nanotechnologies — Magnetic nanomaterials —

Part 1: Specification of characteristics and measurements for magnetic nanosuspensions

1 Scope

This document specifies the characteristics of magnetic nanosuspensions to be measured and lists measurement methods for measuring these characteristics.

This is a generic document and does not deal with any particular application.

2 Normative references

There are no normative references for this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
AC susceptibility
complex ratio between the dynamic magnetization and the applied magnetic excitation field

Note 1 to entry: The dynamic magnetization is given as $M = M_0 e^{(i2\pi ft - \phi)}$ and the applied magnetic excitation field is given as $H = H_0 e^{i2\pi ft}$. The AC susceptibility $\chi = M / H$ is divided into an in-phase component (real part) and an out-of-phase component (imaginary part): $\chi = \chi' - i\chi''$.

Note 2 to entry: In dependence on the type of magnetization that is used, the AC susceptibility of a material is related to volume, mass or amount of the material.

AC volume susceptibility $\chi_V = \frac{M_{0V}}{H_0} \cos\varphi - i \frac{M_{0V}}{H_0} \sin\varphi$

AC mass susceptibility $\chi_m = \frac{M_{0m}}{H_0} \cos\varphi - i \frac{M_{0m}}{H_0} \sin\varphi$

AC molar susceptibility $\chi_n = \frac{M_{0n}}{H_0} \cos\varphi - i \frac{M_{0n}}{H_0} \sin\varphi$

Note 3 to entry: AC susceptibility depends on the excitation field frequency and the temperature, which should also be indicated.

Note 4 to entry: The amplitude of the excitation field must be small enough so there is a linear relation between the amplitude of the dynamic magnetization and the amplitude of the applied AC field.

3.2
agglomerate
collection of weakly or medium strongly bound particles where the resulting external surface area is similar to the sum of the surface areas of the individual components

Note 1 to entry: The forces holding an agglomerate together are weak forces, for example van der Waals forces or simple physical entanglement.

Note 2 to entry: Agglomerates are also termed secondary particles and the original source particles are termed primary particles.

Note 3 to entry: Primary particles can themselves be composites particles with both magnetic and non-magnetic parts.

[SOURCE: ISO/TS 80004-2:2015,3.4]

3.3
aggregate
particle comprising strongly bonded or fused particles, where the resulting external surface area is significantly smaller than the sum of surface areas of the individual components

Note 1 to entry: The forces holding an aggregate together are strong forces, for example covalent or ionic bonds, or those resulting from sintering or complex physical entanglement, or otherwise combined former primary particles.

Note 2 to entry: Aggregates are also termed secondary particles and the original source particles are termed primary particles.

[SOURCE: ISO/TS 80004-2:2015,3.5]

3.4
chemical composition
ratio of the quantities of the chemical elements present in the nanosuspension

Note 1 to entry: The quantities may be expressed in mass, volumen or number of moles.

3.5
core-shell nanoparticle
nanoparticle consisting of a core and shell(s)

Note 1 to entry: A related term nanostructured core-shell particle is defined in ISO/TS 80004-4.

Note 2 to entry: The largest external dimension/length (core diameter plus twice the shell thickness) has to be in the nanoscale . For spherical core-shell nanoparticle, this length is the outer diameter.

Note 3 to entry: A related term, single-core magnetic nanoparticle, is defined in reference [1].

[SOURCE: ISO/TS 80004-2:2015,4.13]

3.6
curie temperature
temperature at which a ferromagnetic material passes from the ferromagnetic state to the paramagnetic state and vice versa

[SOURCE: ISO 11358-1:2014, 3.3]

3.7
differential magnetic susceptibility
differential ratio of the magnetization that is induced by a magnetic field change to the amplitude of the magnetic field change

Note 1 to entry: The magnetic susceptibility of a material can be related to volume, mass or amount of the material.

volume susceptibility $$\chi_{\mathrm{V}} = \frac{dM_{\mathrm{V}}}{dH}$$

mass susceptibility $$\chi_{\mathrm{m}} = \frac{dM_{\mathrm{m}}}{dH}$$

molar susceptibility $$\chi_{\mathrm{n}} = \frac{dM_{\mathrm{n}}}{dH}$$

Note 2 to entry: The initial susceptibility χo is defined as the susceptibility at H = 0.

Note 3 to entry: Magnetic nanosuspensions are considered as magnetically isotropic and their magnetic susceptibility is indicated as a scalar.

3.8
dispersant
additive that facilitates the dispersion of solid in the dispersing medium, and that increases the stability against agglomeration of the mixture thereafter

[SOURCE: ISO 4618: 2014, 2.85, modified]

3.9
dispersing medium
liquid in which the sample is dispersed and suspended

[SOURCE: ISO 14703:2008, 3.5]

3.10
dry matter content
ratio of the mass of residues after drying at certain high temperature to that of sample before drying

3.11
dynamic viscosity
ratio between the applied shear stress and rate of shear of a liquid

Note 1 to entry: It is sometimes called the coefficient of dynamic viscosity, or simply viscosity.

Note 2 to entry: Dynamic viscosity is a measure of the resistance to flow or deformation of a liquid.

Note 3 to entry: The term dynamic viscosity can also be used in a different context to denote a frequency-dependent quantity in which shear stress and shear rate have a sinusoidal time dependence.

[SOURCE: ISO 3104:1994, 3.3, modified]

3.12
equivalent diameter
diameter of a sphere that produces a response by a given particle-sizing method, that is equivalent to the response produced by the particle being measured

Note 1 to entry: The physical property to which the equivalent diameter refers is indicated using a suitable subscript (see ISO 9276-1:1998).

Note 2 to entry: For discrete-particle-counting, light-scattering instruments, an equivalent optical diameter is used.

Note 3 to entry: Other material constants like density of the particle are used for the calculation of the equivalent diameter like Stokes diameter or sedimentation equivalent diameter. The material constants, used for the calculation, should be reported additionally.

[SOURCE: ISO/TS 80004-6:2013, 3.1.5]

3.13
fluid density
mass of unit volume of suspension at specific temperature

3.14
fluid nanodispersion
heterogeneous material in which nano-objects or a nanophase are dispersed in a continuous fluid phase of a different composition

[SOURCE: ISO/TS 80004-4:2011, 3.5]

3.15
freezing point
temperature at which solid crystals form within the dispersing medium as the liquid nanoparticle suspension is cooled under specified conditions of test

3.16
hydrodynamic diameter
equivalent diameter of a particle in a liquid having the same diffusion coefficient as the real particle in that liquid

[SOURCE: ISO/TS 80004-6:2013, 3.2.6]

3.17
magnetic moment
vector quantity describing the ability of a magnetized body to produce a magnetic field outside its own boundaries

3.18
magnetic nanoparticle
Nanoparticles with coupled atomic magnetic moment

3.19
magnetic field hyperthermia
the process where a time varying magnetic field of frequency f and amplitude H_o results in a temperature T increase of a magnetic nanosuspension

3.20
magnetization
vector quantity describing the specific magnetic moment of a material

Note 1 to entry: The magnetic moment of a sample can be related to volume, mass or amount of substance of the sample to obtain the magnetization.

volume magnetization $$M_\mathrm{V} = \frac{\mu_\mathrm{m}}{V}$$

mass magnetization $$M_\mathrm{m} = \frac{\mu_\mathrm{m}}{m}$$

molar magnetization $$M_\mathrm{n} = \frac{\mu_\mathrm{m}}{n}$$

Note 2 to entry: The magnetization should be indicated for sufficiently homogeneous compartments of the sample and those compartments should be mentioned (e.g. magnetization of the nanoparticle cores).

3.21
magnetoviscosity
dynamic viscosity of a liquid suspension of magnetic nanoparticles in the presence of external magnetic field

3.22
multi-core nanoparticle
core-shell nanoparticle with more than one physically separated core embedded in a matrix of shell material

3.23
nanoparticle
nano-object with all external dimensions in the nanoscale where the lengths of the longest and the shortest axes of the nano-object do not differ significantly

Note 1 to entry: If the dimensions differ significantly (typically by more than 3 times), terms such as nanofibre or nanoplate may be preferred to the term nanoparticle.

[SOURCE: ISO/TS 80004-2:2015, 4.4]

3.24
nanophase
physically or chemically distinct region or collective term for physically distinct regions of the same kind in a material with the discrete regions having one, two or three dimensions in the nanoscale

Note 1 to entry: Nano-objects embedded in another phase constitute a nanophase.

[SOURCE: ISO/TS 80004-4:2011, 2.12]

3.25
nano-object
discrete piece of material with one, two or three external dimensions in the nanoscale

Note 1 to entry: The second and third external dimensions are orthogonal to the first dimension and to each other.

[SOURCE: ISO/TS 80004-2:2015,2.2]

3.26
nanoscale
length range approximately from 1 nm to 100 nm

Note 1 to entry: Properties that are not extrapolations from a larger size are predominantly exhibited in this length range.

[SOURCE: ISO/TS 80004-1:2015, 2.1]

3.27
nanosuspension
fluid nanodispersion (3.14) where the dispersed phase is a solid

Note 1 to entry: The use of the term “nanosuspension” carries no implication regarding thermodynamic stability.

[SOURCE: ISO/TS 80004-4:2011, 3.5.1]

3.28
particle
minute piece of matter with defined physical boundaries

Note 1 to entry: A physical boundary can also be described as an interface.

Note 2 to entry: A particle can move as a unit.

[SOURCE: ISO/TS 80004-2:2015,3.1]