TECHNICAL SPECIFICATION

ISO/TS 80004-2

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Nanotechnologies — Vocabulary —

Part 2: Nano-objects

Nanotechnologies — Vocabulaire —

Partie 2: Nano-objets

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Foreword

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The committees responsible for this document are ISO/TC 229, *Nanotechnologies* and Technical Committee IEC/TC 113, *Nanotechnology standardization for electrical and electronic products and systems*. The draft was circulated for voting to the national bodies of both ISO and IEC.

This first edition of ISO/TS 80004-2 cancels and replaces ISO/TS 27687:2008, which has been technically revised.

Documents in the 80000 to 89999 range of reference numbers are developed by collaboration between ISO and IEC.

ISO/TS 80004 consists of the following parts, under the general title *Nanotechnologies — Vocabulary*:

— *Part 1: Core terms*

— *Part 2: Nano-objects*

— *Part 3: Carbon nano-objects*

— *Part 4: Nanostructured materials*

— *Part 5: Nano/bio interface*

— *Part 6: Nano-object characterization*

— *Part 7: Diagnostics and therapeutics for healthcare*

— *Part 8: Nanomanufacturing processes*

The following parts are under preparation:

— *Part 9: Nano-enabled electrotechnical products and systems*

— *Part 10: Nano-enabled photonic components and systems*

— *Part 11: Nanolayer, nanocoating, nanofilm, and related terms*

— *Part 12: Quantum phenomena in nanotechnology*

— *Part 13: Graphene and other two-dimensional materials*

Introduction

It is predicted that applications of nanotechnologies may pervade all areas of life. In the areas of communication, health, manufacturing, materials and knowledge-based technologies, there is a need to provide industry and research with standardized vocabulary and nomenclature to aid the responsible development and application of the technologies. It is also essential that regulators such as health and environmental protection agencies have reliable measurement systems supported by well-founded and robust standards.

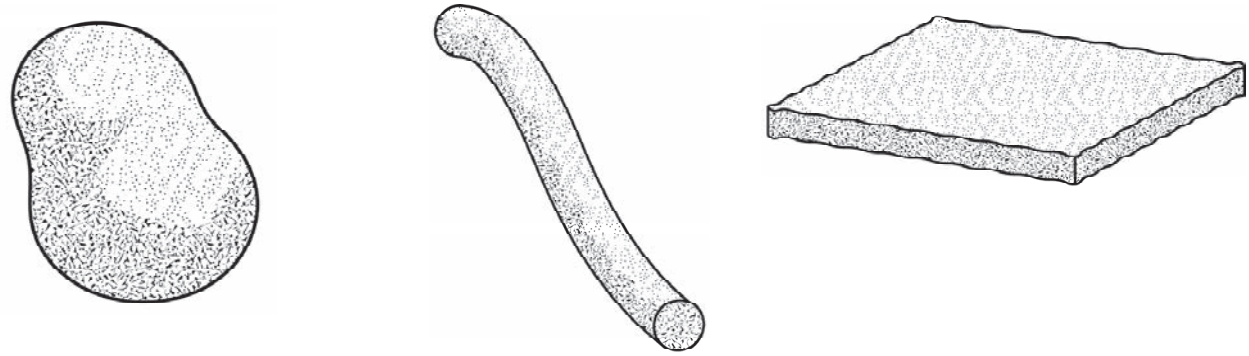
Often in the field of nanotechnologies, naming of materials seen on microscopic images is inspired by the shape of objects found in everyday life, although the physical size is much smaller. The prefix nano- is often added to denote the small size of the object. (The prefix nano- is also used in SI units to indicate 10^{-9} e.g. 1 nanometre = 10^{-9} metre.). Thus, the term "*nanoscale*" (2.1) has been defined to denote the length interval approximately from 1 nm to 100 nm.

To create a unitary vocabulary, this part of ISO 80004 encompasses terms used concerning particles with nanoscale dimensions. The terms in this part of ISO 80004 form part of a larger hierarchy of terms under development for nanotechnologies. These terms are intended to facilitate communications between organizations and individuals in industry and those who interact with them.

Objects with one or more external dimensions in the nanoscale can have properties that make them key components of materials and systems resulting in improved performance over their conventional counterparts. These *nano-objects* (2.2) often have properties that are not simple extrapolations of the properties of their larger form, with these novel properties called emerging, discontinuous or transformative properties.

The size and shape of nano-objects are often intrinsic to their function, so the description and measurement of their size and shape are important and must be considered carefully. The three most basic shapes referred to in this part of ISO 80004 are illustrated in Figure 1. These three simple shapes represent the main classes of structural dimensionality to help categorize nano-objects. Some other common shapes are defined in this part of ISO 80004, but a large number of different shapes are possible.

A number of other parameters in addition to size and shape are also intrinsic to the function and phenomena exhibited by nano-objects. These parameters include composition, morphology, crystalline structure, and surface features, which can all have a major influence on the key nanoscale phenomena exhibited by nano-objects. Such phenomena include magnetic, optical, catalytic, electronic, and other properties.



a) nanoparticle (3 ext. dimensions in the nanoscale)

b) nanofibre (2 ext. dimensions in the nanoscale)

c) nanoplate (1 ext. dimensions in the nanoscale)

Figure 1 — Schematic diagrams showing some shapes for nano-objects

A particular issue concerns nano-objects where one or more external dimensions are larger than the nanoscale. Potential confusion can occur when one of these dimensions greatly exceeds the nanoscale. For example, carbon nanotubes can have overall lengths in the millimetre range and are still nano-

objects according to the definitions in this part of ISO 80004. An example of an approach to this issue is to consider the size or shape at which the health risk from inhalation or other potential routes of exposure to nano-objects becomes small as an upper size limit for nano-objects.

It is acknowledged that a wide variety of approaches to definitions and classifications are applicable to particulate material and some of these regimes may also be relevant to nano-objects. Industrial, regulatory, and scientific domains often use terms such as coarse, fine and ultrafine to denote different size range fractions of *particles* (3.1). Thus for airborne particles, ultrafine particles, specified as PM0.1 (PM means "particulate matter"), refer to particles with aerodynamic diameters of 100 nm or less. Fine particles (PM2.5) refer to particles with aerodynamic diameters of 2,5 µm or less and coarse particles (PM10) refer to those with aerodynamic diameters of 10 µm or less. These size range fractions are used by regulators for risk assessment purposes in many contexts, including traffic pollution, volcanic ash, dust storms, industrial pollution and natural airborne allergens such as pollen.

In this Technical Specification, nano-objects are defined according to their shape as determined by nanoscale dimensionality. In addition, some types of nano-objects are also defined according to structural configuration, morphology, form or functionality. It is beyond the scope of this Technical Specification to consider or recommend specific size, size distribution, or related thresholds for nano-objects, particularly given the wide variability in size, shape, morphology, composition, and surface features of nano-objects, with each combination potentially presenting differing implications for assessments of risk or safety to health or the environment.

There is a hierarchical relationship between many of the different terms in this part of ISO 80004. Elements of this are shown in Figure 2 to illustrate some of the relationships that exist.

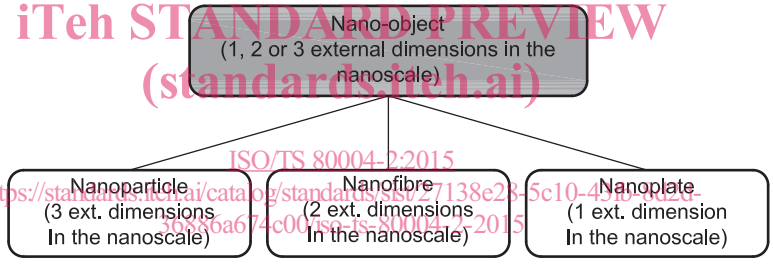


Figure 2 — Fragment of hierarchy of terms related to nano-objects

Nanotechnologies — Vocabulary —

Part 2: Nano-objects

1 Scope

This Technical Specification lists terms and definitions related to particles in the field of nanotechnologies.

2 Core terms related to particles

2.1
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 80004-1:2010, 2.1]

2.2
nano-object
discrete piece of material with one, two or three external dimensions in the *nanoscale* (2.1)

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

[SOURCE: ISO/TS 80004-1:2010, 2.2]

3 Terms concerning particles and assemblies of particles

Nano-objects [for example nanoparticles, nanofibres, and nanoplates, (see Clause 4)], often occur in (large) groups, rather than as isolated or distinct entities. For reasons of surface energy, such coexisting nano-objects are likely to interact. In the description of these interactions, the following terms are often used. The following terms are not restricted with respect to physical size and shape. These terms are included for completeness and importance at the nanoscale.

3.1
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.

Note 3 to entry: This general particle definition applies to *nano-objects* (2.2).

[SOURCE: ISO 26824:2013, 1.1]

3.2
primary particle
original source *particle* (3.1) of *agglomerates* (3.4) or *aggregates* (3.5) or mixtures of the two

Note 1 to entry: *Constituent particles* (3.3) of agglomerates or aggregates at a certain actual state may be primary particles, but often the constituents are aggregates.

Note 2 to entry: Agglomerates and aggregates are also termed secondary particles.

[SOURCE: ISO 26824:2013, 1.4]

3.3
constituent particle
identifiable, integral component of a larger *particle* (3.1).

Note 1 to entry: The constituent particle structures may be *primary particles* (3.2) or secondary particles.

3.4
agglomerate
collection of weakly or medium strongly bound *particles* (3.1) 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* (3.2).

[SOURCE: ISO 26824:2013, 1.2]

3.5
aggregate
particle (3.1) 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 26824:2013, 1.3, modified — Note 1 adapted.]

4 Terms specific to nano-objects

4.1
engineered nano-object
nano-object (2.2) designed for specific purpose or function

[SOURCE: ISO/TS 80004-1:2010, 2.8, modified]

4.2
manufactured nano-object
nano-object (2.2) intentionally produced to have selected properties or composition

[SOURCE: ISO/TS 80004-1:2010, 2.9]

4.3
incidental nano-object
nano-object (2.2) generated as an unintentional by-product of a process

Note 1 to entry: The process includes manufacturing, biotechnological or other processes.

[SOURCE: ISO/TS 80004-1:2010, 2.10, modified]

4.4
nanoparticle
nano-object (2.2) with all external dimensions in the *nanoscale* (2.1) 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* (4.5) or *nanoplate* (4.6) may be preferred to the term nanoparticle.

4.5
nanofibre
nano-object (2.2) with two external dimensions in the *nanoscale* (2.1) and the third dimension significantly larger

Note 1 to entry: The largest external dimension is not necessarily in the nanoscale.

Note 2 to entry: The terms nanofibril and nanofilament can also be used.

Note 3 to entry: See 4.4 Note 1.

4.6
nanoplate
nano-object (2.2) with one external dimension in the *nanoscale* (2.1) and the other two external dimensions significantly larger

Note 1 to entry: The larger external dimensions are not necessarily in the nanoscale.

Note 2 to entry: See 4.4 Note 1.

4.7
nanorod
solid *nanofibre* (4.5)

4.8
nanotube
hollow *nanofibre* (4.5)

4.9
nanowire
electrically conducting or semi-conducting *nanofibre* (4.5)

4.10
nanoribbon
nanotape
nanoplate (4.6) with the two larger dimensions significantly different from each other

Note 1 to entry: See 4.4 Note 1.

[SOURCE: ISO/TS 80004-3:2010, 2.10, modified.]

4.11
nanosphere
spherical *nano-object* (2.2)

Note 1 to entry: For some hollow structures, the term nanocapsule is preferred.

4.12
nano-onion
spherical *nanoparticle* (4.4) with concentric multiple shell structure

[SOURCE: ISO/TS 80004-3:2010, 2.8]