TECHNICAL REPORT

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Nanotechnologies — Plain language explanation of selected terms from the ISO/IEC 80004 series

Nanotechnologies — Explication en langage simple des termes choisis de la série de normes ISO/IEC 80004

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by ISO/TC 229, *Nanotechnologies*.

Introduction

The increasing use of nanomaterials in industry and society means that their utility, risks and benefits throughout their life-cycle are important topics for discussion.

This document offers explanations (including examples) of selected nanotechnology terms and is intended to facilitate an understanding of the use and applications of nanotechnology. Its target audience is those who need to make decisions about the use of nanotechnology. The specific aim is to:

a) promote consistent usage and reduce misinterpretation of terms among users; and

b) facilitate communication and understanding in developing or commercializing applications of nanotechnologies.

This document contains selected key terms and provides definitions and explanations to aid understanding and illustrate, where applicable, the relationship between one term and another, using practical examples where possible.

For ease of reference the ISO definitions are repeated throughout the document as appropriate.

Explanations and examples are chosen to underpin the selected terms published in the ISO/IEC 80004 vocabulary series.

Where new understanding develops, then the tools used to communicate such knowledge will benefit from the constant review and revision of key terms as necessary. New terms can find common usage which are not yet in the ISO/IEC 80004 vocabulary series. Such terms can be synonymous with terms and definitions already found in existing ISO documents.

Nanotechnologies — Plain language explanation of selected terms from the ISO/IEC 80004 series

1 Scope

This document is intended to assist stakeholders who are making decisions about the direction, management and application of nanotechnologies to better understand selected key terms and definitions in the ISO/IEC 80004 vocabulary series for nanotechnologies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TS 80004-1, *Nanotechnologies — Vocabulary — Part 1: Core terms*

ISO/TS 80004-2, *Nanotechnologies — Vocabulary — Part 2: Nano-objects*

ISO/TS 80004-4, *Nanotechnologies — Vocabulary — Part 4: Nanostructured materials*

ISO/TS 80004-11, *Nanotechnologies — Vocabulary — Part 11: Nanolayer, nanocoating, nanofilm, and related terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TS 80004-1, ISO/TS 80004-2, ISO/TS 80004-4 and ISO/TS 80004-11 and the following apply.

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

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

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

3.1
nanoscale
length range approximately from 1 nm to 100 nm

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

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

3.2
nanoscale phenomenon
effect attributable to the presence of nano-objects or nanoscale regions

[SOURCE: ISO/TS 80004-1:2015, 2.13]

3.3
nanotechnology
application of scientific knowledge to manipulate and control matter predominantly in the nanoscale to make use of size- and structure-dependent properties and phenomena distinct from those associated with individual atoms or molecules, or extrapolation from larger sizes of the same material

Note 1 to entry: Manipulation and control includes material synthesis.

[SOURCE: ISO/TS 80004-1:2015, 2.3]

3.4
nanomaterial
material with any external dimension in the nanoscale or having an internal structure or surface structure in the nanoscale

Note 1 to entry: This generic term is inclusive of nano-object and nanostructured material.

[SOURCE: ISO/TS 80004-1:2015, 2.4, modified]

3.5
manufactured nanomaterial
nanomaterial intentionally produced to have selected properties or composition

[SOURCE: ISO/TS 80004-1:2015, 2.9]

3.6
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 80004-1:2015, 2.5]

3.7
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]

3.8
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.

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

3.9
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]

3.10
nano-enabled
exhibiting function or performance only possible with nanotechnology

[SOURCE: ISO/TS 80004-1:2015, 2.15]

3.11
nano-enhanced
exhibiting function or performance intensified or improved by nanotechnology

[SOURCE: ISO/TS 80004-1:2015, 2.16]

3.12
nanocomposite
solid comprising a mixture of two or more phase-separated materials, one or more being nanophase

Note 1 to entry: Gaseous nanophases are excluded (they are covered by nanoporous material).

Note 2 to entry: Materials with nanoscale phases formed by precipitation alone are not considered to be nanocomposite materials.

[SOURCE: ISO/TS 80004-4:2011, 3.2]

3.13
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]

3.14
nanolayer
layer of material with thickness in the nanoscale

[SOURCE: ISO/TS 80004-11:2017, 3.2.1]

3.15
nanocoating
coating with thickness in the nanoscale

[SOURCE: ISO/TS 80004-11:2017, 3.2.2]

3.16
nanofilm
film with thickness in the nanoscale

Note 1 to entry: A nanofilm is a nanolayer which can be freestanding.

Note 2 to entry: A nanofilm can be made of solids or liquids (e.g. liquid film).

Note 3 to entry: A nanofilm can be composed of a monomolecular layer (e.g. Langmuir-Blodgett film).

[SOURCE: ISO/TS 80004-11:2017, 3.2.3]

4 Terms and explanations

NOTE The order of explanations is such that the descriptions build on the previous descriptions to aid understanding rather than to suggest any hierarchy.

4.1 Nanoscale, nanoscale phenomenon

ISO definitions:

nanoscale

length range approximately from 1 nm to 100 nm

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

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

nanoscale phenomenon

effect attributable to the presence of nano-objects or nanoscale regions

[SOURCE: ISO/TS 80004-1:2015, 2.13]

"Nanoscale" is an agreed descriptor principally referring to the size range 1 nm to 100 nm, where 1 nm is 10^{-9} m (0,000000001 m). To appreciate the relative size of the nanoscale dimension, Figure 1 illustrates the ratio of 1 m to 1 nm as approximately the same as between planet Earth and a cherry. Atoms are in the size range 0,1 nm to 0,4 nm and DNA is approximately 2 nm in width.

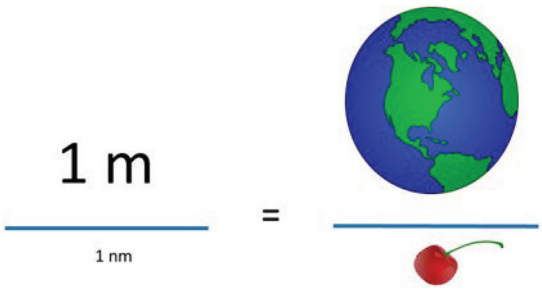
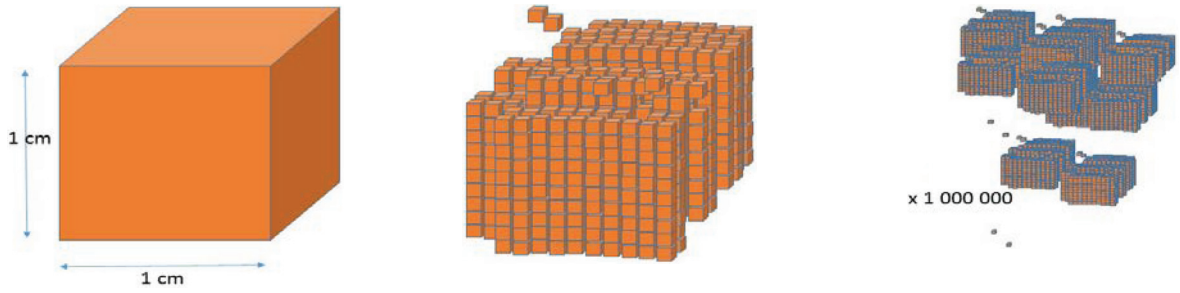


Figure 1 — Comparative size of 1 nm

The range 1 nm to 100 nm is where changes in properties ascribed to materials in the nanoscale are likely to be observed. These changes can occur either because of the increased surface area when an object is reduced into the nanoscale or because the confined size enables different physical and chemical phenomena to occur. Thus Figure 2 illustrates how the surface area increases when an individual object is split into an assembly of smaller objects.



Total surface area 6 cm²

Total surface area 60 cm²

All 1 mm cubes

Total surface area 60 000 000 cm²

All 1 nm cubes

Figure 2 — Increasing surface area by increasing division

Materials in the nanoscale can exhibit properties with new or enhanced characteristics. The properties that can change at the nanoscale might include:

— optical (e.g. colour)

— mechanical (e.g. tensile strength)

— chemical (e.g. catalysis)

— electrical (e.g. conductivity).

EXAMPLE 1 Gold nanoparticles can appear red, green or purple, depending on their size, because they interact with electromagnetic radiation (e.g. visible light) differently compared to larger non-nanoscale gold particles, which appear yellow. These properties of gold have been historically used in stained-glassed windows, which demonstrates that people have been working at the nanoscale for a long time without realizing it.

EXAMPLE 2 Quantum dots (QD) are nanoscale semi-conductor particles that emit light under certain conditions and can be used to create thin displays, such as on televisions and computer/smart phone screens, that are vivid and energy efficient.

EXAMPLE 3 The mechanical strength of steel or rubber tyres can be increased many fold by dispersing nano-objects during manufacture.

EXAMPLE 4 Batteries, fuel cells and catalysts can use the enhanced reactivity associated with nanoparticles to produce cleaner, safer, and more affordable modes of producing and storing energy and more efficient process reactions.

EXAMPLE 5 To improve cooling of computer chips and LEDs, carbon nanotubes are being incorporated into composites to enhance their electrical and thermal conductivity.

EXAMPLE 6 Drug treatments have been developed to take advantage of the fact that the structure of many biological systems is determined by their nanoscale elements. A typical antibody is approximately 10 nm, while viruses range from approximately 10 nm to 400 nm.

The new or enhanced properties attributable to the nanoscale are described as “nanoscale phenomena”.