
**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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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.

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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.

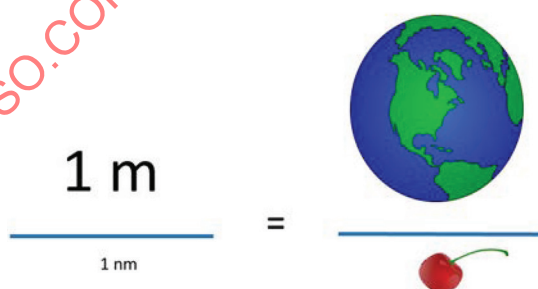


Figure 1 — Comparative size of 1 nm

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.

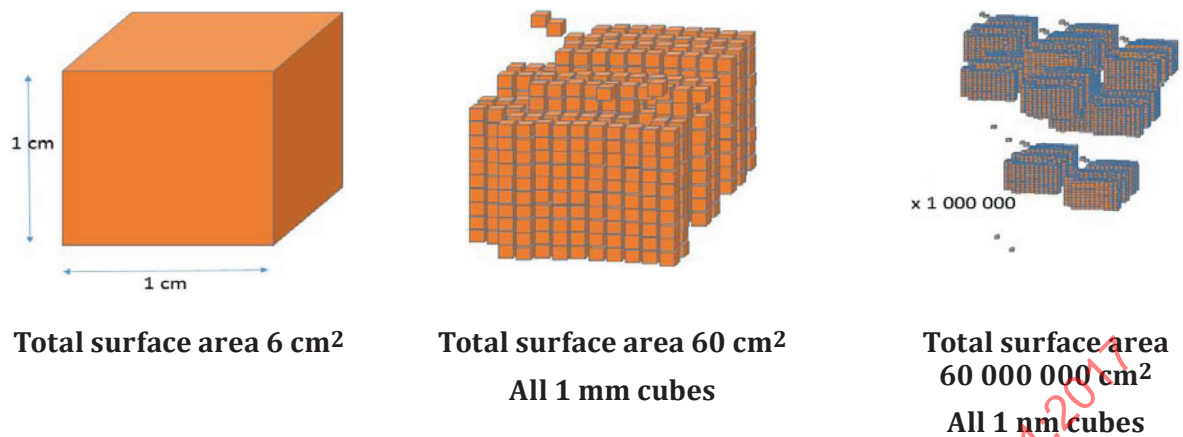


Figure 2 — Increasing surface area by increasing division

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-glass 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”.

4.2 Nanotechnology

ISO definition:

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]

Although scientists and craftsmen have manipulated matter at the nanoscale for centuries (e.g. stained glass windows), it was not until specialized forms of microscopy (e.g. electron microscopy) were developed that we could visualize materials in the nanoscale and more precisely control their structure.

Nanotechnology can improve a product or process in a way that would not be possible otherwise.

EXAMPLE 1 Nanotechnology is being used for water treatment to filter more effectively because of e.g. the ability to construct membranes with smaller holes which only allow water molecules to pass through. Similar techniques are used in milk processing as a substitute for pasteurization.

EXAMPLE 2 Nanotechnology can enable more precise targeted delivery of medicines through, for example, encapsulation and improved cell-surface specific binding. It makes the process more specific and less toxic.

4.3 Nanomaterials

4.3.1 General

ISO definitions:

nanomaterial

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

manufactured nanomaterial

nanomaterial intentionally produced to have selected properties or composition

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

Nanomaterials (see [Figure 3](#)) include:

- 1) nanostructured materials which are materials with an internal structure or surface structure in the nanoscale; and
- 2) nano-objects which have at least one external dimension in the nanoscale.

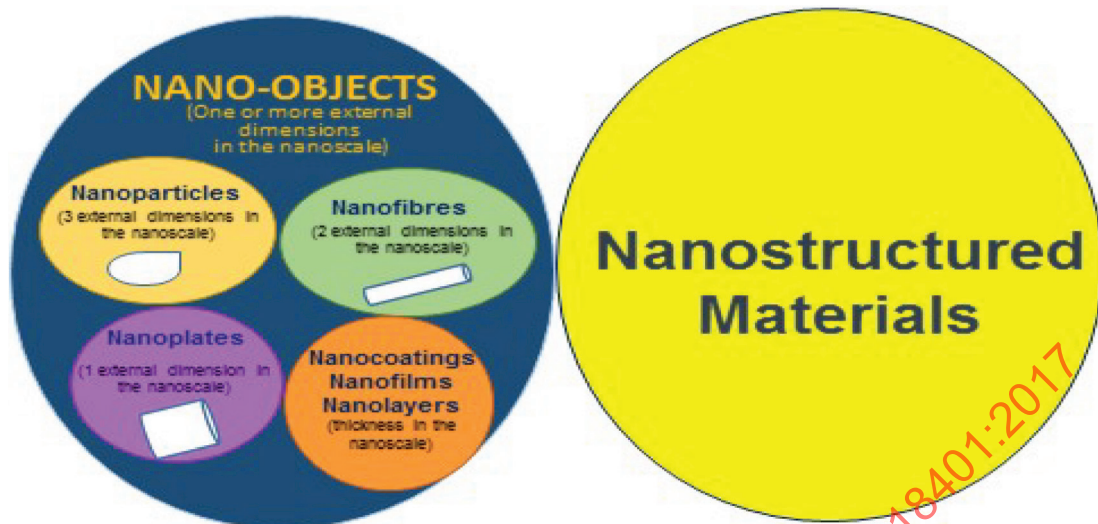


Figure 3 — Nanomaterials

Nanomaterials can be naturally occurring, manufactured or incidental, i.e. a nano-object generated as an unintentional by-product of a process.

For example, a nanomaterial might be:

- naturally occurring from a biological source, e.g. silica formed in rice husks;
- naturally occurring from a geological source, e.g. nanoparticles emitted from an erupting volcano;
- manufactured nanomaterial, e.g. nano-titanium dioxide;
- manufactured from a biological source, e.g. cellulose nanomaterials from organisms; or
- incidental nanomaterial, e.g. welding fume particles, smoke created when using a wood-burning stove, car diesel exhaust.

4.3.2 Nano-objects

4.3.2.1 General

ISO definition:

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]

Nano-objects are presently classified based on their size and shape.

Nano-objects are typically described or grouped in terms of the dimensions constrained in the nanoscale:

- in one dimension (nanoplates);
- in two dimensions (nanofibres, including nanotubes); or

- in all three dimensions (nanoparticles and quantum dots).

For example, a nanoplate has one dimension in the nanoscale but has other dimensions that can be larger than the nanoscale. A “one-dimensional” nano-object is a generally understood “three dimensional” object with one dimension in the nanoscale.

4.3.2.2 Properties, size and shape

The term “nano-object” is the collective or general term, which encompasses the wide range of shapes and sizes of objects in the nanoscale (e.g. nanoparticle, nanofibre and nanoplate, see [Figure 3](#)). Nano-objects therefore also encompass a broad spectrum of shapes. The ISO definition of nano-object and related terms is based on size and shape and not on any particular property or properties because those would be impossible to capture in specific definitions.

ISO definition:

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]

The term nanoparticle depicts a subset of nano-objects with all external dimensions in the nanoscale. If a nano-object has one or two dimensions outside the nanoscale they have a different shape and are categorized as nanofibres or nanoplates, as appropriate. It is also important to note that nanotubes are hollow nanofibres and are therefore nano-objects.

EXAMPLE 1 Applications of nanoparticles:

- anti-microbiological activity, e.g. nanosilver used in wound dressings or clothing; and
- catalysis, chemical storage, drug delivery systems (targeted, controlled drug delivery).

EXAMPLE 2 Applications of nanofibres:

- carbon nanotubes to strengthen materials or products (e.g. tennis rackets);
- carbon nanotubes to enhance electro-conductivity; and
- cellulose nanomaterials used to strengthen packaging.

EXAMPLE 3 Applications of nanoplates:

- food packaging, e.g. nanoclays to increase barrier properties of plastic films;
- effect pigments in cosmetics industry (“blur” wrinkle disappearance);
- graphene as a flexible conductor for flexible display.

An area of widespread application is nanoelectronics, which is the field of science and technology concerned with the development and production of functional electronic devices with nanoscale components.

4.3.3 Nano-objects, agglomerates and aggregates

ISO definitions:

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]

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]

Many nano-objects tend to combine into larger particles, which are known as either agglomerates or aggregates (see [Figure 4](#)).

The difference between agglomerate and aggregate is based on the strength of the bonding between constituent nano-objects. An aggregate of nano-objects is essentially a discrete nanostructured particle and it is virtually impossible to release its constituent nano-objects without fracturing the component material. However, an agglomerate can more easily release its constituent nano-objects because of its relatively weaker bonding. It is the number of weaker bonds in agglomerates that determine the ability to release the constituent nano-objects. Agglomerates can be made up of nano-objects or aggregates of nano-objects (see [Figure 4](#)).

The size of an aggregate or agglomerate can be larger than the nanoscale.

When nano-objects are introduced into a medium they can naturally agglomerate or aggregate. For example, commercially available nanomaterial powders are usually in the form of aggregates or agglomerates.

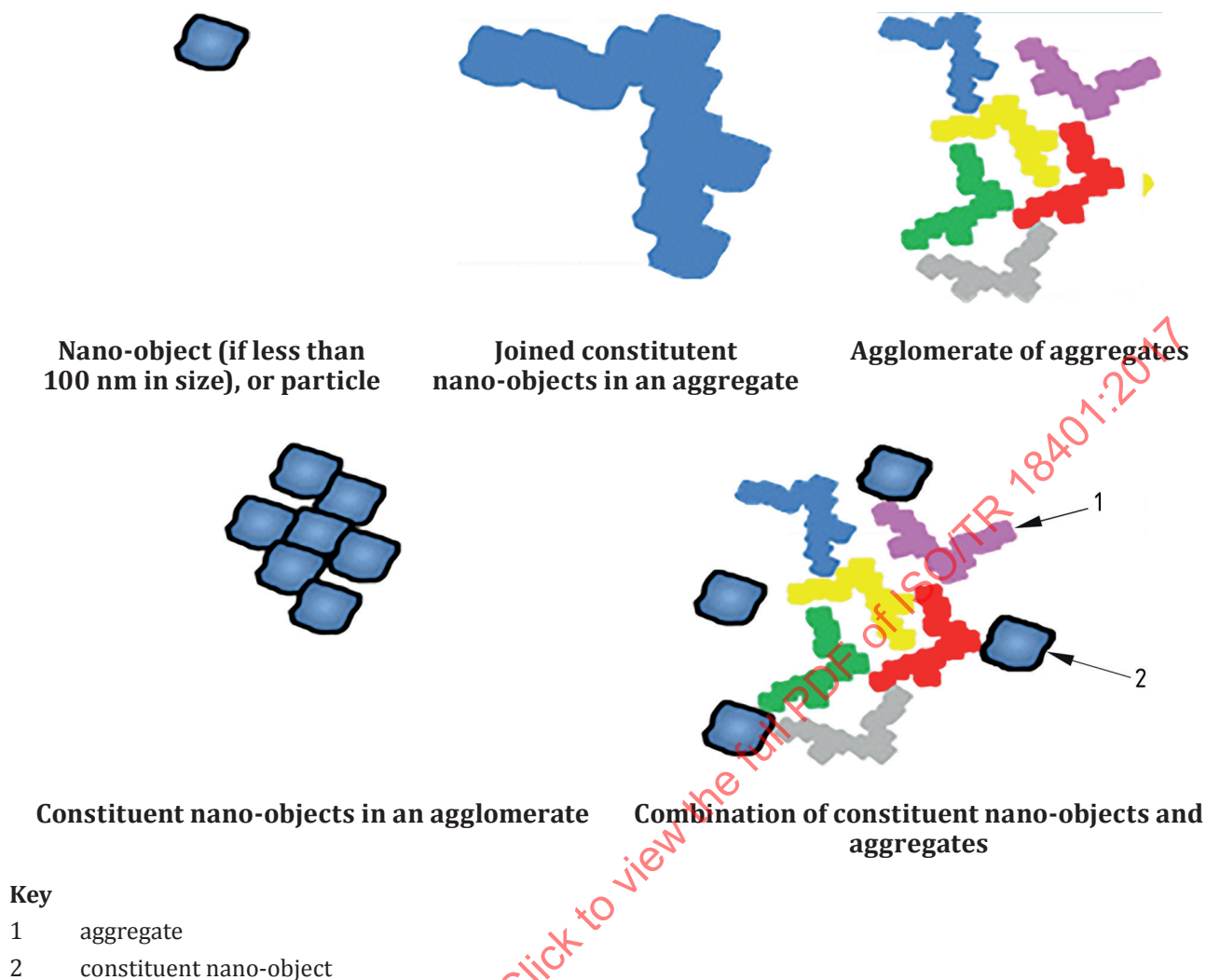


Figure 4 — Nano-objects, and their agglomerates and aggregates

4.3.4 Nano-enabled, nano-enhanced

ISO definitions:

nano-enabled

exhibiting function or performance only possible with nanotechnology

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

nano-enhanced

exhibiting function or performance intensified or improved by nanotechnology

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

Nanomaterials are typically used to achieve new or improved functionality of a process or product. “Nano-enabled” or “nano-enhanced” describe devices or systems that utilize some aspect of nanotechnology to create or enhance functionality. “Nano-enabled” refers to functionality that is not