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Nanotechnologies — Considerations for the measurement of nano-objects and their aggregates and agglomerates (NOAA) in environmental matrices

Nanotechnologies — Considérations pour la mesure des nano-objets, et leurs agrégats et agglomérats (NOAA) dans les matrices environnementales

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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).

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For an explanation of 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 www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

There is an interest in determining the concentration of nano-objects and their aggregates and agglomerates (NOAA) in environmental matrices. Manufactured nanomaterials (NM) enter the environment via release from the manufacturing process and its waste streams, as well as via the use of commercial products and their recycle and disposal streams. Such measurement efforts require an understanding of the occurrence of natural materials that can interfere with the analysis or skew the results, knowledge of how the environment can interact with NM, and insights that require unique collection and analytical techniques specific to the composition of the particle. This document provides a review of published studies that report levels of NOAA in the environment and aspects of collection and sample preparation. The reader is also directed to the Further Reading section of this document for information regarding ISO guidance on sampling of air, water, and sediment, as well as a matrix of measurement techniques.

Not all manufactured NM are discussed here because there might not yet be published studies that examined them in the environment. On the other hand, collection methods and pre-analytical procedures might be similar for some or all NOAA in a given environmental matrix. Furthermore, NOAA isolated from the environment can be characterized using the same instruments and analytical techniques used for pristine NOAA. Thus, the lack of published studies does not preclude the ability to collect a specific NM from any environmental matrix and measure the NOAA present.

Although it is recognized that biota (i.e. living organisms) also can interact with NM by sequestering and/or transforming them, analysis of biota is intentionally excluded so that the scope of this Document does not become too broad. However, the impact of biota should not be overlooked. Such considerations could be part of a subsequent Technical Report.

Furthermore, when NM are used for environmental remediation, and there is interest in measuring residual levels of remediating NM after the environmental medium has been processed. It is anticipated that the considerations described here would be applicable to those investigations.

The audience for this document is expected to be scientists from the regulatory, academic, or industrial communities who wish to answer the question of how much manufactured NM is present in a specific environmental medium. The results could be used for environmental stewardship, for risk assessment, or to calibrate modelled exposure estimates, although these applications are not discussed here.

NOTE The term NM refers to the identity of the nanomaterial, whereas NOAA is a more inclusive term encompassing NM and aggregates that are the focus of the analyses described here.

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Nanotechnologies — Considerations for the measurement of nano-objects and their aggregates and agglomerates (NOAA) in environmental matrices

1 Scope

This document provides some considerations for the collection of environmental samples to be analysed for manufactured NOAA, considerations to distinguish manufactured NOAA from background levels of naturally occurring nanoscale particles of the same composition, and preparation procedures to aid in the quantification of manufactured NM in environmental matrices.

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TS 80004-1 and ISO/TS 80004-2 and the following 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
environmental matrices
ambient air, surface water, sediment, soil, estuarine and marine waters and sediments

3.2
ambient air
outdoor air to which people, plants, animals or material may be exposed

Note 1 to entry: Workplace is excluded.

[SOURCE: ISO 4225:1994, 3.6]

3.3
surface water
water in overland flow and storage, such as rivers and lakes, excluding seawater

[SOURCE: ISO 14046:2014, 3.1.3]

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3.4
sediment
bottom sediment
naturally-occurring solid material deposited by settling from suspension onto the bottom of bodies of water, both moving and static

[SOURCE: ISO 6107-2:2006, 13]

3.5
soil
upper layer of the Earth's crust composed of mineral particles, organic matter, water, air and living organisms

[SOURCE: ISO 18589-1:2005, 3.2.1]

3.6
estuarine water
water in the lower reaches of a river that is freely connected with the sea, subject to the influence of the tides and receiving an influx of salt water and fresh water supplies from upland drainage area

[SOURCE: ISO 772:2011, 1.20]

3.7
seawater
marine water
water in a sea or an ocean

[SOURCE: ISO 14046:2014, 3.1.4]

3.8
pore water
water occupying space between sediment particles in freshwater (including soil), brackish and marine environments

[SOURCE: ISO 11348-1:2007, D.2.4]

3.9
coastal lagoon
shallow body of water, such as a pond or lake, close to the sea and usually with a shallow, restricted inlet from the sea

[SOURCE: ISO 6107-8:1993, 29]

3.10
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]

3.11
nanomaterial
NM
material with any external dimension in the nanoscale [as defined in 2.1 of ISO/TS 80004-1] or having internal structure or surface structure in the nanoscale

Note 1 to entry: This generic term is inclusive of *nano-object* [as defined in 2.5 of ISO/TS 80004-1] and *nanostructured material* [as defined in 2.7 of ISO/TS 80004-1].

Note 2 to entry: See also definitions 2.8 to 2.10 of ISO/TS 80004-1.

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

3.12
euphotic zone
upper layer of a body of water where light penetration is sufficient to support effective photosynthesis

[SOURCE: ISO 6107-3:1993, 29]

4 Symbols and abbreviated terms

AAS	atomic absorption spectroscopy
CNT	carbon nanotube
ICP-MS	inductively coupled plasma mass spectroscopy
HDC	hydrodynamic chromatography
HPLC	high-performance liquid chromatography
HRMS	high-resolution mass spectrometry
NOAA	nano-objects, their aggregates, and agglomerates
NOM	natural organic matter
PM2.5	particulate matter with a diameter of 2,5 µm and smaller
SWCNT	single-walled carbon nanotube
TEM	transmission electron microscopy
TEM-EDX	transmission electron miscroscopy equipped with energy dispersive X-ray detector
UHPLC	ultra-high performance liquid chromatography
UV-vis	ultraviolet-visible spectrometry

5 General considerations

5.1 General

As the use of NM becomes more widespread, questions about what concentrations exist in the environment from their use are likely to be raised. Nowack et al.[1], Mueller and Nowack[2], Liu and Cohen[3], and Keller et al.[4] have suggested potential pathways into the environment from manufacturing waste streams, end-of-use waste streams (e.g. NM in sunscreens that enter the waste stream), and release from products. In order to determine the concentrations of NM present in the environment, several issues/questions need to be addressed:

— What are the background levels of naturally occurring materials of the same or similar composition?

— How do concentrations of naturally occurring materials change over time/geography?

— Can the manufactured NOAA be distinguished from naturally occurring nano-objects?

— What are the instruments that have been used to quantify and characterize NOAA in the environment?

— What are the proper sample preparation methods? Do they vary with the NM of interest, or do they vary with the medium?

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