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Nanotechnologies — High throughput screening method for nanoparticles toxicity using 3D model cells

Nanotechnologies — Méthode de criblage à haut débit de la toxicité des nanoparticules utilisant des systèmes cellulaires 3D

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Foreword

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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

With an increasing number of nano-products including nanoparticles (NPs), potential exposure of consumers to NPs has increased. Therefore, the human and environmental impacts of NPs have recently emerged as an issue. High-throughput screening (HTS) approaches are often used for NPs toxicity screening. However, there are still limitations to provide the reproducible and reliable results based on a HTS method. To assess the potential toxicity of manufactured or engineered NPs, traditional in vitro toxicity studies have been performed using a surface attached two-dimensional (2D) culture system. 2D assays for cellular metabolic activity, cytotoxicity, or oxidative stress have been widely used in the first stage of hazard evaluation. However, several problems were encountered during assay validation, ranging from particle agglomeration in biological media to optical interference with the assay platform. There are ISO documents on the cytotoxic effects of NPs using cell viability assays and detection of reactive oxygen species (ROS) levels, but they can be applicable for a few classes of NPs that are well-dispersed in the media. Additionally, reagents used in the assays can interact with tested NPs or interfere with spectrophotometric reading.

This document describes a new assay platform, consisting of three-dimensional (3D) arrangement of cells on pillar inserts to evaluate cell viability and diminish artefacts arising from optical interferences and NP reactivity with assay components.

This document aims to overcome the optical interference of NPs and obtain reliable and reproducible cell viability results. The 3D-model cells are exposed to fresh cell viability reagent by simply transferring and immersing the pillar insert from one well to another well without optical interference from the NPs. In addition, 3D-model cell culture approaches facilitate cell-cell interactions and enhance cell-to-cell or cell-to-extracellular matrix (ECM) adhesion/signalling, ultimately leading to the expression of phenotypic proteins/genes and the formation of in vivo tissue-like morphology. It generates uniform cell-containing hydrogel droplets on the pillar insert and allows to easily change cell growth media or expose 3D-model cells to analytical reagents by immersing the tip of the pillar insert in different reaction plates.

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Nanotechnologies — High throughput screening method for nanoparticles toxicity using 3D model cells

1 Scope

This document describes a method for high throughput evaluation of cytotoxic response of 3D model cells exposed to NPs without optical interference.

The method in this document is intended to be used in biological testing laboratories that are competent in the culture and growth of cells and the evaluation of cytotoxicity of NPs using 3D-model cells.

This method applies to materials that consist of nano-objects such as nanoparticles, nanopowders, nanofibres, nanotubes, and nanowires, as well as aggregates and agglomerates of these materials.

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

3 Terms and definitions

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

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

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

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

3.1
agglomerate
collection of weakly bound particles or aggregates or mixtures of the two 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, modified — "weakly or medium strongly bound particles" has been replaced with " weakly bound particles or aggregates or mixtures of the two".]

3.2
dispersion
microscopic multi-phase system in which discontinuities of any state (solid, liquid or gas: discontinuous phase) are dispersed in a continuous phase of a different composition or state

Note 1 to entry: If solid particles are dispersed in a liquid, the dispersion is referred to as a suspension. If the dispersion consists of two or more liquid phases, it is termed an emulsion. A super emulsion consists of both solid and liquid phases dispersed in a continuous liquid phase.

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[SOURCE: ISO 19007:2018, 3.2]

3.3
nano-object
material with one, two or three external dimensions in the *nanoscale* (3.5)

Note 1 to entry: This is a generic term for all discrete nanoscale objects.

[SOURCE: ISO/TS 80004-2:2015, 2.2, modified — "discrete piece of" has been added to the definition and Note 1 to entry has been replaced.]

3.4
nanoparticle
NP
nano-object (3.3) with all three dimensions in the *nanoscale* (3.5)

Note 1 to entry: If the lengths of the longest to the shortest axes of the nano-object differ significantly (typically by more than three times), the terms nanorod or nanoplate are intended to be used instead of the term nanoparticle.

3.5
nanoscale
size range from approximately 1 nm to 100 nm

Note 1 to entry: Properties that are not extrapolations from a larger size will typically, but not exclusively, be exhibited in this size range. For such properties, the size limits are considered approximate.

Note 2 to entry: The lower limit in this definition (approximately 1 nm) is introduced to avoid single and small groups of atoms from being designated as *nano-objects* (3.3) or elements of nanostructures, which can be implied by the absence of a lower limit.

3.6
high-throughput screening
method that comprises the screening of a large number of chemicals via automation, miniaturized assays and large-scale data analysis

Note 1 to entry: This protocol can be applied to screen the toxicity of NPs based on 96-well plate or 532 microchip.

4 Background

4.1 General

With the increase in the number of consumer products containing NPs, potential exposure to NPs has increased, and potential human and environmental hazards of NPs have emerged. To assess the effects of NPs, a high-throughput screening method to evaluate cell viability following exposure to NPs is needed. High-throughput approaches have been used to screen for toxicity of manufactured NPs[1].

4.2 Effects of optical properties of NPs on in vitro cell viability assays

NPs possess linear/nonlinear optical absorbance and photoluminescence emission[2][3]. Because of their physicochemical and optical properties, NPs are used in various fields for disease diagnoses or as industrial products. Most NPs exhibit the optical properties in a wide range of absorbance wavelengths, where optical interference can be pronounced in cell viability assays based on absorbance read-outs.

To assess the potential toxicity of manufactured or engineered NPs, traditional in vitro toxicity studies have been performed using 2D model culture systems. During validation of 2D-model assays, several problems, for example, particle agglomeration in biological media and optical interference with the assay system, were encountered[4][5]. In traditional cell viability assays, colorimetric detection is generally used, and luminescent and fluorescent detection methods have been also applied to evaluate the cell viability assay. As shown in Table 1, some NPs such as the Ag NPs show an optical absorption at the wavelengths where the colorimetric assays are monitored.

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