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Nanotechnologies — Method to quantify air concentrations of carbon black and amorphous silica in the nanoparticle size range in a mixed dust manufacturing environment

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National foreword

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Nanotechnologies — Method to quantify air concentrations of carbon black and amorphous silica in the nanoparticle size range in a mixed dust manufacturing environment

Nanotechnologies — Méthode de quantification des concentrations dans l'air de noir de carbone et de silice amorphe à l'échelle nanométrique dans un environnement de fabrication industrielle contenant des mélanges de poussières

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Foreword

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

This second edition cancels and replaces the first edition (ISO/TS 21361:2019) which has been technically revised.

The main changes are as follows:

— references have been updated;

— minor clarifications have been made to the text.

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Introduction

Nanomaterials are widely used in industrial settings in the manufacture of consumer products. Carbon black and amorphous silica are commonly used in consumer products, such as rubber products, insulating materials, and others. Although these materials typically exist as agglomerates in dimensions larger than the nanoscale, there is also the potential for worker exposure to these materials in the nanoscale size range. In spite of the widespread use of nanomaterials such as these, quantification of air concentrations of specific nanomaterials in mixed dust settings, such as a manufacturing environment, has been challenging to date and has been identified as a hindrance to the development of nano-specific occupational exposure limits (see References [3], [4] and [6]). This method outlines a technique whereby particles of carbon black and amorphous silica can be identified, distinguished, and quantified (in terms of air concentrations) by size in such manufacturing settings. It is anticipated that although this method is specific to carbon black and amorphous silica, the general principles of the method can be applied to many materials in a variety of manufacturing environments. This method advances beyond existing techniques for analysis in that it provides quantitative information regarding exposure to specific materials by size; many other methods provide quantitative information on nanoparticle exposures that are incapable of differentiating by material type. This method includes both a defined methodology for collecting air samples in the manufacturing settings as well as a methodology for analysing the sample to obtain appropriate information for quantifying air concentration of the materials of interest. Application of this methodology has recently been published in the peer-reviewed literature (see Reference [5]).

This document specifies a method to quantify and identify particles of either carbon black or amorphous silica, or both, in air samples collected in a mixed dust, industrial, manufacturing environment. It describes air sample collection and the characterization of the particles in the air samples by both particle size and elemental composition. The method is defined for air samples collected with an electrical low pressure cascade impactor (ELPCI). However, the method is suitable for sampling in manufacturing environments where there are a variety of particle types contributing to the overall atmosphere. The particles in the air sample are collected in the various stages of a cascade impactor with cut-offs for median particle size between 6 nm and 10 µm. This impactor determines the number particle size distribution in real-time based on the particle aerodynamic diameter. Particles collected on each stage are collected for off-line analysis using transmission electron microscopy (TEM) and energy dispersive spectrometry (EDS) to identify amorphous silica and carbon black particles. The TEM-EDS measurement provides the elemental composition and source of the particles in each stage. Scanning electron microscopy (SEM) is also an option to TEM in the electron microscopy/dispersive spectrometry combination. While TEM and SEM can also be used to measure particle size directly (see References [8] and [9]), in this method the concentration of particles of a specific nanomaterial in a specific size range (#/cm^3) is given by the product of the total particle count for size range (#/cm^3) obtained from the cascade impactor and the fraction of particles identified as the specific material of interest (e.g. carbon black or amorphous silica) from the TEM-EDS results. Though this technique is described for carbon black and amorphous silica, the technique can be applied to the measurement of other particle types, provided they are in the size range and can be observed by TEM/SEM and chemically characterized by EDS.

At this time, this methodology represents one of the methods available to quantify chemical-specific exposures to nanoparticles by size with this degree of sensitivity. Many of the other existing methods that can speciate and quantify chemical exposure in this size range are mass-based, and thus are limited by mass-based detection limits that are high when compared to the mass of particles in this size range. Other air sampling methods, like the microorifice uniform deposit impactor (MOUDI, see Reference [1]) can be amenable to the techniques described herein but none of them have been evaluated or validated for this purpose and are not included in this document. This methodology offers increased sensitivity for quantification of exposure to specific particle types in the nanoscale when such an interest arises. The sample collection methods and analysis are more labor intensive and more involved than practical for most industrial hygiene risk assessment uses. This methodology can be implemented as a higher tier step in an occupational exposure assessment sampling strategy for nanomaterials, particularly in the event that hot spots for exposure are identified using other methods and there is an interest in understanding the nature of the exposure. Results from this analysis can be used to compare health benchmarks, as they become available, to understand potential health risk for workers and help in selecting appropriate personal protective equipment (PPE).

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