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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 — Quantification du noir de carbonne et de la silice amorphe nanométriques en suspension dans l'air en ambiance de production

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Foreword

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

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Introduction

Nanomaterials are widely used in industrial settings in the manufacture of consumer products. Carbon black and/or 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 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, have been challenging to date and has been identified as a hindrance to the development of nano-specific occupational exposure limits (Gordon, et al. 2014; Hansen, et al. 2012; van Broekhuizen, et al. 2013). This method outlines a technique whereby particles 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 analyzing 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 (Kreider, et al. 2015).

This document will provide guidelines to quantify and identify particles carbon black and/or amorphous silica in air samples collected in a mixed dust industrial manufacturing environment. The guidelines describe air sample collection and the characterization of the particles in the air samples by both particle size and elemental composition. 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. The concentration of particles of a specific nanomaterial in a given 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 of 6 nm to 2,5 µm and can be observed by TEM/SEM and chemically characterized by EDS.

At this time, this methodology represents the 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. Furthermore, although other sampling methods may be amenable to the techniques described herein, none have been evaluated or validated for this purpose. Therefore, this methodology offers increased sensitivity for quantification of exposure to specific particle types in the nanoscale when such an interest arises. This methodology could be implemented as a higher tier step in an occupational exposure assessment sampling strategy for nanomaterials, particularly in the event 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 to health benchmarks, as they become available, to understand potential health risk of workers. In addition, it could be useful in selecting appropriate personal protective equipment (PPE) at a very early stage of the manufacturing process, when required.

