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Microscopical Analysis of Consumer Products Containing Carbon Nanotubes: Determining Potential Airborne Release

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It has been estimated that by 2014, $2.6 trillion in manufactured goods will incorporate nanotechnology, which is approximately 15% of total global output [1]. In particular, carbon nanotubes (CNTs) have been incorporated into a variety of commercially available materials due to their unique properties. With increasing numbers of consumer products containing nanomaterials, especially carbon nanotubes, groups including manufacturers, consumers and regulatory agencies have become concerned with the issue of potential nanoparticle exposure and the possible health risks associated with exposure [2]. We are currently developing several methods that can be employed to test consumer products for exposure risks. This study focuses on airborne exposure from consumer products like air filters, which have potential to release respirable CNTs during normal operation. A two-fold approach to studying the potential for CNT release has been employed.

One focus of the investigation was the compositional characterization of the CNT-containing air filter utilizing microscopical techniques. Of particular interest were the materials comprising the filter, their spatial relationship to each other, and the distribution of the CNTs within the filter material. The complementary techniques of scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS) and confocal Raman microscopy (CRM) were employed to examine the filter. SEM-EDS provided images of the bulk composition of the filter (FIGURE 1) and information on the elemental composition of the materials comprising the air filter, which allowed us to make assumptions regarding the localization of components. Based on the unique Raman spectra of CNTs, analysis of the filter by CRM provided detailed chemical information on the distribution of the CNTs and their spatial relationship to the other materials within the microenvironment examined.

The second focus was assessment of the amount of CNTs, if any, released by the filtration apparatus during use. The method design involved utilization of the product in a controlled chamber with measurable airflow through the filter and into a sampling channel. The channel contains multiple air filter cassettes collecting a known volume of air through isokinetic flow. Cassette filters were prepared for analysis via transmission electron microscopy (TEM) using a modified version of the NIOSH 7402 method [3]. A modified version of the AHERA method for asbestos air samples (EPA 763), with the modification that nanotubes are counted rather than asbestos fibers, was used for TEM analysis [4]. Particles were identified as nanotubes based on their morphology and elemental composition, as well as a comparison with known nanotube reference samples from the test material (FIGURE 2).

References

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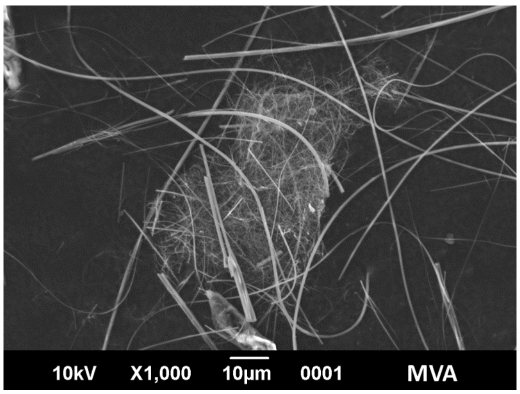

FIG. 1. SEM image of bulk material comprising air filter.

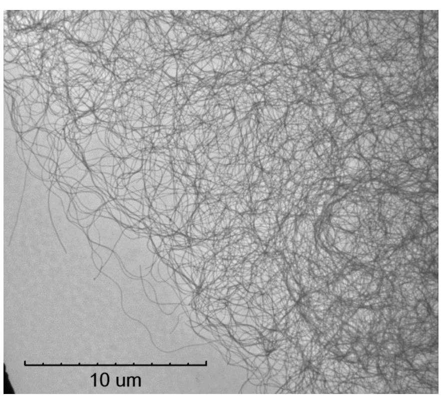

FIG. 2. TEM image of multiwalled carbon nanotube (MWNT) reference material for comparison to CNTs potentially released from the air filter.

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