Airborne PM generated from handling of crushed carbon nanotube-enhanced concrete

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Nano-enabled building materials may improve the performance and functionality of buildings, e.g. by improving their durability or, in the case of carbon nanotubes (CNTs) as additive, improving mechanical strength as well as enable self-sensing to detect crack formation. Concerns are being raised regarding health risks from occupational exposure to dust generated from these materials, and it is currently not known if, or how, CNT added to the concrete will affect the aerosol created when CNT-enhanced concrete is crushed during demolition or secondary use.

To investigate this, three types of CNT-reinforced concretes were prepared using NC7000™ Multi-Walled Carbon Nanotubes (MWCNTs) (⌀: 9.5 nm, l: 1.5 µm) at mass concentrations in 0.05 to 0.5%. The types of concrete were Low density, Normal, and High strength, which were crushed to simulate demolition. Concrete fragments <850 µm were systematically resuspended in a continuous drop set-up based on the EN 15051-3 standard further developed for the specific purpose. The formed aerosol was sampled with online instruments (Aerodynamic Particle Sizer (APS), Condensation Particle Counter (CPC), DustTrak (DT), Nano Tracer (NT), Scanning Mobility Particle Sizer (SMPS)) as well as filters for gravimetric-, Scanning Electron Microscopy (SEM)- and Organic Carbon Elemental Carbon (OCEC) analysis.

Addition of CNTs significantly decreased mean particle number concentrations (PNCs) across the entire characterized size range (7 nm - 20 µm) for low density concrete, whereas the opposite was the case for normal strength and high strength concrete. It was hypothesised that the concrete matrix primarily governs the PM formation, which is in turn modulated by CNT-matrix interactions either suppressing or supporting fragmentation during crushing.

SEM imaging (Figure 1) showed irregularly shaped concrete fragments with partially exposed CNTs protruding from the concrete matrix but no free fibres could be identified

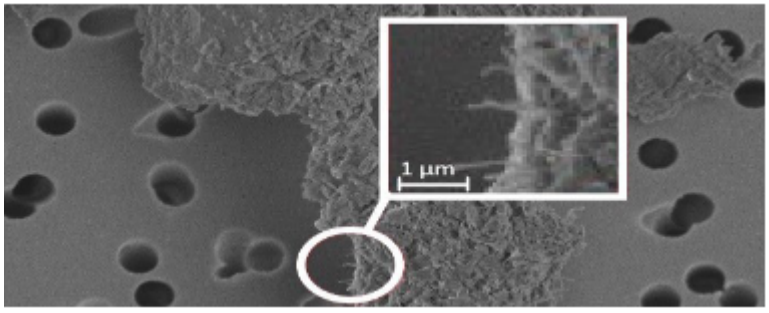

Figure 1: Type 3 with 0.5 wt% CNTs

The majority of the detected particles, regardless of concrete type and wt% CNTs, were within the respirable fraction, i.e., < 4 µm. We therefore stress the development of standardized, matrix-sensitive testing protocols for assessing the risks of occupational exposure related to applications of engineered nanomaterials in the construction sector.

This work was founded by AFA Insurance (dnr 200107).