Safety of Carbon Nanotubes; a Danish Perspective

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Particles entering the lung have an intrinsic capacity for directly generating ROS both outside lung cells as well as within cells and might therefore act as genotoxic substances themselves. Additionally, they may cause influx of neutrophils resulting in increased secondary ROS production. Inflammation and oxidative stress has for long been hypothesized as an important factor in the development of certain types of cancer. For instance, chronic pulmonary inflammation associated with silicosis and asbestosis may result in various forms of lung cancers such as malignant mesothelioma.

At the National Research Centre for the Working Environment we have tested the inflammatory effects in apolipoprotein E deficient ($ApoE^{-/-}$) mice by single intratracheal instillation of single-walled carbon nanotubes (SWCNT), and compared to those generated by instillation with ultra-fine carbon black (Printex 90) and fullerenes C_{60}. Exposure for single-walled carbon nanotubes and Printex 90 caused a highly significant increase in inflammatory mediators after both 3h (52–195-fold and 11–26-fold, respectively) and 24h (7–30-fold and 26–40-fold, respectively). Additionally, an increased fraction of neutrophils were detected at both time points following exposure for Printex 90 and SWCNT although only significant at the 24h point. Fullerenes C_{60} resulted in a much weaker inflammatory response.

Additionally, exposure for SWCNT and Printex 90 significantly increased the concentration of protein in bronchoalveolar lavage (BAL) fluid at both 3 h (1.7 and 1.4-fold, respectively) and 24 h (2.6 and 1.6-fold, respectively). An increase in BAL protein is expected to be a result of cellular damage and leakage of cytosolic fluid. The Comet assay was used for determining DNA damage in bronchoalveolar lavage cells. Cells obtained 3 h after carbon black and single-walled carbon nanotube instillation, but not following fullerene C_{60} instillation, had elevated level of DNA damage measured as % DNA in the tail.

Overall, we detected both cellular damage and DNA damage to pulmonary cells following exposure for SWCNT. However, these experiments also indicated that although very strong the inflammation appeared to be short lived when compared to the other two particles. Taken together this indicates that the inflammatory potential of this particular SWCNT is similar to that of ultra-fine carbon black (Printex 90). However, it should be noted that we assessed early toxicological endpoints rather than pathological observations observed by others.

Guidelines on risk management on carbon nanotubes have recently been published by national agencies and other organisations. I will discuss principles of safe handling of carbon nanotubes in the light of the most recent scientific data.