Deposition of Nano- and Micron-sized Fibers in the Alveolar Region of the Human Lung

Authors: Bahman Asgharian, Owen Price
CIIT Centers for Health Research/Computational Biology, United States

Keywords: fibers, lung deposition, internal dose, risk assessment, nanofibers

Fibrous material such as single- and multi-walled nanotubes and asbestos fibers may pose a health threat when inhaled and deposited on lung airways. Assessment of the risk of inhaled fibers requires accurate characterization of internal dosimetry. Modeling of fiber deposition in the lung is far more involved than that of spherical particles. Due to the shape and coupling of translational and rotational movements, the transport equations of fibers are more complex than those of spherical particles. Traditionally, fiber lung deposition models are obtained from that of spherical particles by substituting fiber equivalent diameters for particle physical diameter in deposition efficiency formulas. The equivalent diameters by different loss mechanisms are found by adjusting for fiber mobility and diffusion properties in transport equations for spherical particles. These models serve only as a first order approximation until more accurate models based purely on fiber transport in the air are developed. In this study, transport equations of fibers in small airways of the lung were formulated and solved for the case of random fiber orientation to obtain expressions for deposition efficiency by sedimentation and diffusion. Deposition efficiencies were also calculated for different airway orientations and fiber aspect ratios. Results were compared with deposition of particles of equivalent mass diameters. Deposition by sedimentation increased with increasing the gravity angle. Fiber length or aspect ratio was found to enhance losses by sedimentation. Fibers had a larger deposition by sedimentation in small lung airways than particles having the same mass as fibers. For losses by diffusion, deposition decreased with increasing fiber length or aspect ratio; spherical particles of the same mass had a higher deposition than that of fibers. These findings can be used in the development of a fiber deposition model to evaluate the fate of inhaled fibers for risk assessment applications.

Point of Contact:
Bahman Asgharian
Associate Investigator
CIIT Centers for Health Research
6 Davis Drive
Durham, NC 27513
919-558-1342
asgharian@ciit.org