Effects of Carbon Nanotubes in Barrier Epithelial Cells via Effects on Lipid Bilayers

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Carbon nanotubes (CNTs) are one of many nanoparticles (NP) which are being developed as part of the burgeoning nanotechnology. The tubes have similar physical properties to known toxic materials, such as asbestos; yet there is a lack of evidence showing that they may be hazardous to humans, specifically to our barrier epithelial cells. We measured the effects of CNTs on human airway epithelial cells (Calu-3 cell line) using electrophysiology. This is a technique which measures transepithelial electrical resistance (TEER), a measure of monolayer integrity; and short circuit current (SCC) a measure of net ion transport across the cell. Exposed cells showed significant decreases in TEER when incubated for 48 hours with physiologically relevant concentrations of 4μg/cm^2 - 0.4ng/cm^2 of multi-wall (MW) and 4μg/cm^2 - 0.04ng/cm^2 single-wall (SW) CNT. TEER is a measure of barrier function which is important in cells that maintain separate compartments in the body. The impaired barrier function, despite sustained cell viability, led us to investigate the mechanism by which the CNT were interacting with the cell when applied topically. Model lipid membranes connected to an ion channel amplifier, Planar Bilayer Workstation (BLM), were used. Membranes were formed using the neutral diphytanoylphosphatidylcholine (DPhPC) and negatively charged diphytanoyl phosphatidylserine (DPhPS) lipids. CNTs caused random, transient currents ranging from 0pA to 6479pA to traverse the membrane. In the presence of Gramicidin A, an ion channel reporter protein, the tubes induced increased gramicidin channel formation in the membrane to saturation level and then membrane lysis. This CNT-lipid interaction indicated that short MWCNTs permits unregulated ion movement across the lipid membrane. Disruption in the selective permeability of the plasmalemma may impact the tissue's barrier function.

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