Cells selectively absorb short nanotubes

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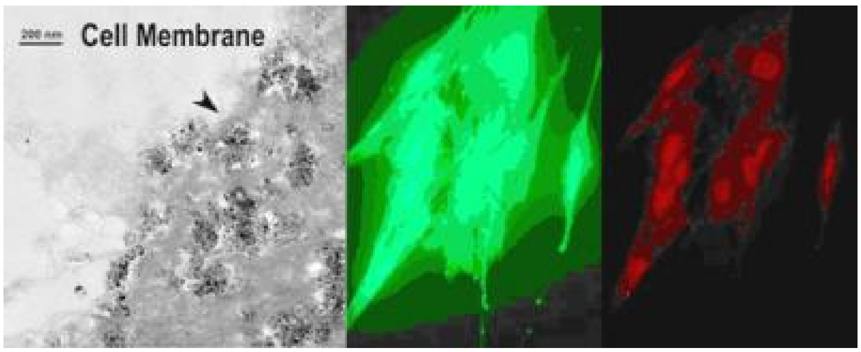

Nanotube length threshold: NIST experiments using human lung cells demonstrate that DNA-wrapped single-walled carbon nanotubes longer than about 200 nanometers are excluded from cells, while shorter lengths are able to penetrate the cell interior (dark lines in the fluorescence image above). Credit: NIST

DNA-wrapped single-walled carbon nanotubes (SWCNTs) shorter than about 200 nanometers readily enter into human lung cells and so may pose an increased risk to health, according to scientists at the National Institute of Standards and Technology. The results of their laboratory studies appear in an upcoming issue of *Advanced Materials*.

Eyed for uses ranging from electronic displays to fuel cells to water filtration, SWCNTs are tiny cylinders—essentially single-sheet rolls of carbon atoms. They are many times stronger than steel and possess superlative thermal, optical and electronic properties, but safety and biocompatibility remain an open question.

"Published data citing in vitro (outside the body) toxicity are particularly inconsistent and widely disputed," writes biomaterials scientist Matthew Becker and his NIST colleagues. Public concerns surrounding the environmental, health and safety impacts of SWCNTs could derail efforts to fast track the development of nanotubes for advanced technology applications. A significant hurdle in outlining the parameters contributing to nanotube toxicity is to prepare well-defined and characterized nanotube samples, as they typically contain a distribution of lengths, diameters, twists and impurities.

The team chose to isolate the effects of nanotube length. They first adsorbed short DNA molecules onto the nanotubes because this renders them soluble in water and allows them to be sorted and separated by length. The researchers then exposed human lung fibroblasts to solutions containing unsorted nanotubes. Regardless of the concentration levels, the cells did not absorb between about one-fourth and one-third of the SWCNTs in the solutions. Further examination of the results revealed that only short nanotubes made it into the cellular interior.

In the next phase of the research, the team exposed the cells to sorted nanotubes of controlled length. They found that tubes longer than about 200 nanometers were excluded from the cells and remained in solution. Cells exposed to the longer nanotube solutions did not undergo a decrease in metabolic activity, but cells exposed to nanotubes below that threshold absorbed them and, depending on the concentration level, died or showed other signs of toxicity. "Our results demonstrate that cellular uptake in these lung cells depends significantly on the length of the nanotubes," Becker explains. "This is the first of many steps in the critical goal of reducing health risk by de novo engineering of the nanotubes themselves."

Citation: M.L. Becker, J.A. Fagan, N.D. Gallant, B.J. Bauer, V. Bajpai, E.K. Hobbie, S.H. Lacerda, K. B. Migler and J.P. Jakupciak. Lengthdependent uptake of DNA-wrapped single-walled carbon nanotubes. *Advanced Materials*, published on-line : 20 March 2007.

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