Nano Sponges for Drug Delivery and Medicinal Applications

These non-toxic nano sponges are a means to deliver a drug or payload to cells in an extended-release fashion.

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This invention is a means of delivering a drug, or payload, to cells using non-covalent associations of the payload with nano-engineered scaffolds; specifically, functionalized single-walled carbon nanotubes (SWNTs) and their derivatives where the payload is effectively sequestered by the nanotube's addends and then delivered to the site (often interior of a cell) of interest.

Polyethylene glycol (PEG) and other water-soluble organic molecules have been shown to greatly enhance the solubility of SWNTs in water. PEG groups and other water-solubilizing addends can act to sequester ("sponge") molecules and deliver them into cells. Using PEG that, when attached to the SWNTs, the SWNT/PEG matrix will enter cells has been demonstrated. This was visualized by the addition of fluorescein isothiocyanate (FITC) to the SWNT/PEG matrix. Control studies showed that both FITC alone and FITC/PEG did not enter the cells. These observations suggest that the FITC is highly associated with the SWNT/PEG matrix that brings the FITC into the cells, allowing visualization of SWNTs in cells.

The FITC is not covalently attached, because extended dialysis in hot DMF will remove all fluorescence quickly (one week). However, prolonged dialysis in water (1–2 months) will only slowly diminish the fluorescence. This demonstrates that the SWNT/PEG matrix solubilizes the FITC by sequestering it from the surrounding water and into the more solubilizing organic environment of the SWNT/PEG matrix of this type. This can be extended for the sequestering of other molecules such as drugs with PEG and other surfactants.

For example, it was shown that the water-insoluble anti-cancer drug paclitaxel (Taxol) could be effectively dissolved in water via the sponging action of the SWNT/PEG matrix in solution. When one milligram of paclitaxel dissolved in 70 µL of ethanol is added into 1 mL of water, the drug will immediately precipitate out of solution once in contact with the water. However, when the same amount of dissolved paclitaxel is added into 1 mL of the SWNT/PEG matrix solution in water, no paclitaxel precipitates out of solution. This is attributed to the paclitaxel being sequestered from the water and into the more favorable SWNT/PEG matrix. In this way, water-soluble solutions of paclitaxel were made.

In preliminary studies, using the well established MIT assay, the "sponged" paclitaxel was shown to have comparable cell-killing ability as the cremophor-stabilized Taxol used in current clinical cancer treatment. The SWNT/PEG matrix, which was shown to be non-toxic to cells, could be an effective alternative for the drug delivery vehicle cremophor, which is known to cause debilitating side effects in some cancer patients. The nano sponge should behave similarly in the solubilization of other molecules with limited or no water solubility. In addition, the material also serves as a protective barrier, sheltering the drug or payload from premature destruction within the body before it reaches the final destination of the cell. Moreover, one could simply add the functionalized SWNTs into a solution of the drug or fluorescent tag of choice, incubate in order to have the SWNT/PEG matrix sequester the drug or tag, and then administer the entire solution for delivery.

This work was done by James M. Tour, Rebecca Lucente-Schultz, Ashley Leonard, Dimitry V. Kosynkin, Brandi Katherine Price, and Jared L. Hudson of Rice University; and Jodie L. Conyers Jr., Valerie C. Moore, S. Ward Casscells, Jeffrey N. Myers, Zvonimir L. Milas, Luka Milas, and Kathy A. Mason of the University of Texas for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

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Molecular Technique to Understand Deep Microbial Diversity

NASA's Jet Propulsion Laboratory, Pasadena, California

Current sequencing-based and DNA microarray techniques to study microbial diversity are based on an initial PCR (polymerase chain reaction) amplification step. However, a number of factors are known to bias PCR amplification and jeopardize the true representation of bacterial diversity. PCR amplification of the minor template appears to be suppressed by the exponential amplification of the more abundant template. It is widely acknowledged among environmental molecular microbiologists that genetic biosignatures identified from an environment only represent the most dominant populations. The technological bottleneck has overlooked the presence of the less abundant "minority population," and underestimated their role in the ecosystem maintenance.