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Designer 'Nanobatons' Could Be Used To Trap Oil, Deliver Drugs: Nanoparticles Assemble By Millions

ScienceDaily (May 29, 2008)
— In a development that could lead to new technologies for cleaning up oil spills and polluted groundwater, scientists at Rice University have shown how tiny, stick-shaped particles of metal and carbon can trap oil droplets in water by spontaneously assembling into bag-like sacs.

The tiny particles were found to assemble spontaneously by the tens of millions into spherical sacs as large as BB pellets around droplets of oil in water. In addition, the scientists found that ultraviolet light and magnetic fields could be used to flip the nanoparticles, causing the bags to instantly turn inside out and release their cargo -- a feature that could ultimately be handy for delivering drugs.

"The core of the nanotechnology revolution lies in designing inorganic nanoparticles that can self-assemble into larger structures like a 'smart dust' that performs different functions in the world -- for example, cleaning up pollution," said lead research Pulickel Ajayan, Rice's Benjamin M. and Mary Greenwood Anderson Professor in Mechanical Engineering and Materials Science. "Our approach brings the concept of self-assembling, functional nanomaterials one step closer to reality."

The research was published online May 29 by the American Chemical Society's journal Nano Letters.

The multisegmented nanowires, akin to "nanoscale batons," were made by connecting two nanomaterials with different properties, much like an eraser is attached to the end of a wooden pencil. In the study, the researchers started with carbon nanotubes -- hollow tubes of pure carbon. Atop the nanotubes, they added short segments of gold. Ajayan said that by adding various other segments -- like sections of nickel or other materials -- the researchers can create truly multifunctional nanostructures.

The tendency of these nanobatons to assemble in water-oil mixtures derives from basic chemistry. The gold end of the wire is water-loving, or hydrophilic, while the carbon end is water-averse, or hydrophobic. The thin, water-tight sacs that surround all living cells are formed by interlocking arrangements of hydrophilic and hydrophobic chemicals, and the sac-like structures created in the study are very similar.

Ajayan, graduate student Fung Suong Ou and postdoctoral researcher Shaijumon Manikoth demonstrated that oil droplets suspended in water became encapsulated because of the structures' tendency to align their carbon ends facing the oil. By reversing the conditions -- suspending water droplets in oil -- the team was able to coax the gold ends to face inward and encase the water.

"For oil droplets suspended in water, the spheres give off a light yellow color because of the exposed gold ends," Ou said. "With water droplets, we observe a dark sphere due to the protruding black nanotubes."

The team is next preparing to test whether chemical modifications to the "nanobatons" could result in spheres that can both capture and break down oily chemicals. For example, they hope to attach catalysts to the water-hating ends of the nanowires that will cause compounds like trichloroethene, or TCE, to break into nontoxic constituents. Another option would be to attach drugs whose release can be controlled with an external stimulus.

"The idea is to go beyond just capturing the compound and initiate a process that will make it less toxic," Ajayan said. "We want to build upon the method of self assembly and start adding functionality so these particles can carry out tasks in the real world."

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