Nanotubes May Heal Broken Bones

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Human bones can shatter in accidents, or they can disintegrate when ravaged by disease and time. But scientists may have a new weapon in the battle against forces that damage the human skeleton.

Carbon nanotubes, incredibly strong molecules just billionths of a meter wide, can function as scaffolds for bone regrowth, according to researchers led by Robert Haddon at the University of California at Riverside. They have found a way to create a stronger and safer frame than the artificial bone scaffolds currently in use.

Human bones are both organic and inorganic. The organic part is made of collagen, the most abundant protein in mammals. The inorganic component is hydroxyapatite, a type of calcium crystal. The collagen forms a sort of natural scaffold over which the calcium crystals organize into bone. The idea in Haddon's research is to use the nanotubes as substitutes for the collagen to promote new bone growth when bones have been broken or worn down.

Haddon and his team chemically treated carbon nanotubes to attract hydroxyapatite in work they published in the June 14 issue of *Chemistry of Materials*.

"This is nice work," said James Mitchell Tour, a chemistry professor at Rice University. "Anything you can do to take care of people's bones by augmenting the mineralization process is a big deal. It's really nice to see nanotubes being used to function like that."

Carbon nanotubes are an excellent choice for supporting bone, scientists say, because at the molecular scale they are the strongest human-made fiber in existence.

"The advantage of the carbon nanotube here is that at the molecular scale, it is the strongest fiber man will ever make," said Michael Strano, an assistant professor of chemical and biomolecular engineering at the University of Illinois at Urbana-Champaign. "The chemical bonds (in carbon nanotubes) are nature's strongest. Man cannot envision a molecule that will be stronger along its length."

Strano, an expert in carbon nanotube materials. believes the importance of the work stretches beyond bone scaffolds. Though the nanotubes were treated in this case to attract a mineral that might help grow and repair bones, Strano was excited by the possibility of treating the nanotubes in other ways so that they attract, grow and direct all sorts of minerals.

Haddon agreed that his team's biggest accomplishment was discovering how to get the carbon nanotubes to encourage the crystal calcium growth. "Pristine carbon nanotubes can not effectively serve as the nucleus for the growth of hydroxyapatite," he said. "When we tailored the properties of the nanotubes through chemistry, we were able to grow the hydroxyapatite. This result reinforces our belief that, for many applications, nanotube properties have to be tailored through chemistry."

Haddon hopes soon to test how the human body will respond to carbon nanotubes. Even though humans are carbon-based, that's not an iron-clad guarantee that the two will get along smoothly.

Other major questions need to be answered as well. The nanotube solution would likely be injected as a liquid at the site of bone trauma or degradation. Researchers aren't sure if it will know how to organize itself and facilitate growth of the right amount of bone in the right place. It's also possible the nanotube-enhanced bone could be too strong for the surrounding bones and damage the un-enhanced bones, similar to the way a diamond rubbing against copper would eventually degrade the copper.

Nanotube researchers tend to be engineers and material chemists, not experts in tissue engineering. So collaboration between the chemists and bioengineering experts is essential. Tour has established such a partnership with Antonios Mikos, a bioengineering professor at Rice. Together they are researching ways to use nanotubes to strengthen the artificial polymer scaffolds currently in use to repair shattered bones. Tour said they have found that a polymer scaffold composed of just 0.1 percent nanotubes (by weight) has roughly double the structural integrity of a polymer alone.

"Nanotubes are already a big deal in the rubber and elastomer industries," Tour said. "It's going to be a big deal in the medical industry. When we talk about enhancing rigidity in the medical field, one immediately thinks of bones. That's a good place to start."