Nanotubes inspire new technique for healing broken bones

Scientists have shown for the first time that carbon nanotubes make an ideal scaffold for the growth of bone tissue. The new technique could change the way doctors treat broken bones, allowing them to simply inject a solution of nanotubes into a fracture to promote healing.

The report appears in the June 14 issue of the American Chemical Society's journal Chemistry of Materials. ACS is the world's largest scientific society.

The success of a bone graft depends on the ability of the scaffold to assist the natural healing process. Artificial bone scaffolds have been made from a wide variety of materials, such as polymers or peptide fibers, but they have a number of drawbacks, including low strength and the potential for rejection in the body.

"Compared with these scaffolds, the high mechanical strength, excellent flexibility and low density of carbon nanotubes make them ideal for the production of lightweight, high-strength materials such as bone," says Robert Haddon, Ph.D., a chemist at the University of California, Riverside, and lead author of the paper. Single-walled carbon nanotubes are a naturally occurring form of carbon, like graphite or diamond, where the atoms are arranged like a rolled-up tube of chicken wire. They are among the strongest known materials in the world.

Bone tissue is a natural composite of collagen fibers and hydroxyapatite crystals. Haddon and his coworkers have demonstrated for the first time that nanotubes can mimic the role of collagen as the scaffold for growth of hydroxyapatite in bone.

"This research is particularly notable in the sense that it points the way to a possible new direction for carbon nanotube applications, in the medical treatment of broken bones," says Leonard Interrante, Ph.D., editor of Chemistry of Materials and a professor in the department of chemistry and chemical biology at Rensselaer Polytechnic Institute in Troy, N.Y. "This type of research is an example of how chemistry is being used everyday, world-wide, to develop materials that will improve peoples' lives."

The researchers expect that nanotubes will improve the strength and flexibility of artificial bone materials, leading to a new type of bone graft for fractures that may also be important in the treatment of bone-thinning diseases such as osteoporosis.

In a typical bone graft, bone or synthetic material is shaped by the surgeon to fit the affected area, according to Haddon. Pins or screws then hold the healthy bone to the implanted material. Grafts provide a framework for bones to regenerate and heal, allowing bone cells to weave into the porous structure of the implant, which supports the new tissue as it grows to connect fractured bone segments.

The new technique may someday give doctors the ability to inject a solution of nanotubes into a bone fracture, and then wait for the new tissue to grow and heal.

Simple single-walled carbon nanotubes are not sufficient, since the growth of hydroxyapatite crystals relies on the ability of the scaffold to attract calcium ions and initiate the crystallization process. So the researchers carefully designed nanotubes with several chemical groups attached. Some of these groups assist the growth and orientation of hydroxyapatite crystals, allowing the researchers a degree of control over their alignment, while other groups improve the biocompatibility of nanotubes by increasing their solubility in water.

"Researchers today are realizing that mechanical mimicry of any material alone cannot succeed in duplicating the intricacies of the human body," Haddon says. "Interactions of these artificial materials with the systems of the human body are very important factors in determining clinical use."

The research is still in the early stages, but Haddon says he is encouraged by the results. Before proceeding to clinical trials, Haddon plans to investigate the toxicology of these materials and to measure their mechanical strength and flexibility in relation to commercially available bone mimics.

Source: American Chemical Society