Magnetic nanoparticles for potential cancer treatment

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Virginia Commonwealth University researchers have created highly magnetized nanoparticles based on metallic iron that could one day be used in a non-invasive therapy for cancer in which treatment would begin at the time of detection.

"We envision a potential for these materials to combine both detection and treatment into a single process," said Everett E. Carpenter, Ph.D., an assistant professor of chemistry at VCU.

Carpenter is discussing his ongoing work of the synthesis and characterization of these functional magnetic nanoparticles for use in biomedical applications at the 2005 American Chemical Society National Meeting & Exposition in Washington, D.C., which began Aug. 28 and continues through Sept. 1.

More than 12,000 researchers from across the country are presenting new multidisciplinary research and highlighting important advances in biotechnology, nanoscience, nanotechnology, and defense and homeland security.

"Eventually, our goal is to use the scientific understanding of the growth mechanisms of these nanoparticles to develop materials for biomedical applications," said Carpenter. "By engineering the magnetic properties of enhanced ferrites it is possible to develop materials for the treatment of various cancers, such as breast cancer."

Carpenter and his team are working to determine how to best construct the core-shell structure and learn which shell materials are most ideal for biomedical applications such as magnetodynamic therapy (MDT), or as MRI contrast enhancement agents.

According to Carpenter, in the future it may be possible for a patient to be screened for breast cancer using MRI techniques with engineered enhanced ferrites as the MRI contrast agent. He said if a tumor is detected, the doctor could then increase the power to the MRI coils and localized heating would destroy the tumor region without damage to the surrounding healthy cells.

Another promising biomedical application is MDT, which employs magnetic nanoparticles that are coupled to the radio frequency of the MRI. This coupling converts the radio frequency into heat energy that kills the cancer cells. European researchers studying MDT have shown that nanoparticles are able to target tumor cells. Carpenter said that because the nanoparticles target tumor cells and are substantially smaller than human cells, only the very few tumor cells next to the nanoparticles are killed, which greatly minimizes damage to healthy cells.

"Our goal is to tailor the properties of the nanoparticles to make the use of MDT more universal," said Carpenter. "The only thing slowing down the development of enhanced ferrites for 100 megahertz applications is a lack of understanding of the growth mechanisms and synthesis-property relationships of these nanoparticles.

"By studying the mechanism for the growth of the enhanced ferrites, it will be possible to create shells that help protect the metallic core from oxidation in biologically capable media," he said.

Enhanced ferrites are a class of ferrites that are specially engineered to have enhanced magnetic or electrical properties and are created through the use of core-shell morphology. He said that in this approach the core can be a highly magnetic material like iron or iron alloys, while the shell can be a mixed metal ferrite with tailored resistivity.

“Ferrites (iron oxides) are used in many applications that require both a high magnetization and high electrical resistance; properties which are typically mutually exclusive,” said Carpenter. “These two properties are tied not only to the structure of the material but also to the way in which the material is synthesized and processed.”

Today, polymer encapsulated iron oxide particles are used in biomedical applications. However, Carpenter said that the high magnetization of the enhanced ferrite nanoparticles may potentially improve the absorption of the radio frequency, thereby providing better detection of tumor regions and the use of less MRI contrast re-agent.

In 2002, Carpenter invented a new material based on metallic iron. He said the magnetic power of the iron nanoparticles he created is 10 times greater than that of the currently available iron oxide nanoparticles, which translates to a substantial reduction in the amount of iron needed for imaging or therapy.

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Source: Virginia Commonwealth University