Coated Ultrasmall Quantum Dots Suitable for In Vivo Imaging

December 3 2007

Quantum dots have shown promise in a variety of imaging and therapeutic applications, particularly when they are coated to render them biocompatible. However, such coating can increase the size of quantum dots signficantly, which can adversely effect their pharmacokinetic and biodistribution properties.

Now, researchers at the Massachussetts Institute of Technology and Beth Israel Deaconess Medical Center have developed a new procedure that produces ultracompact quantum dots. Tests with these new materials show that this coating not only does not impair the superior optical properties of the quantum dots but also improves how the quantum dots behave in living animals.

Moungi Bawendi, Ph.D., a member of the MIT-Harvard Center of Cancer Nanotechnology Excellence, and John Frangioni, M.D., Ph.D., led this study. Their results appear in the *Journal of the American Chemical Society*.

To create these compact quantum dots, the investigators first create dual-layer nanocrystals that have a zinc-cadmium-sulfide (ZnCdS) core surrounded by a cadmium selenide (CdSe) shell. This combination of materials creates a compact yet bright quantum dot. Next, the researchers add a coating of cysteine, a sulfur-containing amino acid that binds tightly to the CdSe shell.

When stored in the presence of a reducing agent, these quantum dots are

stable for 1 week at room temperature and at least 3 months at 4°C. Dynamic light scattering, a technique used to study nanoparticle size, showed that the diameter of these quantum dots was 5.9 nanometers. More importantly, their size did not increase when incubated with serum, demonstrating that the cysteine coating prevented proteins from collecting on the quantum dot surface.

The researchers note that the exceptionally small size of their quantum dots and their stability in serum led to new in vivo behavior. When injected into rats, the majority of the quantum dots accumulated in the bladder within 4 hours, demonstrating that these nanoparticles are small enough to be filtered out of the kidneys. In practical terms, this finding suggests that these compact quantum dots, if attached to a small targeting molecule, could be used to image tumors without having to worry about accumulation within the body. Any injected dose that did not bind to its target would clear rapidly, decreasing background noise and improving the sensitivity of tumor imaging.

This work, which was supported in part by the National Cancer Institute's Alliance for Nanotechnology in Cancer, is detailed in the paper "Compact cysteine-coated CdSe(ZnCdS) quantum dots for in vivo applications." This paper was published online in advance of print publication. An abstract of this paper is available through PubMed.

Source: National Cancer Institute