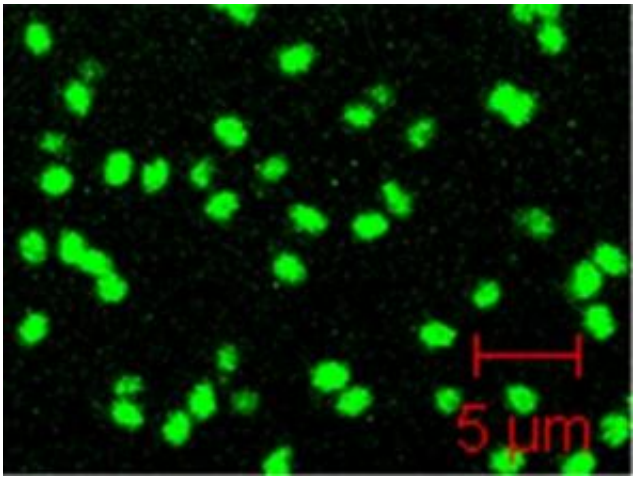
Carbon-based quantum dots could mean 'greener' technology in medicine, biology

May 23 2006



Microscope image of bacterial spores (Bacillus subtilis) labeled with luminescent carbon nanoparticles. B. subtilis serves as a common model for anthrax research. These carbon nanoparticles, or carbon dots, could lead to safer, disposable biosensors to detect biological warfare agents. Measurement shown is 5 micrometers. Image courtesy of Dr. Ya-Ping Sun of Clemson University

Chemists at Clemson University say they have developed a new type of quantum dot that is the first to be made from carbon. Like their metal-based counterparts, these nano-sized "carbon dots" glow brightly when exposed to light and show promise for a broad range of applications, including improved biological sensors, medical imaging devices and tiny light-emitting diodes (LEDs), the researchers say.

The development, which could help broaden the use of quantum dot technologies, is described in a research communications published online today by the *Journal of the American Chemical Society*. The paper will appear in the journal's June 7 print edition.

The carbon-based quantum dots show less potential for toxicity and environmental harm and have the potential to be less expensive than metal-based quantum dots, the scientists say. Cheap disposable sensors that can detect hidden explosives and biological warfare agents such as anthrax also are among the possibilities envisioned by the researchers.

"Carbon is hardly considered to be a semiconductor, so luminescent carbon nanoparticles are very interesting both fundamentally and practically," says study leader Ya-Ping Sun, Ph.D., a chemist at the university, located in Clemson, S.C. "It represents a new platform for the development of luminescent nanomaterials for a wide range of applications."

Quantum dots have generated much interest in recent years, especially for potential applications in biology and medicine. These tiny particles -- thousands of times smaller than the width of a human hair -- have been developed from compounds composed of lead, cadmium and, more recently, silicon. But these materials have raised concerns over potential toxicity and environmental harm. As a result, scientists have begun to look for more benign compounds for making quantum dots.

Researchers have known for some time that carbon nanoparticles, due partly to their enormous surface area, have unusual chemical and physical properties quite different from their bulk form. Using nanoparticles produced from graphite, Sun and his associates demonstrated that when these carbon nanoparticles are covered with special polymers, they glow brightly when exposed to light, behaving as tiny light bulbs. The dots glow continuously as long as a light source is

present, they say.

The scientists believe that this photoluminescence may be due to the presence of "pockets" or holes on the surface of the carbon dots that trap energy. The polymer coating acts as a "molecular band-aid," enabling light emission from the inside of the polymer casing, they say. Scientists believe that metal-based quantum dots emit light by a somewhat different mechanism.

The two-sided polymer coating allows researchers to attach antibodies or other labeling materials to the carbon dot, says Sun. This could lead to improved dyes for medical imaging and also the development of sensors that light up in the presence of a target, such as anthrax or even food-borne pathogens. In lab studies, the researchers successfully labeled anthrax-like spores with luminescent carbon dots, resulting in glowing spores that were easily viewed under a microscope.

Source: American Chemical Society