New research raises questions about buckyballs and the environment

May 9 2005

In a challenge to conventional wisdom, scientists have found that buckyballs dissolve in water and could have a negative impact on soil bacteria. The findings raise new questions about how the nanoparticles might behave in the environment and how they should be regulated, according to a report scheduled to appear in the June 1 print issue of the American Chemical Society's peer-reviewed journal *Environmental Science & Technology*. ACS is the world's largest scientific society.

A buckyball is a soccer ball-shaped molecule made up of 60 carbon atoms. Also known as fullerenes, buckyballs have recently been touted for their potential applications in everything from drug delivery to energy transmission. Yet even as industrial-scale production of buckyballs approaches reality, little is known about how these nano-scale particles will impact the natural environment. Recent studies have shown that buckyballs in low concentrations can affect biological systems such as human skin cells, but the new study is among the earliest to assess how buckyballs might behave when they come in contact with water in nature.

Scientists have generally assumed that buckyballs will not dissolve in water, and therefore pose no imminent threat to most natural systems. "We haven't really thought of water as a vector for the movement of these types of materials," says Joseph Hughes, Ph.D., an environmental engineer at Georgia Tech and lead author of the study.

But Hughes and his collaborators at Rice University in Texas have found

that buckyballs combine into unusual nano-sized clumps — which they refer to as "nano-C60" — that are about 10 orders of magnitude more soluble in water than the individual carbon molecules.

In this new experiment, they exposed nano-C60 to two types of common soil bacteria and found that the particles inhibited both the growth and respiration of the bacteria at very low concentrations — as little as 0.5 parts per million. "What we have found is that these C60 aggregates are pretty good antibacterial materials," Hughes says. "It may be possible to harness that for tremendously good applications, but it could also have impacts on ecosystem health."

Scientists simply don't know enough to accurately predict what impact buckyballs will have on the environment or in living systems, which is exactly why research of this type needs to be done in the early stages of development, Hughes says.

He suggests that his findings clearly illustrate the limitations of current guidelines for the handling and disposal of buckyballs, which are still based on the properties of bulk carbon black. "No one thinks that graphite and diamond are the same thing," Hughes says. They're both bulk carbon, but they are handled in completely different ways. The same should be true for buckyballs, according to Hughes.

These particles are designed to have unique surface chemistries, and they exhibit unusual properties because they are at the nanometer scale — one billionth of a meter, the range where molecular interactions and quantum effects take place. It is precisely these characteristics that make them both so potentially useful and hazardous to biological systems. "I think we should expect them to behave differently than our current materials, which have been studied based on natural bulk forms," Hughes says. "Learning that C60 behaves differently than graphite should be no surprise."

Overall, the toxicological studies that have been reported in recent years are a signal that the biological response to these materials needs to be considered. "That doesn't mean that we put a halt on nanotechnology," Hughes says. "Quite the opposite."

"As information becomes available, we have to be ready to modify these regulations and best practices for safety," he continues. "If we're doing complementary studies that help to support this line of new materials and integrate those into human safety regulations, then the industry is going to be better off and the environment is going to be better off."

Source: American Chemical Society