New cancer weapon: nuclear nanocapsules

August 23 2007

Rice University chemists have found a way to package some of nature's most powerful radioactive particles inside DNA-sized tubes of pure carbon -- a method they hope to use to target tiny tumors and even lone leukemia cells.

"There are no FDA-approved cancer therapies that employ alpha-particle radiation," said lead researcher Lon Wilson, professor of chemistry. "Approved therapies that use beta particles are not well-suited for treating cancer at the single-cell level because it takes thousands of beta particles to kill a lone cell. By contrast, cancer cells can be destroyed with just one direct hit from an alpha particle on a cell nucleus."

The study's results are available online and slated to appear in an upcoming issue of the journal *Small*.

In the study, Wilson, Rice graduate student Keith Hartman, University of Washington (UW) radiation oncologist Scott Wilbur and UW research scientist Donald Hamlin, developed and tested a process to load astatine atoms inside short sections of carbon nanotubes. Because astatine is the rarest naturally occurring element on Earth -- with less than a teaspoon estimated to exist in the Earth's crust at any given time -- the research was conducted using astatine created in a UW cyclotron.

Astatine, like radium and uranium, emits alpha particles via radioactive decay. Alpha particles, which contain two protons and two neutrons, are the most massive particles emitted as radiation. They are about 4,000

times more massive than the electrons emitted by beta decay -- the type of radiation most commonly used to treat cancer.

"It's something like the difference between a cannon shell and a BB," Wilson said. "The extra mass increases the amount of damage alpha particles can inflict on cancer cells."

The speed of radioactive particles is also an important factor in medical use. Beta particles travel very fast. This, combined with their small size, gives them significant penetrating power. In cancer treatment, for example, beams of beta particles can be created outside the patient's body and directed at tumors. Alpha particles move much more slowly, and because they are also massive, they have very little penetrating power. They can be stopped by something as flimsy as tissue paper.

"The unique combination of low penetrating power and large particle mass make alpha particle ideal for targeting cancer at the single-cell level," Wilson said. "The difficulty in developing ways to use them to treat cancer has come in finding ways to deliver them quickly and directly to the cancer site."

In prior work, Wilson and colleagues developed techniques to attach antibodies to carbon fullerenes like nanotubes. Antibodies are proteins produced by white blood cells. Each antibody is designed to recognize and bind only with a specific antigen, and doctors have identified a host of cancer-specific antibodies that can be used to kill cancer cells.

In follow-up research, Wilson hopes to test the single-celled cancer targeting approach by attaching cancer-specific antibodies to astatine-loaded nanotubes.

One complicating factor in any astatine-based cancer therapy will be the element's short, 7.5-hour half-life. In radioactive decay, the term half-

life refers to the time required for any quantity of a substance to decay by half its initial mass. Due to astatine's brief half-life, any treatment must be delivered in a timely way, before the particles lose their potency.

Source: Rice University