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Boron-nitride nanotubes show potential in cancer treatment

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A new study has shown that adding boron-nitride nanotubes to the surface of cancer cells can double the effectiveness of Irreversible Electroporation, a minimally invasive treatment for soft tissue tumors in the liver, lung, prostate, head and neck, kidney and pancreas. Although this research is in the very early stages, it could one day lead to better therapies for cancer.

The study was carried out by researchers in Italy at the Institute of Life Sciences, Scuola Superiore Sant'Anna in Pisa with BNNTs provided by researchers at NASA's Langley Research Center, the Department of Energy's Thomas Jefferson National Accelerator Facility and the National Institute of Aerospace.

Irreversible Electroporation is a new therapy for difficult-to-treat cancers in soft tissues. It is offered in many cancer treatment centers across the United States, and is being studied for effectiveness on a wide variety of specific cancers. Researchers at the Institute of Life Sciences began experimenting with BNNTs to see if the nanotubes could make the treatment more effective.

"Irreversible Electroporation is a way of putting holes in the wall of a tumor cell," said Michael W. Smith, chief scientist at BNNT, LLC and formerly a staff scientist at NASA's Langley Research Center.

Smith explained that when a hole of proper size is made in the wall of a cell, the cell reacts in a predictable fashion. Although the exact mechanism has not been pinpointed, researchers suspect that such a hole could trigger cell suicide. "The cell will literally go, Oh, something's terribly wrong, and kill itself. That's called apoptosis," he added.

Smith read about the Italian researcher's trials with BNNTs in a journal, and he offered the researchers a sample of the very high-quality Jefferson Lab/NASA Langley/NIA BNNTs. These BNNTs are highly crystalline and have a small diameter. Structurally, they also contain few walls with minimal defects, and are very long and highly flexible.

The Italian researchers first suspended the BNNTs in glycol-chitosan, a type of bio-soap solution, and blasted the tubes with sound waves to chop them into smaller bits. The solution, containing varying amounts of BNNTs, was then dumped on clusters of human epithelial carcinoma cells (also known as HeLa cells) in the lab to see if the BNNTs alone would kill the cells. The researchers determined the amount of BNNTs that killed roughly 25 percent of the cancer cells over 24 hours.

The researchers then exposed the HeLa cells to that amount of BNNTs in solution and zapped the cells with 160 Volts of electricity, which was the electroporation device supplier's suggested voltage and corresponds to an electric field of 800 Volts per centimeter. The researchers also treated unexposed cancer cells with the same voltage.

They found that the Irreversible Electroporation treatment method killed twice as many cancer cells with BNNTs (88 percent) on the cell surface than without (40 percent).

"They were able to get, in a petri dish, more than double the effectiveness. So, this technique works twice as well with our nanotubes on the cells than without them. That's a big deal, because you can either use a lot less voltage or kill a lot more cells," said Smith.

Smith and his colleague, Kevin Jordan, a Jefferson Lab staff engineer and chief engineer at BNNT, LLC, said that BNNTs have a long list of potential uses.

"Technology researchers say these nanotubes have energy applications, medical applications and aerospace applications," said Jordan.

The researchers are now attempting to scale up the production process, while also improving the purity of the BNNTs. Their aim is to be able to produce mass quantities of tubes for exploration of the full gamut of potential applications.

For instance, the Italian researchers will need more high-quality BNNTs to continue their studies in mice. Moving to this next step is promising, but the research is still in the very early stages, and it still has a long way to progress before the technique will be considered for use in the clinic to treat cancer.

Researchers at NASA's Langley Research Center, the Department of Energy's Thomas Jefferson National Accelerator Facility and the National Institute of Aerospace created a new technique to synthesize high-quality boron-nitride nanotubes (BNNTs). The pressurized vapor/condenser (PVC) method was developed with Jefferson Lab's Free-Electron Laser and was later perfected using a commercial welding laser. In this technique, the laser beam strikes a target inside a chamber filled with nitrogen gas. The beam vaporizes the target, forming a plume of boron gas. A condenser, a cooled metal wire, is inserted into the boron plume. The condenser cools the boron vapor as it passes by, causing liquid boron droplets to form. These droplets combine with the nitrogen to self-assemble into BNNTs.

The research was published online ahead of print in the journal *Technology in Cancer Research and Treatment*.

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