Smart Nanocarriers to Combat Tumors

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A ‘smart’ nanocarrier technology developed by a team of researchers at the Institute of Bioengineering and Nanotechnology (IBN) is set to vastly improve the way cancer patients are treated.

Anticancer drugs are now being administered to patients using methods that cause the indiscriminate killing of both diseased and healthy cells. Such chemotherapy leads to side-effects, such as nausea, fatigue, and hair loss, and makes the patient weak and frail. Between 1998 and 2002, 38,447 people in Singapore were diagnosed with some type of cancer, while 20,289 died of the disease. Hence, there is a crucial need for the development of more effective cancer therapy, which not only minimizes side-effects but also directly targets diseased cells.

Scientists at IBN have found a way to tackle this problem through the use of anticancer drug delivery vehicles that transport drugs only to where they are needed in the body. This method significantly reduces or even eliminates the severe side-effects typically induced by conventional chemotherapeutics.

The team led by IBN Group Leader Dr Yi-Yan Yang has created ‘smart’ nanocarriers that can house anticancer drugs in their inner cores. Such polymeric core-shell nanoparticles are small in size (generally less than 200 nm), with shells that protect enclosed bioactive compounds against degradation and digestive fluids.

These nanocarriers, which are both pH-sensitive and temperature-sensitive, are structurally stable in the normal physiological environment.

However, in slightly acidic environments that are characteristic of tumor tissues and endosomes (a cell component), they deform and precipitate, thus releasing the enclosed drug molecules.

“Previous attempts by other scientists involved the use of core-shell nanoparticles that were only sensitive to temperature. Drug delivery may be controlled by superficially heating and cooling the environment of the nanoparticles,” said lead scientist Dr Yang.

“The novelty of our invention compared to carriers that are only temperature-sensitive is the ability of IBN’s core-shell nanoparticles to target drugs to deep tissues or cell compartments without changes in temperature.”

Dr Yang explained that once IBN’s ‘smart’ nanocarriers encounter cancer tissues, they form a hydrophobic shell that allows them to adhere to tumor sites. Biological signals are also tagged onto the shell of these nanoparticles, enabling them to recognize and zoom in on tumor sites. After being taken up by cancer cells, the nanocarriers can absorb protons in the endosomes and release their payload into the cell’s cytoplasm, and subsequently its nucleus.

So far, the IBN team has proven that their core-shell nanoparticles can deliver anticancer drugs much more efficiently into cancer cells, compared to current techniques. Their in vivo studies using a mouse breast tumor model has also shown that doxorubicin (an anti-cancer drug) loaded in these smart nanoparticles can suppress tumor growth more efficiently than free doxorubicin.

“IBN’s ‘smart’ nanocarriers do not show significant cytotoxicity, and offer great potential in targeting drugs to tumor tissues with high efficacy,” added Dr Yang. “This invention may also be used in in vitro and animal studies for drug discovery.”

The prospects for IBN's technology are significant, with the cancer drug delivery market expected to grow to US$15.4 billion by the year 2007.

The team's findings were recently published in the leading journal Advanced Materials,* and a United States patent has been filed on the invention.

* K. S. Soppimath, C. W. Tan and Y. Y. Yang, "pH-Triggered Thermally Responsive Polymer Core-Shell Nanoparticles for Targeted Drug Delivery", Advanced Materials 17 (2005) 318-323.

Source: Institute of Bioengineering and Nanotechnology