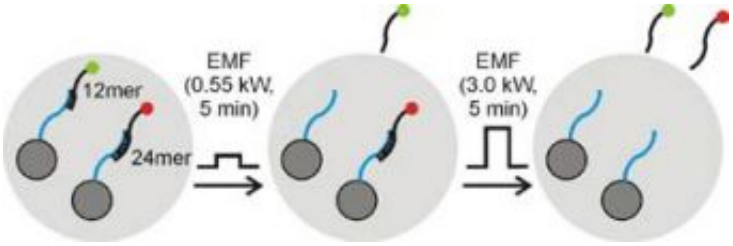
Remote-control nanoparticles deliver drugs directly into tumors

November 16 2007



Here, dark gray nanoparticles carry different drug payloads (one red, one green). A remotely generated five-minute pulse of a low-energy electromagnetic field releases the green drug but not the red. A five-minute pulse of a higher-energy electromagnetic field releases the red drug, which had been tethered using a DNA strand twice as long as the green tether, as measured in base pairs. Image courtesy / Bhatia/von Maltzahn, MIT. Derfus, UCSD

MIT scientists have devised remotely controlled nanoparticles that, when pulsed with an electromagnetic field, release drugs to attack tumors. The innovation, reported in the Nov. 15 online issue of *Advanced Materials*, could lead to the improved diagnosis and targeted treatment of cancer.

In earlier work the team, led by Sangeeta Bhatia, M.D.,Ph.D., an associate professor in the Harvard-MIT Division of Health Sciences & Technology (HST) and in MIT's Department of Electrical Engineering and Computer Science, developed injectable multi-functional nanoparticles designed to flow through the bloodstream, home to tumors and clump together. Clumped particles help clinicians visualize tumors

through magnetic resonance imaging (MRI).

With the ability to see the clumped particles, Bhatia's co-author in the current work, Geoff von Maltzahn, asked the next question: “Can we talk back to them?”

The answer is yes, the team found. The system that makes it possible consists of tiny particles (billionths of a meter in size) that are superparamagnetic, a property that causes them to give off heat when they are exposed to a magnetic field. Tethered to these particles are active molecules, such as therapeutic drugs.

Exposing the particles to a low-frequency electromagnetic field causes the particles to radiate heat that, in turn, melts the tethers and releases the drugs. The waves in this magnetic field have frequencies between 350 and 400 kilohertz-the same range as radio waves. These waves pass harmlessly through the body and heat only the nanoparticles. For comparison, microwaves, which will cook tissue, have frequencies measured in gigahertz, or about a million times more powerful.

The tethers in the system consist of strands of DNA, “a classical heat sensitive material,” said von Maltzahn, a graduate student in HST. Two strands of DNA link together through hydrogen bonds that break when heated. In the presence of the magnetic field, heat generated by the nanoparticles breaks these, leaving one strand attached to the particle and allowing the other to float away with its cargo.

One advantage of a DNA tether is that its melting point is tunable. Longer strands and differently coded strands require different amounts of heat to break. This heat-sensitive tuneability makes it possible for a single particle to simultaneously carry many different types of cargo, each of which can be released at different times or in various combinations by applying different frequencies or durations of

electromagnetic pulses.

To test the particles, the researchers implanted mice with a tumor-like gel saturated with nanoparticles. They placed the implanted mouse into the well of a cup-shaped electrical coil and activated the magnetic pulse. The results confirm that without the pulse, the tethers remain unbroken. With the pulse, the tethers break and release the drugs into the surrounding tissue.

The experiment is a proof of principal demonstrating a safe and effective means of tunable remote activation. However, work remains to be done before such therapies become viable in the clinic.

To heat the region, for example, a critical mass of injected particles must clump together inside the tumor. The team is still working to make intravenously injected particles clump effectively enough to achieve this critical mass.

“Our overall goal is to create multifunctional nanoparticles that home to a tumor, accumulate, and provide customizable remotely activated drug delivery right at the site of the disease,” said Bhatia.

Co-authors on the paper are Austin M. Derfus, a graduate student at the University of California at San Diego; Todd Harris, an HST graduate student; Erkki Ruoslahti and Tasmia Duza of The Burnham Institute in La Jolla, CA; and Kenneth S. Vecchio of the University of San Diego.

Source: MIT

https://phys.org/news/2007-11-remote-control-nanoparticles-drugs-tumors.html