Magnetism Turns Drug Release On and Off

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Many medical conditions, such as cancer, diabetes and chronic pain, require medications that cannot be taken orally, but must be dosed intermittently, on an as-needed basis, over a long period of time. A few delivery techniques have been developed, using an implanted heat source, an implanted electronic chip or other stimuli as an "on-off" switch to release the drugs into the body. But thus far, none of these methods can reliably do all that's needed: repeatedly turn dosing on and off, deliver consistent doses and adjust doses according to the patient's need. But now, a research team led by Daniel Kohane of Children's Hospital Boston has devised a solution that combines magnetism with nanotechnology.

The investigators created a small implantable device, less than 1 centimeter in diameter, that encapsulates the drug in a specially engineered membrane, embedded with magnetic iron oxide nanoparticles. The application of an external, alternating magnetic field heats the magnetic nanoparticles, causing the gels in the membrane to warm and temporarily collapse. This collapse opens up pores that allow the drug to pass through and into the body. When the magnetic field is turned off, the membranes cool and the gels re-expand, closing the pores and halting drug delivery. No implanted electronics are required.

The device, which Kohane's team is continuing to develop for clinical use, is described in the journal Nano Letters. The work detailed in the current paper was conducted in collaboration with Robert Langer, of the Massachusetts Institute of Technology and principal investigator of the MIT-Harvard Center for Cancer Nanotechnology Excellence.

The size of the released dose from the device was reproducibly controlled by the duration of the "on" magnetic field pulse, and the rate of release remained steady over multiple cycles. Testing indicated that drug delivery could be turned on with only a 1 to 2 minute time lag before drug release, and turned off with a 5 to 10 minute time lag. The membranes remained mechanically stable under tensile and compression testing, indicating their durability, showed no toxicity to cells, were not rejected by the immune system in a rat model, and remained functional after forty five days in vivo. The membranes are activated by temperatures higher than normal body temperatures, so would not be affected by the heat of a patient's fever or local inflammation.

This work is detailed in a paper titled, "A Magnetically Triggered Composite Membrane for On-Demand Drug Delivery." Investigators from McMaster University and the University of Zaragoza also participated in this study. An abstract of this paper is available at the journal's Web site.

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