Team develops thin-film 'micro pharmacy'

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From left, Broad Institute postdoctoral associate Kris Wood, Bayer Professor of Chemical Engineering Paula Hammond and chemical engineering graduate student Dan Schmidt show the thin film they have developed. The film releases drugs and other chemical agents upon application of a small electrical field. Credit: MIT

A new thin-film coating developed at MIT can deliver controlled drug doses to specific targets in the body following implantation, essentially serving as a “micro pharmacy.”

The film could eventually be used to deliver drugs for cancer, epilepsy, diabetes and other diseases. It is among the first drug-delivery coatings that can be remotely activated by applying a small electric field.

“You can mete out what is needed, exactly when it's needed, in a systematic fashion," said Paula Hammond, the Bayer Professor of Chemical Engineering and senior author of a paper on the work appearing in the Feb. 11 issue of the *Proceedings of the National Academy of Sciences.*

The film, which is typically about 150 nanometers (billionths of a meter) thick, can be implanted in specific parts of the body.

The films are made from alternating layers of two materials: a negatively charged pigment and a positively charged drug molecule, or a neutral drug wrapped in a positively charged molecule.

The pigment, called Prussian Blue, sandwiches the drug molecules and holds them in place. (Part of the reason the researchers chose to work with Prussian Blue is that the FDA has already found it safe for use in humans.)

When an electrical potential is applied to the film, the Prussian Blue loses its negative charge, which causes the film to disintegrate, releasing the drugs. The amount of drug delivered and the timing of the dose can be precisely controlled by turning the voltage on and off.

The electrical signal can be remotely administered (for example, by a physician) using radio signals or other techniques that have already been developed for other biomedical devices.

The films can carry discrete packets of drugs that can be released separately, which could be especially beneficial for chemotherapy. The research team is now working on loading the films with different cancer drugs.

Eventually, devices could be designed that can automatically deliver drugs after sensing that they're needed. For example, they could release chemotherapy agents if a tumor starts to regrow, or deliver insulin if a diabetic patient has high blood sugar.

“You could eventually have a signaling system with biosensors coupled with the drug delivery component,” said Daniel Schmidt, a graduate student in chemical engineering and one of the lead authors of the paper.

Other lead authors are recent MIT PhD recipients Kris Wood, now a postdoctoral associate at the Broad Institute of MIT and Harvard, and Nicole Zacharia, now a postdoctoral associate at the University of Toronto.

Because the films are built layer by layer, it is easy to control their composition. They can be coated onto a surface of any size or shape, which offers more design flexibility than other drug-delivery devices that have to be microfabricated.

“The drawback to microfabricated devices is that it's hard to coat the drug over a large surface area or over an area that is not planar,” said Wood.

Another advantage to the films is that they are easy to mass-produce using a variety of techniques, said Hammond. These thin-film systems can be directly applied or patterned onto 3D surfaces such as medical implants.

Source: Massachusetts Institute of Technology