

Mark Prausnitz, a professor in Georgia Tech's School of Chemical and Biomolecular Engineering, holds an array of polymer micro-needles that are approximately 1000 μm tall.

Microneedles Open New Doors for Transdermal Drug Delivery

They may be painful, but hypodermic needles have long been a reliable drug delivery method. However, recent advances in biotech-based pharmaceuticals have made the centimeter-size of traditional needles out-of-scale with the nano-sized active ingredients they must now transport. To address this issue, researchers at the Georgia Institute of Technology (Georgia Tech, Atlanta, GA) are developing a new, microscopic injectable drug delivery method that can target specific layers of the skin.

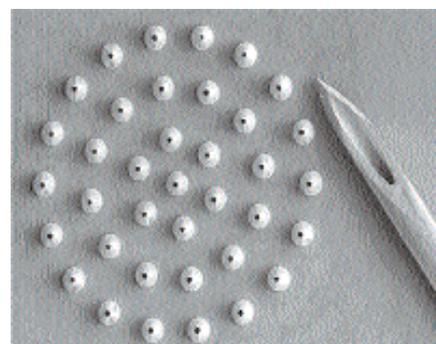
The novel dual-delivery method combines the advantages of hypodermic syringes and transdermal patches. Composed of dozens to hundreds of hollow microneedles, a 1–2-cm² transdermal patch is applied to the skin to increase its permeability. An array of microneedles that are 100–1000 μm in length poke through the top layers of skin and allow micron-scale drugs to pass into the body. Rapid delivery could be achieved by coupling the microneedles with an electrically controlled micropump

that delivers medications at prescribed times. The pump would include an interface that allows patients or healthcare providers to control the amount of drug delivered. Because the needles are too small to stimulate nerve endings, patients wouldn't feel any pain when a microneedle injection is performed.

According to Mark Prausnitz, associate professor in Georgia Tech's School of Chemical and Biomolecular Engineering, a key advantage to this delivery method is that the microneedles and pump are external to the body at all times. Whereas traditional delivery methods make it very difficult to interact with a drug once it enters the body, the new technology allows the timing and dosage of a drug to be adjusted while a patient is receiving the treatment. "The microneedle delivery method would be particularly effective for changing the dosage of insulin or pain medications as more or less treatment is needed," Prausnitz states.

The ability to target specific levels or depths in the skin is another unique feature of the microneedle technology. "One of the limitations of current hypodermic delivery techniques is they aren't able to localize drug in the top layers of skin," Prausnitz points out. "They affect tissue deeper down, and as a result, they cause pain, irritation, or other problems." In addition to eliminating patient discomfort, the Georgia Tech is particularly interested in using microneedles to reach the upper, capillary-rich layers of the skin where drugs would be more readily absorbed and special dendritic immune cells reside. For this reason, the team believes that microneedle delivery of more effective vaccinations is a potential application for the technology. In addition, there are several practical advantages for vaccine microneedle delivery. "Microneedles could work well for mass vaccinations because they're cost-effective, could be applied by individuals with minimal training, and may require smaller doses of the drug," Prausnitz states.

The Georgia Tech research team anticipates that drug formulations would need to be altered for use with this delivery method. Because microneedles are significantly smaller than traditional hypodermic needles, it would be impossible to rapidly inject the same quantity of solution through a



Microscopic view of an array of microneedles shown next to the tip of a typical hypodermic needle.

microneedle. "The most likely consequence on formulations is that they'd need to be more concentrated so that smaller doses could be used," notes Prausnitz.

Georgia Tech is also experimenting with ways to cost-effectively manufacture their microneedle technology. The research team recently fabricated molds of their silicon microneedles that can then be used to produce arrays of iden-

tical metal or polymer microneedles using a modified form of injection molding. "In many cases the molds are reusable as many as 100 times," says Prausnitz. Because the metal and polymer materials are inexpensive and the injection molding techniques don't need to be performed in a cleanroom, the single-step molding process can be easily adapted to industrial mass production. The molding technique has

the potential to produce billions of microneedle arrays each year for as little as five cents per array. To bring the technology to market, the research team licensed their intellectual property to an outside company that is in the process of performing clinical trials that will assess the ease and efficacy of microneedle-based delivery.

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