SCIENCE FILE CONVERSATIONS IN SCIENCE

Gadgets that can melt in your body
‘Transient electronics’ that dissolve safely may have a future in medical care.

BY ERYN BROWN

Many of us may fret about losing our electronic gadgets. John A. Rogers, a professor of materials science and engineering at the University of Illinois at Urbana-Champaign, is working to build electronic devices that vanish on purpose.

In a study published this week in the journal Science, Rogers and colleagues described how they assembled a toolbox of tiny biodegradable components made of silicon, magnesium and silk that can completely dissolve in the body. In a conversation with The Times, Rogers explained the virtues of such “transient electronics” — and why someday you might want your smartphone to disappear too.

What do you mean by “transient electronics”? It is a new kind of electronics whose characteristic feature is that it physically disappears over time in an engineered, controlled, programmable way. The materials dissolve in water or in biofluids and yield a biocompatible end product. As a result a number of new, interesting application opportunities open up.

Like what?

Like a biomedical implant that’s designed to either diagnose or treat an internal wound — and then simply disappear so you don’t have to go back in and fish it out.

How do you make electronics dissolve?

You have to go back and look at all the different components that are required to build an electronic circuit — such as semiconductors, conducting materials, and substrate materials — and then find materials that are transient and can also work well together to yield high-performance electronic properties. We wound up with a complete palette of materials that allow us to do sophisticated things, in which all of the constituents will completely dissolve in water or bio-fluids.

And these are made of silicon, magnesium and silk?

Yes. Silicon is the semiconductor material, and it is interesting because it is the platform material for the vast majority of electronics that are out there today. It’s also interesting because even though it has only a very modest dissolution rate in water and biofluids, the way that we use it — in ultra-thin sheets — it will completely dissolve. The end product of that dissolution is silicic acid, which is a well-known nutritional supplement, so we think the prospects for long-term biocompatibility are very good.

What does magnesium replace in the circuit?

Copper or aluminum — it is the conductor. Its conductivity is not quite as good as copper’s, so you take a slight hit there, but it’s water-soluble. It is also a common ingredient in multivitamin tablets, so it’s another type of material that’s good for circuits and probably not bad for the body.

And the silicon and magnesium components are embedded in the silk?

Yes. Our collaborators at Tufts University have figured out how to take silkworm cocoons, purify the material, and make coatings and packages out of it. Silk is water-soluble.

The other key aspect about it is that you can control its dissolution rate by controlling its degree of crystallinity. You can immerse it in water or biofluids for up to a year without completely dissolving it. So we can use it as a package to encapsulate the circuits.

What can these circuits do?
In our Science paper, we describe a device designed to mitigate the effects of surgical site infections. These turn out to be one of the leading causes of readmission into the hospital after a surgical procedure. A lot of bacteria these days are antibiotic-resistant, so it’s more and more difficult to treat them with drugs. We would like to treat them with transient electronics in the form of a kind of applique that goes into the body at the site of the surgery just before the patient is sewn up. It heats the site of the surgery about 5 degrees centigrade — a change in temperature that is sufficient to kill bacteria.

We control the silk properties in the package to last about two weeks. That turns out to be the most critical period of risk for a surgical site. After that point, in most cases the wound is healed, and the device is no longer needed. It just disappears completely into the body.

How does the device get power?

Wirelessly. The device has a special antenna built into it, and we can expose it to radio-frequency radiation from an external source through the skin. That energy can power the heater device.

You implanted one of these heaters in a mouse, right?

That’s right, to show that it’s biocompatible and that it had the lifetime we had programmed in.

Did it work?

Yes. We induced heating in the animal after implantation, and we did tissue studies to show there was no inflammation associated with the device or its reabsorption into the body.

Now we are infecting animals with bacteria so that we can actually use the device to kill the bacteria in vivo.

What other dissolvable implantables are you thinking about?

You can use electrical stimulation to stimulate muscle contraction or accelerate bone growth, so there are all kinds of uses for physical rehabilitation and treatment of fractures. And the silk itself can be used as a matrix for storing drugs, so you could use the circuits to trigger controlled drug delivery.

Where else might transient electronics prove useful?

There are two other main areas that we’re thinking about right now. One is environmental monitoring.

Consider a situation where you have a large-scale chemical spill and you’re trying to clean it up. It might be useful to drop out of an airplane 100,000 of these transient electronic devices that could sense and measure key parameters of the chemical spill and wirelessly transmit that information back to a local base station. You could perform real-time monitoring of what’s going on in the spill to help make the cleanup more efficient. Then those sensors could simply melt away into the environment.

The most challenging area, but one we’re very interested in, is making transient consumer electronic devices. As the pace of technology evolution is increasing, people don’t carry their smartphones for more than a couple of years. Ideally, what you would like is a smartphone that simply dissolves after it has served its useful lifetime. You could eliminate some of the waste stream.

When might we see transient electronic devices in use?

With implanted devices, you have to go through a rigorous battery of animal tests before you get to clinical trials with humans. We’re hopeful we can be in humans in maybe two years. Then the time frame for trials is set by the Food and Drug Administration.

This interview has been edited for space and clarity. eryn.brown@latimes.com
A DEVICE to treat infection is implanted into a rat. It later was absorbed without harming the animal.

Photographs from Beckman Institute
A CIRCUIT made using magnesium and silicon components on a thin film of silk is dissolved in water.