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Next-Generation Thermoelectrics

Imagine charging your cellphone anywhere without having to plug in. Or barely breaking a sweat outside in the middle of summer. How about using a high-performance personal computer that cools its own components?

These ideas, and many like them, may be the realities of the not-so-distant future, thanks to UC Santa Barbara chemical engineering professor Rachel Segalman and materials professor Michael Chabinyc. Funded by a $900,000 grant from the U.S. Department of Energy, the researchers will investigate ways of improving thermoelectric performance in polymeric materials. Their work may yield new materials that can turn heat into energy or — vice-versa — energy into heating and cooling.

Polymers are usually used as materials for plastic wrap or cell phone cases, but they can also be made to conduct electricity or ions, like sodium. Segalman and Chabinyc are seeking to understand how electrical and ionic charges can be used to form new types of thermoelectrics.

“A thermoelectric device turns heat directly into electricity,” explained Segalman. Much of the power we get from the grid results from the burning of fossil fuels, she pointed out, which in turn runs mechanical cycles — the turbines in the power plants — that translate the energy into electricity. Thermoelectric devices, in contrast, skip the mechanical step.

Thermoelectric generators rely on temperature differences to generate power; temperature influences the movement of electrons from one side of the material to another, creating the flow of current. The bigger the temperature difference, the more current can be generated.

Of particular interest to the researchers, however, are the smaller temperature differentials.

“We’re interested in things that work at near-room temperature,” Segalman said. Among them: small appliances, and even our bodies. According to Segalman, these common sources of relatively minimal degrees of heat can be used to create power for devices that require small amounts of energy, such as Band-Aid sized sensors that could transmit information about a patient, or to operate LED light sources and cellphones. In other applications, the heat energy wasted by data centers that power the internet could be recaptured.

Conversely, small amounts of energy could be translated into heating and cooling materials, such as furniture or clothing that would provide comfort to the user, decreasing the need for whole-room cooling or heating.

Thermoelectrics is already in use in devices ranging from the cooling and heating seats in upscale automobiles to wine refrigerators and even satellites orbiting the Earth, noted Segalman. The solid-state technology is favored for its lack of moving parts, which minimizes the possibility of breakage and allows for more silent operation.

Currently, only the high-end market can afford to utilize the technology, though as Segalman said, “We’ve recently proved that you can make thermoelectrics from plastics.”

Added Chabinyc, “Semiconducting polymers are already being tested for use in next generation solar cells, but thermoelectrics are a new application.” In this investigation, he and Segalman will study how ions, which are the charge carriers in batteries, can contribute to the thermoelectric effect alongside electrical charge carriers in polymers.

The results of this study could open the door to less expensive and more versatile thermoelectric materials that would come in handy not only for consumers but also in less common and more urgent circumstances such as search-and-rescue, medical, disaster recovery and military operations.

It’s too early yet to tell how cheap and available these materials would be, said Segalman. Until the basic scientific questions of how polymers with mixed conduction pathways contribute to the thermoelectric effect are well understood, the economics of these devices will be hard to predict.

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