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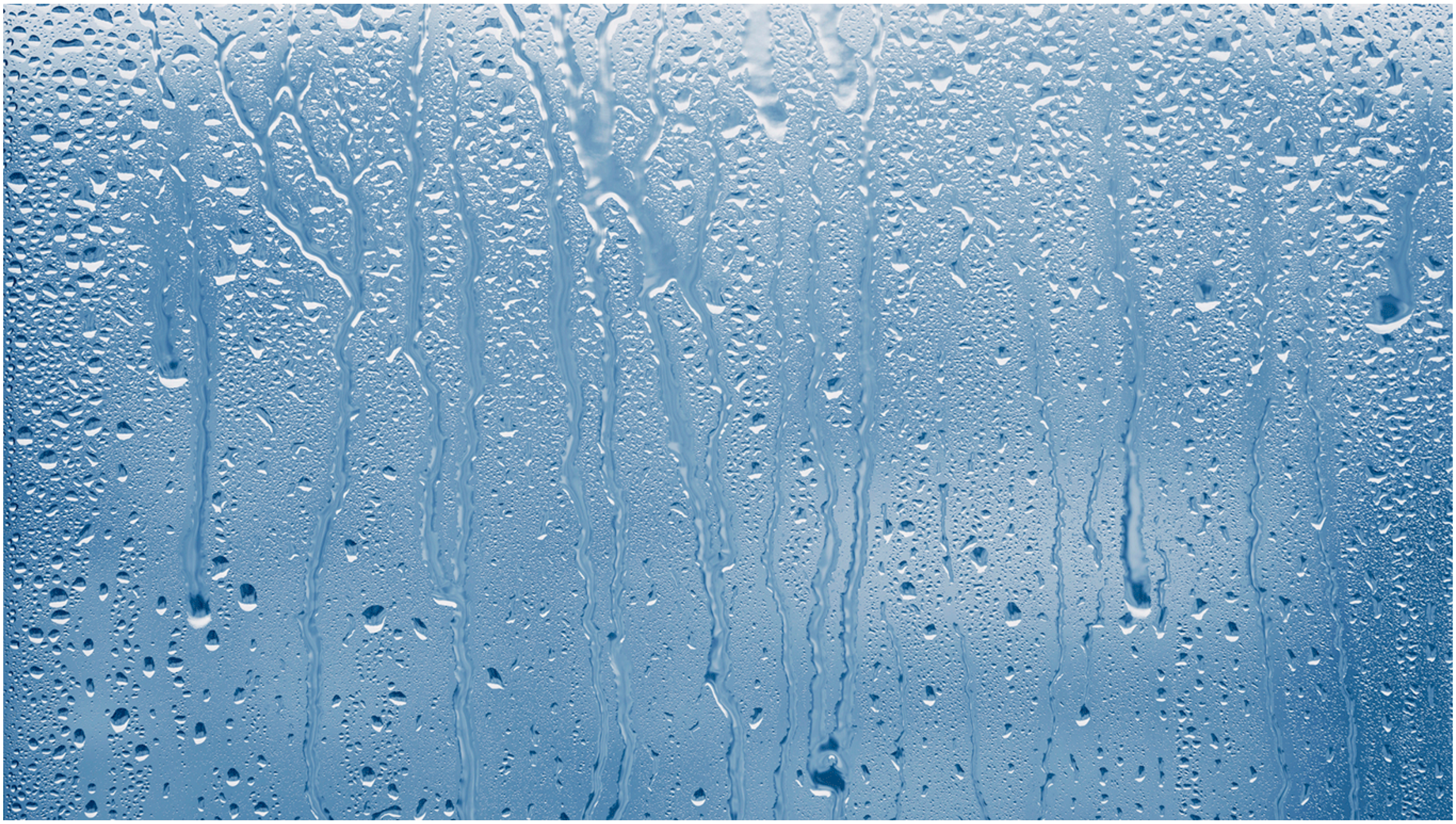

With a damp TV, Berkeley engineers demonstrate the potential of a green energy harvester

September 6, 2021 by William Schulz

Watching television in the shower might not rank terribly high on the scale of today's available personal-tech indulgences. But imagine if the TV — or other small electronic device — was powered by water vapor billowing up from the marble floor tiles.

Such moisture-induced energy harvesting is what UC Berkeley researchers, led by mechanical engineering professor Liwei Lin, report in a study published today in Nature Communications. They say it is a potential new source of green energy, particularly in areas of naturally high humidity.

The study describes a unique phenomenon of moisture-induced autonomous oscillations of the electrical potential on a polymer: upon exposure to a certain level of moisture, a polymer gel's surface electrical potential will oscillate, generating a closed circuit of alternating current (AC) electricity.

In fact, a new class of energy harvesters based on the so-called moisture electric effect on the mechanisms of proton transportations, ion transportations and electrokinetic reactions has been demonstrated recently, Lin said. However, operating times for these systems is usually brief and intermittent because they depend on moisture stimulation in one hydration-dehydration cycle.

Generating electrical current based on changing ambient moisture levels from low to high generally has poor energy outputs because it can be difficult to rapidly change moisture levels or sustain a specific high-low cycle.

Lin said his team, including study first author Yu Long, a Ph.D. student in his lab, came across something special with their gel polymer.

"What's interesting in this material," Lin said of the gel polymer, "is that the moisture induces in it a constant and chaotic oscillation. We just need to maintain a certain moisture level for our energy harvester to work, and it will do so over a fairly large range of levels."

Lin said the specially made gel polymer is soft and transparent. When triggered by a certain level of moisture, there are something like five chemical reactions happening in the material. How, exactly, they are related to oscillation of the surface electrical potential is unknown.

The green energy harvester is not a battery. Rather, it harnesses electrochemical mechanisms that can produce a continuous, useable

Lighting up an LCD in a bathroom with moisture from the shower. The inset shows the enlarged view of the system. A photo of a fabricated energy harvester is shown on the right. (Images by Yu Long, UC Berkeley)

flow of electrical current in a small device. Relying as it does on oscillations in the gel, Lin said, one analogy might be the self-winding watch. Mechanisms inside such a watch take advantage of wearer movement that can be converted to controlled motion that keeps the watch running without a battery.

To demonstrate how their energy harvester works, the team hit the showers. Illustrations in their paper show an LCD display, mounted just above a bathtub and powered by their new device concept. The energy harvester ran for 15,000 seconds, or just a little over four hours, "under one moisture excitation," the authors report.

Because the output voltage of individual harvesters is low — about 0.4 volts — five were needed to power the LCD display in the team's experiment.

With low voltage, "we can always put a few of the devices together to power something like a small LCD display," Lin said. "However, the current will still be low and so, too, the total power. It will be a low-power device — for now. We want to see how we might modify the polymer gel material such that we have a much higher current output."

But while broad commercial potential for the moisture-induced energy harvester might be elusive for now, there are possible applications that could make a difference for end users.

For example, Lin said, a natural history researcher may have a piece of battery-operated recording or monitoring equipment in the field, perhaps someplace very remote and difficult to access. Changing the battery even once a year could be prohibitively expensive. But in the right environmental conditions, an energy harvester like the one his team developed might last on order of 30 years or more.

Other possible uses include continuous operation of low-power devices, like smoke alarms or automobile tire pressure sensors. Batteries that keep the sensors operating separately from main systems, in both cases, are in typically hard to reach areas. A moisture-induced energy harvester could circumvent an annoying battery changing routine.

"There could be many more potential uses for energy harvesters based on the interesting electrochemical behavior we have seen using the polymer gel in our device," Lin said.

Topics: Energy, Faculty, Mechanical engineering, Research