Q&A: Three things to know about a sustainable energy breakthrough

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"The air contains an enormous amount of electricity," says Jun Yao, assistant professor of electrical and computer engineering in the College of Engineering at the University of Massachusetts Amherst, and the paper's senior author. "Think of a cloud, which is nothing more than a mass of water droplets. Each of those droplets contains a charge, and when conditions are right, the cloud can produce a lightning bolt—but we don't know how to reliably capture electricity from

lightning. What we've done is to create a human-built, small-scale cloud that produces electricity for us predictably and continuously so that we can harvest it." Credit: Pixabay/CC0 Public Domain

Sustainable energy generation solutions such as wind, solar, and hydroelectric have long presented enticing alternatives to fossil fuels. However, several factors, including the intermittent nature of these sources and their dependence on specific geographic conditions, have hindered their widespread adoption and effectiveness.

Recently, however, researchers from the University of Massachusetts have reported a recent breakthrough wherein the team was able to, for the first time, harness one of the most abundant renewable resources, the air. Penn Today met with the School of Engineering and Applied Science's James Pikul to discuss the mechanisms and implications of this promising new technology.

What have these researchers developed?

They have created a device that can harvest electrical energy from the air's humidity. And what's particularly neat is that they can use many materials to do so, provided they have a lot of holes that are less than 100 nanometers in diameter, which are called nanopores. Depending on the material used, you'd get varied results in terms of efficiency and power output, but this is promising, and the wide availability of materials has the potential to drive down the costs of these devices and avoid the exotic materials required in many other harvesters.

The caveat is that these devices generate very low currents, as in nanoamps, which means the power output is limited at the moment.

How does this work?

Well, by virtue of hydrogen-oxygen bonds, water molecules are quite polar, which means that one side of the molecule is positively charged and the other side is negatively charged. This occurs because the oxygen atom strongly attracts electrons, making it more electronegative than the hydrogen atoms. So, the oxygen side of a water molecule is more negative, and the side with hydrogen atoms is more positive.

In this device, the nanopores force a humidity gradient in the material so that more water molecules are present at the top of the device, which is exposed to air, then the bottom of the device. This paper suggests that the water molecules impose a net negative charge on the nanoporous material due to the way the water molecules interact with the surface. Since more water molecules interact with the top of the device, the top builds up more negative charge which creates a voltage difference with the bottom of the device, which has fewer water molecules. This charge imbalance can generate a current of electrons to bring this balance to equilibrium, which is what powers a device and how we get electricity from batteries.

What might the implications of their findings be?

I think any new ideas that have the potential to deliver clean power are exciting. From my understanding, this is their second paper demonstrating that electricity can be generated from air, and since the details are not well understood, there are lots of new opportunities to understand why this works and make devices that perform better and perhaps good enough to power real devices.

They claim that this can run more consistently than any other source of renewable energy, citing that it would harvest 24/7, but the humidity is

always changing so the quality of power it produces will vary in similar frequencies as other renewable sources, following a day-night cycle, for example. This will mean you still need batteries or capacitors to store the energy, so it is available when we need it.

Either way, it is quite impressive that they've found a way to get constant power generation in something so prevalent as air. This is also a really interesting new mechanism, I'm excited to learn more about the science, its true limitations, and the extent to which this can be scaled and also the new possibilities this will open up for other researchers in this space. One of the biggest problems we have today is delivering clean energy to homes and transportation, reliably, so any technology that's progressing that goal or providing new ideas I welcome.

Provided by University of Pennsylvania

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