This humidity digester breathes in atmospheric water and exhales energy

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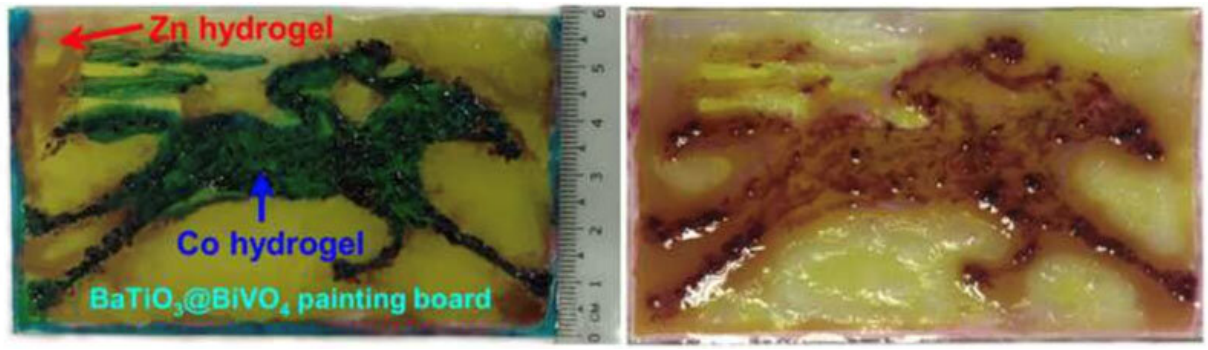

The picture on the left is two different hydrogels (translucent - zinc, green - cobalt) and after placing it under 90 percent humidity the hydrogels look glossy and changed colors (zinc --> murky, cobalt --> pinkish brown.) Credit: National University of Singapore

Integrating a super moisture-absorbent gel with light-active materials, researchers in Singapore have developed a humidity digester to dry the ambient air while generating energy. The method, presented November 20 in the journal *Joule*, is a green alternative to air conditioners with a trick—pulling water out of thin air.

Like plants, artificial photosynthetic devices, also known as photoelectrochemical (PEC) systems, feed on light and water to generate energy. This phenomenon inspired the researchers to integrate light-

active materials and super-hygroscopic hydrogels. The hydrogels based on zinc and cobalt can harvest more than four times their weight of water from humid air. The humidity digester can reduce relative humidity by 12 percent and generate a low current under ambient light.

"A lot of people say Singapore is hot, but actually, it's not that hot at all. People feel hotter because of relative humidity, as it can affect how we perceive temperature," says senior author Swee Ching Tan of the Department of Materials Science and Engineering, National University of Singapore. "That got me thinking, what if I can invent something that harvests water from our ambient air and, at the same time, reduces relative humidity and provides water or energy?"

The research team in Singapore came up with a humidity digester composed of a moisture-hungry hydrogel, cathode, photoanode, and a solar cell. Just like batteries, it generates power from atmospheric humidity instead of an electrolyte. The photoanodes, acting as a photo-electrocatalyst, oxidize the absorbed water in the presence of light to split water and produce energy. The hydrogel constantly replenishes the system with water that is pulled out from the air to sustain the energy generation process. The assembly generates electricity while dehumidifying the room.

"The second-generation cobalt hydrogel that we developed absorbs moisture faster than any commercially available drying agents in the market. We have done an experiment by placing the hydrogel in a box, and the relative humidity dropped to about 30-35 percent lower than the outside ambient," says Tan. "We put our hand in the dry box; it felt like a fridge. It's so cold inside the box because it's so dry." Tan believes that the humidity digester is a possible replacement for air conditioners when its paired with a fan.

Although one of the goals of the research team is to generate energy, the

device puts out a photocurrent of about 0.4 mA/cm2, which is relatively low. However, compared to commercial air conditioning units, the humidity digester can improve thermal comfort with significantly less energy input. Even scaling the device up to commercial standards, it will be easier to install, is portable, and the operation cost will only be a fraction of an air conditioner.

"It is a common belief that humidity affects only equatorial or tropical countries. But people from Europe are also equally affected by high humidity levels because of associated water condensation problems. High levels of humidity cause their homes to become moldy." The humidity digester has an ample application doubling as a dehumidifier and outperforms commercial drying agents.

"The world population is increasing, and people generally spend a lot of money on air conditioners to maintain adequate thermal comfort. The increasing need for air conditioners to cool us down results in increased energy consumption as well. This device, when coupled with a fan, can help reduce relative humidity and thereby improve thermal comfort and reduce the reliance on air conditioners. This could lead to potential energy and monetary benefits."

More information: *Joule*, Yang et al.: "Energy Harvesting from Atmospheric Humidity by a Hydrogel-Integrated Ferroelectric-Semiconductor System" , DOI: 10.1016/j.joule.2019.10.008 , www.cell.com/joule/fulltext/S2542-4351(19)30524-0

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