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## Processors

# Video: Printed paper, biodegradable batteries developed

Peter Brown

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Researchers from the Nanyang Technological University, Singapore (NTU Singapore) have developed a zinc-based battery that is as thin as paper as well as biodegradable that could one day be a revolutionary power source for flexible and wearable electronic systems.

The batteries are made of electrodes screen-printed on both sides of a piece of cellulose paper that is reinforced with hydrogel. Once the battery has been drained, it can be buried in the soil and breaks down completely in a month.

### Initial experiments

NTU demonstrated the battery on a 4 cm x 4 cm square of printed paper battery and was able to power a small electric fan for at least 45 minutes. Bending or twisting the battery did not interrupt the power supply.

A second experiment used a 4 cm x 4 cm battery to power a light emitting diode (LED) where researchers cut away parts of the paper battery but the LED remained lit.

Using this ability to bend or twist the battery, it could be integrated into flexible electronics such as foldable smartphones or biomedical sensors for health monitoring.

"Traditional batteries come in a variety of models and sizes, and choosing the right type for your device could be a cumbersome process," said Fan Hongjin, professor of physical and mathematical sciences at NTU.

"Through our study, we showed a simpler, cheaper way of manufacturing batteries, by developing a single large piece of battery that can be cut to desired shapes and sizes without loss of efficiency. These features make our paper batteries ideal for integration in the sorts of flexible electronics that are gradually being developed."

### Eco-friendly

The hydrogel and cellulose used to make the battery are naturally broken down by bacteria, fungi and other micro-organisms after being buried in the soil.

Researchers tested this capability by burying the battery in the soil of a rooftop garden at the NTU campus.

The hydrogel-reinforced cellulose paper started fracturing after two weeks and degraded completely in a month. [Privacy Policy](#)

"We believe the paper battery we have developed could potentially help with the electronic waste problem, given that our printed paper battery is non-toxic and does not require aluminum or plastic casings to encapsulate the battery components," said Lee Seok Woo, an assistant professor of electrical and electronic engineering at NTU. "Avoiding the packaging layers also enables our battery to store a higher amount of energy, and thus power, within a smaller system."

As the battery decomposes, the electrode materials are released into the environment where the nickel or manganese used in the cathodes will remain in their oxide or hydroxide forms. The zinc found in the anode will be naturally oxidized to form a non-toxic hydroxide.

The next steps involve the team hoping to demonstrate integration of the printed paper battery to other printed electronics, electronic skins and other energy storage systems that can be deployed in the environment.

The full research can be found in the journal [Advanced Science](#).

To contact the author of this article, email [PBrown@globalspec.com](mailto:PBrown@globalspec.com)

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