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THE LIVING BATTERY: SUSTAINABLE FUTURE OF FUNGI POWERED BATTERIES

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In a world increasingly driven by technology, where every new gadget, device, and innovation is powered by batteries, the conversation surrounding sustainability is more pressing than ever. With predictions that by 2030, the globe will produce a staggering 75 million metric tons of electronic waste, the urgency to find more sustainable, environmentally friendly alternatives to traditional batteries is reaching new heights. And this is where the story of a revolutionary new technology begins—a story involving fungi, the natural world, and a promise of cleaner, meet the new fungus battery that needs to be fed instead of charged.

Fungus batteries are just one example of how nature inspires innovative solutions to some of our most pressing environmental challenges. In recent years, we have seen other fungi-based projects take off, from building materials to clothing, all aiming to reduce waste and pollution. One such project includes a tile system that resembles the texture of elephant skin, created from fungal mycelium, and is being explored as a more sustainable alternative to traditional building materials.

As we continue to search for ways to reduce the environmental impact of technology, fungi may become a central player in the quest for sustainable solutions. Their ability to break down organic matter, generate energy, and form complex structures makes them ideal for future innovations in green technology. If the fungal battery continues to develop at its current pace, it could be the beginning of a broader shift away from toxic, non-recyclable materials toward eco-friendly solutions in electronics, energy, and beyond.

The Quest for Sustainable Power

We live in an era in which batteries are ubiquitous. From the smallest wristwatch to the most complex electric vehicles, these power sources are the lifeblood of modern technology. However, the batteries that power our devices today come at a significant environmental cost. Most of these batteries are filled with toxic metals and synthetic materials that are difficult to recycle and leach harmful chemicals into the environment once discarded. This problem is exacerbated by the ever-growing amount of e-waste generated worldwide. The vast majority of batteries are made of substances such as lithium, cobalt, and nickel, which are rare, expensive, and often sourced through mining operations that cause significant ecological damage. As the demand for electronic devices and electric vehicles continues to rise, so does the need for better battery technology that is less harmful to the planet and better for our future. A groundbreaking development in Switzerland offers a glimpse of a world where power generation might not involve toxic chemicals or precious metals but something far more natural, sustainable, and ultimately transformative: a fungus.

A Fungus Battery That Works on Nutrients, Not Electricity

In a bold leap toward sustainable technology, scientists at Empa, Switzerland's renowned materials science institute, have developed a living power source: a fungus battery. This battery is not just a clean idea; it is an actual working prototype that is fully biodegradable, compostable, and made almost entirely from natural materials. Instead of plugging it in to recharge, this battery requires nutrients and water for operation. At first glance,

this idea may sound unusual, but its potential is enormous. Imagine a world where we could simply compost batteries instead of discarding them, which take hundreds of years to decompose. Imagine a battery that does not pollute our landfills, relies on harmful chemicals, or needs to be plugged into an energy-hungry grid. This fungus-powered battery could be the answer we've been searching for.

How the Fungus Battery Works

So, how does a living organism, such as a fungus, power a device? The concept is ingenious in its simplicity. This bio-battery is built using two different species of fungi: *Saccharomyces cerevisiae*, a type of yeast, and *Trametes pubescens*, a fungus. At first, it sounds like something straight out of a science fiction novel—fungi that generate electricity. However, in reality, it is a beautiful harmony of biology and technology. The battery's anode is yeast, which feeds on sugar. As it breaks down sugar, it releases electrons that flow through the circuit to the cathode. Enzymes from *T. pubescens* assist in completing the circuit, producing an electric current. The materials that make up this fungal battery are as remarkable as the fungi themselves. The battery structure is 3D printed using an innovative ink made from cellulose, carbon materials, and fungal cells. This ink is not only biodegradable but also supports the direct growth of fungi within the battery. It is like creating a small ecosystem within the battery, where organisms can thrive and perform their functions. Once the battery is printed, fungi continue to develop and grow within the structure. Within a few weeks, the battery became fully functional. Even more impressive is that the battery can be stored in a dry state and only needs to be activated by adding water and nutrients. This feature makes the fungus battery particularly ideal for use in remote locations where traditional batteries are impractical or where traditional power infrastructure is lacking.

A Glimpse into the Future of Energy

The fungus battery generates between 300 and 600 mV of electricity. Although this may not sound like a lot when compared to the powerful lithium-ion batteries we are accustomed to, it is more than enough to power small devices such as environmental sensors. When multiple fungus batteries are linked together, they can power such devices for up to 65 h. This could be a game-changer for applications in remote regions, agriculture, and medical devices—areas where traditional batteries often fail to perform or are too expensive to replace. For example, in agriculture, these batteries can power sensors that monitor soil conditions or water levels, providing farmers with real-time data without the need for an external power source. Similarly, in remote medical applications, these batteries can be used to power devices that monitor patients' health, particularly in areas where reliable electricity is scarce. Because these batteries are biodegradable, there is no need to worry about harmful waste piling up after their useful life is over. In addition to their practical applications, fungal batteries present an exciting new frontier in green technology. The fact that they are made from natural, biodegradable materials opens the door to a world where electronics and power sources can be both functional and environmentally friendly.

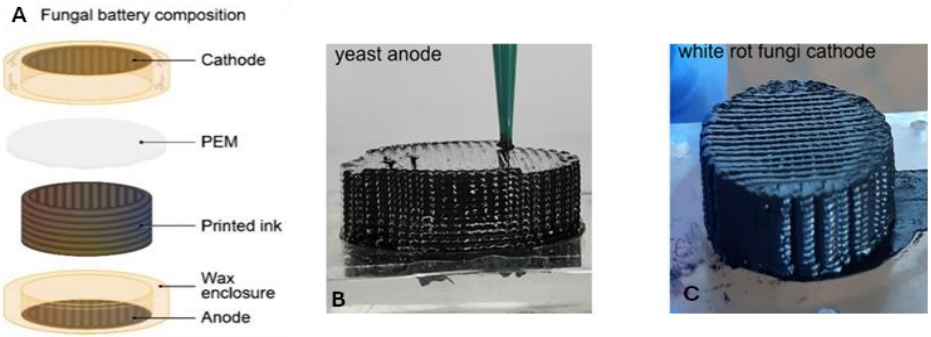

Figure 1. A. Components of the battery B. 3D printed anode C. 3D printed cathode (Reyes *et al*. 2024)

Challenges and the Road Ahead

Despite the technology, fungus batteries are still in their early stages of development. Researchers are continuously experimenting with different fungi to determine how they can boost power output, extend the battery shelf life, and enhance the overall efficiency of the system. There is also the challenge of scaling up production and refining the battery design for mass adoption. However, the progress so far is undoubtedly promising. One of the key hurdles that must be overcome is the relatively low power output of these battery types. While they are sufficient for small applications, such as environmental sensors, they require significant improvements in power generation to be used for larger devices, such as smartphones or laptops. Researchers are working on ways to make fungi grow more efficiently, potentially improving their ability to generate higher voltages. In addition, there is the challenge of durability. As with any biological system, fungi can be affected by external conditions, such as temperature, humidity, and nutrients. Scientists are investigating how to make batteries more resilient and able to withstand harsh environments or prolonged use without degradation. However, these challenges are not insurmountable. As technology and science continue to evolve, we can expect more breakthroughs that will bring us closer to creating fungus-powered batteries that can power larger devices and meet the demands of our tech-driven world.

Looking Ahead

As we look toward the future, the fungus battery serves as a shining example of what is possible when we turn to nature for answers. With further research and development, it could become a common feature in our everyday lives, powering everything from remote sensors to medical devices, while leaving behind no toxic waste. It represents not only a technological breakthrough but also a glimpse into a more sustainable, biocentric future for our planet. Perhaps, it is a reminder that sometimes the best solutions to our modern challenges can come from the most ancient of sources: fungi.

Reference

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