Futuristic Fantastic Batteries

must charge in seconds, last months

We've seen a plethora of battery discoveries coming out of universities and research institutions all over the world. Tech companies and car manufacturers are pumping big money into battery development. Still there's nothing "new" in our phones and everyone's waiting for the killer replacement to good old lithium-ion.

Compiled by **Jan Buiting**, Editor-in-Chief

No worries, the wonder battery may be here sooner than you think, and it may be any one of the technologies on parade in this article, or another from a totally unexpected corner (watch MIT and Fraunhofer). Please be cautioned though, this article contains some "extremely forward looking views", some of which were already featured in recent editions of Elektor's weekly e-zine.

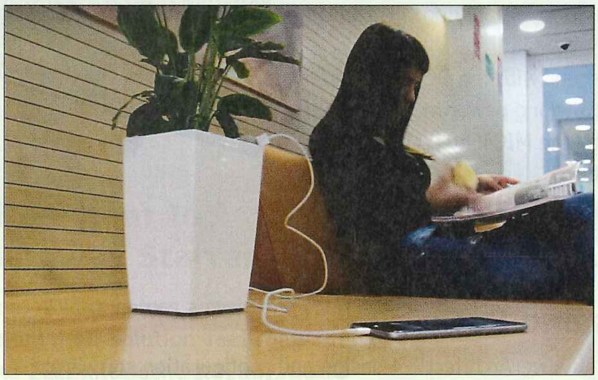


Figure 1. Bioo: electricity from plant photosynthesis.

It's soo eco: Bioo plant charger

The Bioo already exists and can be bought now [1]. It's a plant pot that utilizes photosynthesis to charge your tablet or smartphone. Bioo (Figure 1) is capable of supplying two to three charges per day at 3.5 V / 0.5 A via a USB port cleverly disguised as a small rock. The pot uses organic materials that react with the water and organic matter from the plant's photosynthesis process.

The resulting reaction is claimed to generate enough power to charge gadgets. Thinking Big, Bioo Forest might power cities with 100% green energy and automatically provide the best reason ever to protect plants and trees.

Golden: nanowire batteries

Developed at the University of California, Irvine, nanowire batteries that can withstand plenty of recharging could mean the battery that does not die was just discovered.

A thousand times thinner than a human hair, nanowires pose a great possibility for future batteries. Sadly they always broke down when recharging but now, gold nanowires in a gel electrolyte avoid that. These batteries were recharged over 200 Ktimes in three months and showed no degradation at all. This could be ideal for future EVs, spacecraft and phones that will never need new batteries.

Lightweight: fuel cell for phones & drones

Lighter fuel cells could mean phones only need to charge once a week and drones stay airborne for over an hour (Figure 2). Porous stainless steel with thin-film electrolyte and electrodes of minimal heat capacity are the ingredients. The result is a battery that's more durable and longer lasting than lithium-ion.
Further development for phones, drones and even electric cars is expected soon and with the hub of the research in South Korea we might even see it in the next Samsung Galaxy S8 smartphone.

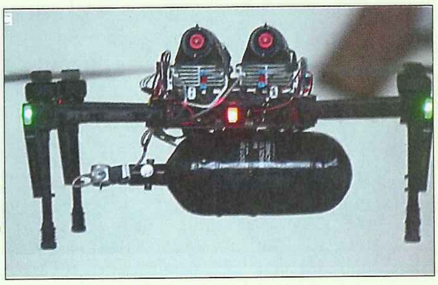


Figure 2. xperimental drone flying on fuel cell power. (BBC)

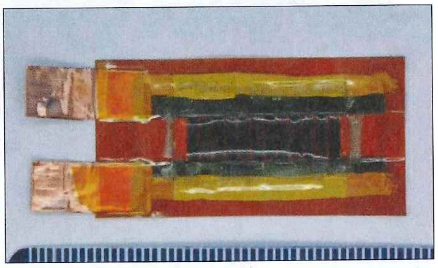


Figure 3. Microsupercapacitor prototype. (Rice University)

Laser-made: microsupercapacitors

From Rice University comes a breakthrough in microsupercapacitors (Figure 3). Currently they are expensive to make but that could change at the drop of a hat. By using lasers to burn electrode patterns into sheets of plastic, manufacturing costs and effort drop massively.

The result is a battery that can charge 50 times faster than current batteries and discharge even slower than current supercapacitors. They're even tough, able to work after being bent over 10,000 times in testing.

Foamy: foam batteries

With 3D on their minds Prieto was the first company to create a working battery that uses a copper foam substrate (**Figure 5**). Such batteries will not only be safer (thanks to nonflammable electrolyte) but they will also offer longer life and faster charging.
Not forgetting five times higher density, low manufacturing cost and smaller size than current products. That's why Prieto aims to place its batteries into wearables first. The batteries can be upscaled though for use in phones and possibly cars in the future.

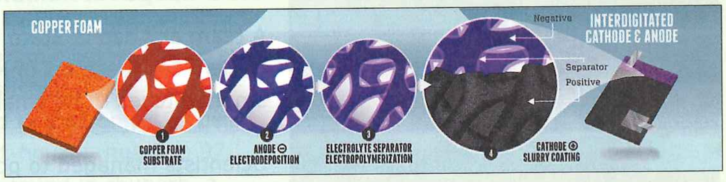


Figure 5. Prieto's copper-foam-substrate battery technology. (Prieto)

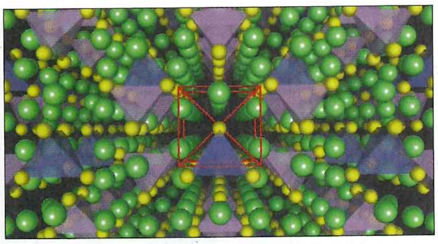


Figure 6. No drip, no filling, no spilling — solid-state batteries last thousands of charge cycles. (MIT)

Rev up: solid-state batteries

Scientists at MIT, working with Samsung, have discovered solid-state batteries that are better than current lithium-ion efforts. These batteries (**Figure 6**) should be safer, last longer and offer more power. Current lithium-ion batteries rely on an electrolyte liquid to transport charged particles between the two electrodes. It's this liquid that can be flammable and which degrades the battery, limiting life.

According to the MIT report these new batteries could be charged for hundreds of thousands of cycles before degrading. They could also provide a 20 to 30% improvement in power density meaning that much more charge for whatever they are powering. And they aren't flammable so they're ideal for electric cars.

Eggnog: nano 'yolk' 3x capacity, 6 mins charge

Also from some great minds at MIT stems a battery that triples the capacity of current offerings yet charges to full in just 6 minutes, that's close to the average concentration span of a teenager. It also does not degrade rapidly over time meaning it should last a long while.
The bonus here is that production is inexpensive and easy to scale. Figure 7 shows the student-friendly "diagram".

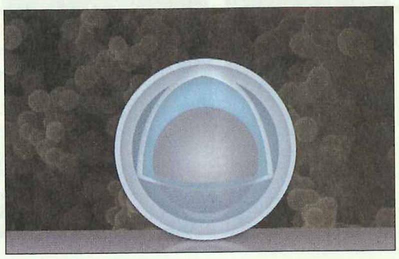


Figure 7. MIT's idea of a nano 'yolk' battery. (MIT)

Faster still: aluminum graphite

Possibly challenged by MIT, scientists at Stanford University create an aluminum graphite battery that could replenish to full in a smartphone in just a minute (**Figure 8**).Their batteries are flexible, long lasting and charge ridiculously fast. The only issue is they hold about half the power of a current lithium battery, but with charging to full in just a minute that's not too much of a problem, is it?

Figure 8. Aluminum-graphite battery charges in 1 minute — they say. (Stanford University)

Runs on water: Alfa battery lasts 14 days

The Alfa battery with 40 times the capacity of lithium-ion is a breakthrough in aluminum-air technology. You recharge the battery by simply topping it up with water, be it salty or normal.
The new battery (**Figure 9**) is claimed to last 14 days by its creators Fuji Pigment, and will be out later this year. Fuji expect to see these batteries to appear in cars first. Hopefully mobiles will be next in line.
While the alu-air battery with 8.1 kW/kg (claimed) capacity dwarfs Lithium-Ion with its 0.12 – 0.2 kWh/kg it's still lithium-air that comes out on top with 11.4 kWh/kg.

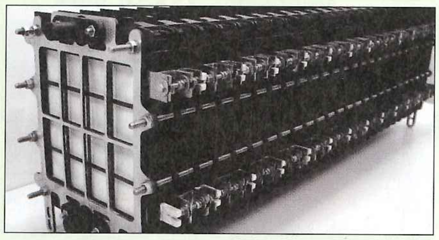


Figure 9. The Alfa battery is based on aluminum-air technology. (Fuji Pigment)

Figure 10. Arizona State University's flexible strap battery is Kirigami-derived.

Ultra-adaptive: flexible battery

A team at Arizona State University have come up with a flexible battery using the ancient Japanese art of Kirigami. A flexible strap battery (**Figure 10**) should allow smartwatches to be smaller and last longer on a charge.

Scientists managed to power a Samsung Gear 2 using a flexible band with the batteries inside. This was stretchy enough to move from the wrist to the biceps, and move with flexing, while still powering the smartwatch. With this technology we can look forward to thinner smartwatches plus clothing with brains and power built in, soon.

Paper-like but tough: foldable battery

Bendable gadgets are possible with the Jenax J.Flex battery (**Figure 11**). This paper-like battery can fold and is water resistant, making it ideal for embedding in clothing or wearables. And beyond that, foldable tablets that you could fit into your pocket just like a phone or a piece of paper!
The battery has already been created and has even been safety tested, including being folded over 200 Ktimes without losing performance.

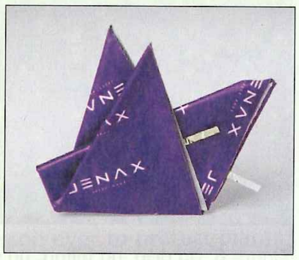


Figure 11. The Jenax foldable battery holds a great promise for wearables.

Phew: power from water dew

Still in the embryonic stage at MIT this futuristic device uses interleaved flat metal plates to produce power from water dew in the air (**Figure 12**). Initial tests have produced small amounts of power, at 15 picowatts, with a promise though to upscale to at least 1 microwatt. Even that is minute and only when time is not issue, and with plenty of dew water, then a charger the size of a coolbox lid might just charge a phone in 12 hours.

Figure 12. A dew powered phone could be reality one day.

1800 km range: aluminum-air for EVs

As part of test program, a small car (**Figure 13**) managed to go 1800 km (approx. 1100 miles) on a charge put into a high-power aluminum-air battery. The technology uses oxygen to fill its cathode, making it far lighter than liquid-filled Li-ion batteries. Alu-air batteries drain, turning the metal into aluminum hydroxide which can then be recycled to make new batteries. As a "small disadvantage", the developers say, "users have to swap out batteries every few months". Luckily the new battery is much lighter and cheaper than current products.

Figure 13. The Alu-air battery has both potential and down sides for electrical vehicles. This little car reportedly went 1800 km on a single charge.

Gotta go: urine-powered batteries

With further funding in the pipeline from The Bill Gates Foundation, Bristol Robotic Laboratory have embarked on a battery that can be powered by urine (**Figure 14**). Reportedly it's efficient enough to charge a smartphone. Using a Microbial Fuel Cell micro-organisms take the urine, break it down and output electricity — to put it simply. On a scale large enough to charge a smartphone there are several cells into which the urine is passed via tubes. The unit creates electricity and also expels a broken down version of the waste making it safer to dispose of.

Figure 14. With a Microbial fuel cell, micro-organisms can turn urine into electrical power, well drink to that.

Not unlike rhubarb: the organic battery

Depending on the time-to-market of a recent MIT discovery, organic batteries can be added to the list of power sources of the future that are truly sustainable.
A proof-of-concept organic flow battery (**Figure 15**) was found to cost only $27 per kilowatt-hour compared to metal batteries at $700 per kilowatt-hour — nearly a 97 per cent saving. Using quinone molecules comparable to those found in rhubarb, a battery was made that is not only as efficient as metal but that could also be made on a huge scale.

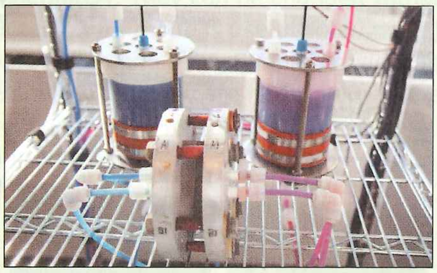
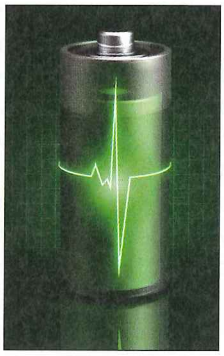


Figure 15. If you haven't heard of quinone molecules, well in good numbers they make a fine organic battery.

Forget lithium: sodium-ion batteries



Scientists in Japan propose new batteries based on sodium, one of the most common materials on the planet rather than rare lithium — and they'll be up to seven times more efficient than conventional batteries.
Research into Na-ion batteries (**Figure 16** — artist's impression) has been going on since the eighties in an attempt to find a cheaper alternative to lithium. Salt is the sixth most common element on the planet and not subject to "supply issues" as with lithium. Some e-prophets proclaim lithium will soon become too rare and expensive for the glut of battery-powered to appear on the roads. Commercializing Na-ion batteries is expected to kick off for smartphones, cars and other devices in the next 5 to 10 years.

Figure 16. Given time the sodium-ion battery might take over from lithium-Ion. (artist's impression)

Conclusion

The above is only a small selection of battery and battery-related technologies mostly in development in laboratories at the time of writing, with a few happy examples of real-life products like Upp [2]. The existence of the latter does not mean wide acceptance by the consumer yet — you are unlikely to see a Bioo or a fuel cell in an airport departure lounge and it will be plain old AC power and lithium-ion ruling the roost there for some time to come.
Battery technology is very much alive and has great appeal to non-technical audiences, mostly due to the source of the electrical energy (after conversion), including unexpected ones like potatoes, human skin, human muscle flexing, street noise, onions, peptides, and mental activity. ◀

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Web Links

[1] Bioo: www.bioo.tech/

[2] Upp: www.beupp.com/