**What you’re looking at here is three common or garden house bricks that have been chemically doped in such a way as to enable them to power this small LED light.**

**Pretty amazing eh? Imagine if your whole house was made of bricks that could do that!**

**The only drawback of this particular example that I’ve knocked up for you here is that it only really works when I add this 12 volt battery to the system. In fact, if I’m completely honest I could probably take the bricks away really.**

**And that’s because I personally wouldn’t have the first notion of how to mess about with a house brick to make it conduct electricity. In fact, until recently if anyone had made the suggestion that such a thing were even possible within the known laws of physics I would most likely have said they were completely crazy.**

**Luckily though, there are some pretty crazy people out there, and many of them work in laboratories. Nothing is out of bounds for these people. No concept too wild or hair-brain to at least be investigated with scientific experimentation. It is people like these who have made some of the greatest breakthroughs in science and medicine over the centuries…**

**at least the ones who didn’t poison themselves to death or blow themselves up!**

**And that pioneering spirit has now led a team of researchers at Washington University in St Louis, Missouri to publish details of an ordinary common or garden house brick that they really have managed to chemically dope to allow it to store electrical energy.**

**So, I thought I’d better take a closer look.**

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**Hello and welcome to Just Have a Think.**

**I think most of us have got our heads around the concept of using battery storage in our homes in conjunction with solar panels on our roofs, but I suspect very few of us could have envisaged a solar roof working seamlessly with a brick wall to provide some or all of our household electricity requirements.**

**I do accept of course that there’s a much greater tendency towards timber framed buildings in some parts of the world, not least in North America, but buildings constructed using brick walls are sufficiently commonplace for a technology like this to be pretty revolutionary if it can be developed and scaled up.**

**So, the first thing I need to do is calm down a bit and have a careful look at what it is that the team at Washington University have actually achieved.**

**The patent that the team has had approved is for a chemical process that uses the red pigment in a brick to trigger a reaction that creates a polymer capable of conducting electricity.**

**That red pigment is actually a type of iron oxide called hematite. If it was on a piece of steel it would be called rust, but it’s essentially the same stuff.**

**What they’ve produced is, in the strictest terms, actually a micro supercapacitor, not a battery. So what’s the difference?**

**Well, we’ve looked at how batteries work a couple of times on this channel, and most people have a pretty good idea of the process – essentially two electrical terminals, a cathode and anode are separated by an electrolyte. When the power is switched on you get a chemical reaction that causes electrons to flow through the electrolyte from one electrode to the other. That movement of electrons produces an electrical current. Once the chemical reaction is depleted the battery is flat. Rechargeable batteries like the lithium ion variety we’re now all so familiar with, can run this reaction in either direction so they can be plugged into a power source to recharge the solution hundreds of times over. Batteries can hold large amounts of energy, but they take hours to charge up. Capacitors use static electricity, otherwise known as electrostatics, instead of chemistry to store energy. They actually store electrical charge, which is measured in Farads, named after the British chemist and physicist Michael Faraday. Inside a capacitor, there are two conducting plates made of metal at either side, and between them there’s an insulator called a dielectric usually made of a fairly thick ceramic material like mica.**

**When the power is connected, positive charges form on one plate and negative charges on the other, creating an electric field between them. When the power is disconnected the capacitor discharges and sends power to the load for a short period. That guards against brief outages and helps protect electronic components. The great thing about capacitors is that they’re much lighter than batteries, they don’t generally contain harmful chemicals or toxic metals and they’ve got almost limitless charging and recharging capacity, certainly in the region of millions of cycles. And they can store that charge almost instantly. The trouble is they can only store tiny amounts of energy. Nothing like as much as batteries. A supercapacitor is an attempt to find the best of both worlds between a battery and an ordinary capacitor.**

**It’s got two similarly separated metal plates, but those plates are coated with a porous substance like powdered charcoal. Effectively that coating gives the plates a much bigger surface area for storing electrical charge. And instead of a dielectric separator, both plates are soaked in an electrolyte containing positively and negatively charged ions and separated by a very thin insulator made of carbon, paper or plastic. When the power is switched on, a positive charge builds up at one metal plate and a negative charge at the other, just like a normal capacitor. Electrostatic attraction means that the negative ions in the electrolyte get attracted to the positively charged plate and the positive ions move the negatively charged plate. When they touch the plates the ions form a full surface layer a single ion in thickness and an electrical charge is stored in the really tiny distance between those ions and the metal plate. It’s called the Helmoholtz Double Layer and it’s own physics are outside the scope of this video, but suffice to say, this double layer means you can bring the two metal plates much closer together.**

**The clever physics boffins will tell you that the ability of a capacitor to store charge INCREASES with greater surface area on the plates AND with decreasing separation between them. Supercapacitors achieve both these goals.**

**Ordinary capacitors are very handy in things like electronic circuits where they store really tiny amounts of charge, usually measured in microfarads, nanofarads or even picofarads.**

**A supercapacitor can store a charge that can be billions of times larger than an ordinary capacitor. Teslas new acquisition, Maxwell technologies, have supercapacitors that can store several thousand farads of charge, which is still only maybe twenty percent of the energy you can get into a battery, but remember they can store and release energy almost instantly, which makes them a very attractive option as a sort of energy reservoir that can be called upon to smooth out spikes in demand for electrical power in a device or machine, which in turn prolongs the life of the main battery pack. Tesla likes them because they can be used as temporary energy stores for the regenerative braking systems on their electric vehicles.**

**So how on earth have our friends over at Washington University managed to create a supercapacitor inside a brick?**

**Well bricks are naturally very porous and that’s an extremely useful property because it means you’ve already got a very large surface area to play with.**

**So, the team went down to Home Depot and bought a bunch of house bricks for 65 cents a piece.**

**Then they filled the pores in the bricks with an acid vapour a bit like the stuff you get at the DIY store for cleaning rust off your metal tools. That liberates ferrous ions from the hematite and leaves a bunch of partially dissolved iron nuclei.**

**Then it starts getting a bit technical.**

# **A second gas is added which is a vapourised monomer known as 3,4-Ethylenedioxythiophene, or EDOT, and for what it’s worth, I can tell you that EDOT is an organic sulphur compound, with this chemical formula, consisting of thiophene and ethyl glycol.**

**It’s the precursor of an electrically conductive polymer called Poly3,4-Ethylenedioxythiophene or PEDOT. And it just so happens that the partially dissolved hematite in the brick reacts very happily with EDOT in a process known as oxidative radical polymerization to produce PEDOT.**

**The reaction takes place over 14 hours at 160 degrees Celsius. After about 4 hours tiny nanotubes of PEDOT start to penetrate the inner porous network of the brick serving as a sort of ion sponge that can store and conduct electricity. As the reaction continues the nanotubes grow out as blue tinted electrically conductive filaments on the surface of the brick and after 14 hours the thickness of that coating reaches its optimum level. An epoxy coating is added which acts as the electrolyte and as a binder and a separator to prevent short circuiting. It also makes the bricks waterproof.**

**Now, as usual on this channel, that layman’s explanation is extremely simplified, believe it or not! If you want to really fry your brain on the microscopic technical intricacies of hydrolysis, precipitation and oxidative radical polymerisation to produce a nanofibrillar PEDOT coated brick electrochemical electrode, then you’ll need to make yourself a strong cup of coffee and dive into the full research paper. And of course, as always, I’ll leave a clickable link to the paper in the description section below.**

**Anyway, the team found that they only needed to coat one face of the brick with the PEDOT polymer in order to make it electrically conductive, so you could still have your nice red brick facing outwards, with the blue coloured conductive face on the inside of your home ready to provide electrical charge.**

**The team claim the coated bricks are capable of storing charge at temperatures ranging from minus twenty degrees Celsius right up to plus sixty Celsius.**

**According to the lead researcher Julio D’Arcy**

**“Advantageously, a brick wall serving as a supercapacitor can be recharged hundreds of thousands of times within an hour.”**

**D’Arcy also touted the simplicity of the fabrication method compared to other energy storage devices, noting that the synthesis occurs in a single step because it is a self-assembly process. He said**

**“We found a sweet spot where we can engineer self-assembly and then watch nature happen. Instead of having multiple synthetic steps, we have a single one. The high conductivity, energy density, and nanofiber structure were the result of controlling the interaction between the vapor and the thin film, so they come together just how we want. In this case, it was seamless.”**

**The next step in the project will be to improve energy density and scale up the chemical synthesis to reduce costs and speed up production. The team also plan to add other semiconductor materials into the nanofibres to boost the amount of energy they can store, and they’re experimenting with 3D pattern formation to maximise that all important surface area for storing charge.**

**In laboratory tests, a few pieces of polymer-coated brick really did illuminate an LED light like this one. The team say that, based on their calculations, 60 regular sized bricks would provide enough energy to run emergency lighting for 50 minutes, and it would only take 13 minutes to recharge them. And bear in mind that an average house has upwards of eight thousand bricks in its walls, and because brick walls tend to be adjacent to roofs, the obvious choice for providing that recharge is a set of solar panels.**

**Now obviously these very early laboratory examples are not yet capable of providing all the power for home appliances, and that’s probably not something they will ever do, but they could provide a very useful source of additional instantly available energy capacity that could reduce energy bills and prolong the life of the lithium ion battery storage systems that more and more homes are now combining with roof mounted solar panels.**

**As the research concludes**

**“Our supercapacitor technology adds value to a ‘dirt-cheap’ construction material and demonstrates a scalable process affording energy storage for powering embedded microdevices in architectural applications that utilize fired brick.”**

**It is of course, another one of those laboratory ‘proof of concept’ developments that will inevitably require some decent funding and more development, but that’s the same story for every technological breakthrough in history. Even something as basic and commonplace as the electric light bulb had its beginnings as a laboratory experiment after all.**

**The project has already won fifty thousand dollars in funding from the US Leadership and Entrepreneurial Acceleration Program, or LEAP and D’Arcy says they are now actively seeking commercial partners to work with them to accelerate the R&D of the concept.**

**So it’s just possible that in the future when you say a device can be plugged into the wall, you may well mean it literally.**

**That’s it for this week.**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.
See you next week**