**I’ve got to be honest, one thing I never imagined I’d be talking to you good folks about is the idea of making batteries from trees.**

**That’s about as counterintuitive as it gets, right? I mean wood is an electrical insulator, not a conductor, isn’t it?**

**But then again, I’ve been constantly astonished by the stuff I’ve learnt from the scientific community over the years I’ve been running this channel, so I suppose nothing should really surprise me anymore!**

**And, sure enough, there really is a battery coming to market very soon that uses wood as one of its raw materials.**

**I made a little mock-up of what I thought a wood-based battery might look like, but I wasn’t a hundred percent convinced I’d got all the details strictly accurate, and I haven’t managed to get any power out of it just yet (furtive look to camera)**

**So, I contacted one of the lead scientists on the project to see if he could offer a bit of help, and it turns out that, just like so many of the other technologies I’ve covered, there’s much more to this one than meets the eye.**

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

**Well, the first thing I discovered is that I was completely off course with my little design concept here, which is news that I’m sure will come as no great surprise to any of you! So, after hours of careful toil to craft this particular work of art, I’m afraid it has to go straight into my waste basket of ill-conceived ignorance.**

**The real thing is of course far more sophisticated than my pathetic effort, and it’s the result of many years of research and development by a team of scientists at Linköping University in Sweden, led by Professors Magnus Berggren and Xavier Crispin.**

**And it was Professor Crispin who did his best to gently steer my somewhat confused mind through the various processes involved in producing the battery when I caught up with him via ZOOM recently.**

**So, here’s my best attempt at interpreting how this particular energy storage system works.**

**Let’s start with the tree thing, first of all. The material that’s actually of interest to the team is lignin, which is the gluey substance that makes up about twenty-five percent of a tree’s structure. The rest of a tree is made up of cellulose and hemicellulose. So, just to be completely clear, there aren’t teams of lumberjacks going out into the Swedish wilderness and hacking down entire forests to make these batteries. They’re actually recovering the lignin from the paper milling industry, which only uses the cellulose part of the tree, and which usually just burns lignin as part of a waste slurry known as black liquor.**

**Now, here’s where it all gets a bit technical. Professor Crispin explained that lignin is an aromatic heteropolymer, which means its structure contains small rings of benzene. Those benzene rings contain specific types of electrons, called Pi electrons, which, under the right electrochemical conditions, can be liberated without destroying the benzene ring itself. Those electrons could then, in theory, be directed through an electrical circuit to do some work before returning back into the benzene ring at the end of the process. Moving electrons is basically what a battery does, so it looks like we’ve got something potentially interesting going on here. But, as I mentioned at the start of the video, lignin is not an electrical conductor, it’s an electrical insulator, so those Pi electrons don’t naturally want to go anywhere at all.**

**The insight, discovered in twenty twelve by another Linköping professor called Olle Inganäs, was to find a way of bringing electrons to and from the benzene ring by creating a nanocomposite material of conducting polymers, which as the name suggests is a specific class of polymers that can conduct electricity. Down at that mind-blowingly miniscule nano scale, the polymer chains act like molecular wires which can then be embedded into the lignin to facilitate the movement of electrons into the benzene rings to store a charge.**

**You with me so far?**

**Professor Inganäs’ achievement was quite the breakthrough, and it kick started a decade of research and development bringing us right up to the present day.**

**In their relentless drive to get the cost of the battery down to something that could compete with lithium-ion batteries, the researchers came to realise that the original polymer material was probably going to be way too expensive, so the hunt was on for a cheaper alternative. And it turns out the solution lay in plain old carbon, which is an extremely abundant material that can do the same conducting job as the expensive polymer. But it still needed to work at the same nano scale to provide the molecular highways for those electrons to flow along, and that meant utilising another technology we looked at in a recent video - dry ball milling. That step crushes the carbon together with the lignin, which for reasons of science that even the scientists aren’t a hundred percent sure about, causes the carbon to mix with the lignin to become a nanocomposite material enabling the electrons to travel along the carbon molecular pathways to reach the aromatic electroactive component of the lignin. On the other side of the cell is a zinc electrode, and the whole thing is contained in an electrolyte made of a super concentrated solution of potassium polyacrylate, which is an absorbent material commonly used in babies’ nappies, or diapers.**

**There are some really tangible advantages in creating a battery in this way, not least of which is the avoidance of problematic components like lithium, cobalt, or nickel in the battery chemistry. The volume of paper being produced today is so vast that, according to Professor Crispin’s research team, even if you made all the batteries in the world with waste lignin from paper mills, you’d still only be using a small fraction of the immense volume the paper industry produces.**

**All the other materials are abundant and inexpensive too, and the potassium polyacrylate in the electrolyte also has the added advantage of eliminating the fire risk that occasionally besets lithium-ion batteries.**

**The technology is now being commercialised by a spin off company called Ligna Energy founded by the three professors Inganäs, Crispin and Berrgren. The target for the first generation of lignin- based batteries is to provide power for internet of things, or IOT devices. As Professor Crispin pointed out, once 5G and 6G become the ubiquitous ‘over the air’ communication standards then the ‘internet of things’ will turn into the ‘internet of everything’. And that means there will be billions and billions of tiny batteries all over the planet, each performing its own very specific function for a very short, prescribed length of time. For example, a light or heat sensor sending a brief signal to the internet to control the on/off function of a particular device. All those sensors and signallers need power, which will need to be provided by a battery.**

**The goal is to use lignin-based batteries in a concept known as Zero Energy Devices, first proposed by the Swedish telecommunications giant Ericsson. Now that might sound a bit like the proverbial perpetual motion machine to you and me, but it really just means equipping these tiny machines with their own small solar cell that can recharge the unit’s battery. That means the battery can be much smaller because it doesn’t have to carry the energy capacity to last the lifetime of the device. And it means you never need to replace the battery either, because it gets a continuous supply of energy directly from light.**

**Ligna Energy is working with another Linköping University start-up company called Epishine who are using roll to roll printing technology to produce long films of flexible plastic solar cells using conducting and semi polymers that can be processed from a solvent. It’s an incredibly cheap and efficient way to produce the huge volumes of light energy harvesting devices that’ll be needed in the coming decades as we move towards a world where every appliance and almost every surface we interact with will have some kind of sensing and measuring technology constantly pinging data back to a centralised internet-based controller designed to optimise energy efficiency. To someone of my vintage it’s really the stuff of pure science-fiction, but nevertheless, here it is, in real life, about to arrive in all of our lives in a very big way!**

**But Ligna Energy doesn’t want to stop at tiny devices. They see no reason why Lignin-based energy technologies can’t be used at the other end of the scale for energy storage on national electricity grids to compliment, or even compete with, existing lithium-ion battery banks.**

**There is still some development work to do before they reach that lofty goal though. The potential difference across each cell is currently about 1.3 volts and the energy density is currently about forty watt hours per kilogram, which is similar to lead acid batteries but without the toxic lead content of course! That’s not yet at the level of lithium-ion though, which typically has an energy density of more than two hundred watt hours per kilogram. It’s a parameter that Professor Crispin is confident can be increased in future iterations of the lignin battery by applying an extra step of clever chemistry to the lignin itself to enable it to store more charge. They already have a pretty robust and stable set up though. Lab test batteries have achieved several thousand cycles with very little loss of capacity. So, the future could be bright for this particular energy storage solution. And the world may not have to wait too long to see a lignin-based cell in real life. Ligna and Epishine are working towards production of the small thin film version within the next two to three years.**

**So, what’s your view on this one. Do you feel this could be a more sustainable alternative to the current crop of lithium battery technologies on the market? Are you looking forward to an internet of everything, or do you see it as some sort of dystopian nightmare? Whatever your view, the place to leave your thoughts, as always, is the comments section below this video. And I’ll be very interested to see what you think.**

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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**