**When it comes to battery energy storage solutions for our sustainable future, I sometimes feel like we’re witnessing a phenomenon a bit like the gold rush of the mid nineteenth century. Pretty much every week I read at least one news story about the latest breakthrough in battery chemistry that researchers claim will revolutionise the EV market or the national grid. But, just like many of the three hundred thousand or so folks that rushed to California in eighteen forty-eight following James Marshalls discovery of gold at Sutter’s Mill, a lot of these modern-day pioneers are likely to find that the apparently transformational material or process that they’ve unearthed turns out to be a pale imitation of the real thing.**

**Lithium-ion batteries are of course the current stand out success story in the field, and there’s no doubt they’ve utterly changed our modern world. But as we move ever more rapidly away from fossil fuels, vehicle manufacturers and energy providers are constantly clamouring for new technologies with higher storage capacities and lower demands on critical minerals.**

**At the same time, sectors like aviation are desperately looking for lighter-weight batteries that might just make flights longer than a thousand miles viable in the future.**

**One technology that’s been kicking around on the ‘might one day be possible’ list, is lithium-sulphur batteries. They’re yet another example of a technology where any description usually has to start with the phrase “in theory”. So…**

**In theory Lithium Sulphur batteries can store as much as five times the energy of existing lithium-ion batteries. As with so many other technologies, it sounds fantastic until researchers actually try to build one. In the case of lithium sulphur batteries they discovered that both electrodes were so unstable that the result was an impractically short cycle life and an inherently slow power performance. Scientists have been trying to fix these problems for at least a decade, but they’ve never managed to overcome the fundamental problem of achieving high capacity simultaneously with extended cycle life. Until now…possibly. To paraphrase the words of the great modern day philosopher Mary Poppins, it appears that in this case, it could be a spoonful of sugar that makes the medicine go down.**

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

**So, the scientists have got a tantalisingly promising material in the form of sulphur but an agonisingly frustrating set of barriers to overcome. That annoyingly slow power performance, for example, is largely due to very poor ion diffusion across the thickness of the sulphur cathode.**

**Lithium-sulphur batteries work in a fairly standard way, with energy being stored when positively charged lithium ions are absorbed by an electrode, in this case made of sulphur particles. One of the results of that absorption is the formation of lithium-containing sulphur compounds known as polysulphides. As the battery discharges, the polysulphides remove sulphur and gradually degrade the cathode. And as they move across the electrolyte, they form a sort of mossy growth that insulates the anode and degrades performance. It’s a phenomenon the science bods refer to as Polysulphide Shuttle.**

**To make matters worse, as the electrode gets charged, it swells up to almost twice its original size and then shrinks back down again at discharge. That expansion and contraction causes distortion and cracking which also reduces the operational longevity of the system. So, while most lithium-ion batteries have a rated lifetime of somewhere between five hundred and fifteen hundred charge cycles, lithium-sulphur batteries have previously only managed about fifty. Which is more or less useless.**

**Pioneering research in 2010 and 2012 by nanotechnology expert Linda Nazar and her team addressed the challenge of low conductivity in the sulphur cathode and introduced polysulphide absorbents and mediators to the cathode’s composition which went some way towards fixing the polysulphide shuttle problem. More recently, other researchers developed what they called an expansion-tolerant architecture to get over that distortion problem. But even so, the holy grail of high capacity plus long cycle life had largely remained unachievable until this latest breakthrough from a group of scientists at Monash University in Australia.**

**The team had already managed to bump up the number of charge cycles by four times from fifty to about two hundred, by creating a springy matrix of carbon and sulphur compounds that was better able to expand and contract without distortion or cracking, but that still didn’t really cut the mustard compared to existing lithium-ion batteries.**

**The real game changer was outlined in a research paper published in Nature Communications in September 2021. It was actually inspired by the findings contained in a dusty old geochemistry paper from the late nineteen eighties which described how sugar can help soils retain sulphur compounds. Hardly the sort of thing you’re likely to read when you’re in the field of battery chemistry, but that’s exactly what PhD student Yingyi Huang did. She took the paper to her Professor, Mainak Majumber, and they agreed that adding sugar to a Lithium Sulphur battery might just be worth a try.**

**To be more specific, the team were looking to gain an understanding of the interaction between saccharide-based binders and the lithium polysulphides, or LiPS, that were generated between the anode and cathode as the batteries charged and discharged.**

**What they found was that the LiPS very happily interacted with glucose as a result of their lithium atoms binding with oxygen atoms in the glucose molecule, and that different binding energies could be produced depending on the exact type of lithium polysulphide in question. Those binding energies were much higher than the levels previously achieved by an existing non-glucose based binder called polyvinylidene fluoride, or PVDF.**

**All very interesting, I hear you ask, but what competitive advantage did these interactions bring?**

**Well, according to the researchers, incorporating a glucose-based additive into the springy cathode matrix stabilises the sulphur and prevents it from dispersing and coating the lithium electrode.**

**It also improves the web-like structure of the cathode, opening up the matrix so there’s more space for lithium ions to interact with the sulphur.**

**Their results showed that forty two percent of polysulphides eventually adsorbed in the presence of glucose compared with only sixteen percent with previous methods. The consequence of the Monash team’s improvements was an increase in the battery’s operational durability up to a thousand charge cycles – much closer to existing lithium-ion technology.**

**And according to the team, because these batteries don’t need any rare elements like cobalt and nickel, they’re much cheaper to produce than their lithium-ion equivalents.**

**The team are confident that they can consistently produce a one thousand charge cycle battery with a capacity of five-hundred-watt hours per kilogram, and in conjunction with an energy research company called Enserv Australia, they plan to reach full production levels for EV batteries within five years.**

**They’re not the only team pursuing the huge potential of lithium-sulphur battery technology though. In fact, just one week after the publication of the Monash paper, an advanced materials company called Lyten, based in Silicon Valley, California, launched their LytCell EV™ lithium-sulphur battery platform.**

**Lyten have apparently just come out of stealth mode, following several years working with the US government to develop their technology into what they refer to as ‘various defence related applications’.**

**They say what they’ve achieved is a Graphene-based Lithium-Sulphur architecture called Lyten Sulphur Caging that performs the same function of arresting that pesky polysulphide shuttle problem that we looked at earlier.**

**They don’t provide any specific detail on exactly how their technology works, but according to their promotional blurb, Lyten 3D Graphene® is a novel three-dimensional graphene material platform that can be engineered and tuned at the molecular level to specific battery application requirements.**

**Lyten claim their battery has the potential to reach a gravimetric energy density of no less than nine-hundred watt hours per kilogram, which would not only outperform the Monash team, but also far exceed existing lithium-ion batteries and even the current crop of solid state batteries that are just starting to come to market.**

**Under Department of Defense test protocols, a LytCell™ prototype design has apparently demonstrated an operational durability of more than 1,400 cycles, with a charge time of less than twenty minutes, which would put it right up there with the longest lasting EV batteries available today.**

**And as a very important additional benefit, Lyten's**[**batteries**](https://www.electricvehiclesresearch.com/glossary/16/batteries-printed)**will be safer in vehicles than conventional Lithium-ion batteries because Lithium Sulphur doesn’t contain oxygen from metallic oxides, which is what drives the thermal runaway events that have plagued some electric vehicles in the past.**

**Production and market availability for the LytCell battery is expected by twenty-twenty five.**

**Now, you good folks out there know that I’m not a cynical man and I try to take an open-minded view of these new technological advancements in the hope that they’ll genuinely contribute towards a more sustainable energy future.**

**These two competing technologies are certainly potentially very exciting, but as is so often the case, there’s likely to be a lot more work required before we see a fully formed commercial version of either of them. There’s a world of difference between a few battery cells being tested in carefully controlled laboratory conditions, versus mass produced battery packs getting churned out in harsh factory conditions with all the challenges that that entails. And I imagine that’s a caveat that some of you might want to expand on a little further, so if you do, or if you’ve got actual experience of working with these technologies or in facilities that produce EV batteries, then why not jump down to the comments section below and leave your thoughts there.**

**That’s it for this week though.**

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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.**