**So, I was looking online for some research data on the latest state of play in the lithium-ion battery recycling industry and I found this weighty tome from the website Research and Markets – the self-proclaimed world’s largest market research store.**

**The real version of this thing, as opposed to the virtual version that I’m animating here, is more than four hundred pages long, and the Research and Markets website tells me it could be mine for the bargain price of only four thousand five hundred and eight pounds, which is about six thousand dollars.**

**Now, don’t get me wrong, I love doing research, but I’ll be honest, I don’t love it enough to shell out that kind of money!**

**Luckily the good folks at Research and Markets are kind enough to provide the broad headlines on their website.**

**So, what are they then?**

 **Well, the global lithium-ion battery recycling industry was valued at just over seven billion dollars in twenty-twenty-four and it’s projected to jump up to almost twenty-four billion by twenty-thirty, which for the statisticians among you represents a compound annual growth rate of almost twenty-two percent. Which is a pretty steep curve!**

**Unsurprisingly then, there is feverish activity going on all over the planet to develop a stand-out process for dismantling these notoriously complicated articles and effectively separating out all the constituent parts into reusable piles without necessarily using huge amount of energy to melt them all or nasty chemicals to dissolve them.**

**And that’s proving to be quite a tricky challenge.**

**Now though, a team of science bods in China (of course) reckons they’ve come up with a process that ticks both of those boxes AND recovers virtually one hundred percent of the materials in less than fifteen minutes.**

**So, we should probably have a look at that, shouldn’t we?**

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

**There’s lots of good stuff going on in the lithium-ion battery recycling world right now, spurred in part by new EU legislation that comes into force in August twenty-thirty.**

**That law states that electric vehicle batteries produced by European car makers will have to contain a minimum of six percent each of recycled lithium and nickel, and sixteen percent of cobalt, with those proportions rising still further in twenty-thirty-five. That’s got European recyclers racing to get ahead of their global competitors, mainly coming from China, which currently dominates the industry with a whopping seventy percent of global share.**

**ToZero in Munich, Germany, for example is developing a process that it claims has net-zero emissions and can recover all critical materials including industrial scale graphite. Altilium in the UK reckons its process can reduce the overall CO2 emissions of a typical battery by seventy percent and lower the cost by twenty percent.**

**Then there’s a slew of companies over in North America, perhaps the best known of which is Redwood Materials in Nevada, founded by ex-Tesla CTO JB Straubel. They use mechanical shredding and hydrometallurgy to recover ninety-five percent of lithium, cobalt, nickel and copper.**

**Just a very quick one-O-one on hydrometallurgy? Why not?**

**It’s a process that uses water-based chemistry to recover materials instead of high-temperature smelting, otherwise known as pyrometallurgy. Batteries get shredded or crushed into a powder called black mass which is then typically mixed with chemicals like sodium carbonate and sulfuric acid to leach out different metals into resaleable products like Lithium Carbonate, Cobalt Sulphate or NICKEL Sulphate. Hydrometallurgy is generally favoured over pyrometallurgy in battery recycling because it typically uses less energy, has a higher metal recovery rate and creates less air pollution and fewer CO2 emissions.**

**It's a process that is also employed at American Battery Technology Company or ABTC, also in Nevada, with a closed loop, so-called feedstock agnostic process to recover lithium, nickel, cobalt and manganese.**

**A third Nevadan operation, called Aqua Metals uses an ELECTRO-hydrometallurgy process that they call Aqua Refining to liberate lithium, cobalt and nickel with a claimed ninety-five percent reduction in waste compared to traditional hydrometallurgy.**

**LiCycle, (Eastern Ontario College Consortium) up in Toronto, Canada goes one step further, claiming to recover all the critical materials PLUS the plastics from housings and casings.**

**Over in British Columbia, there’s RecycLiCo who offer ON-SITE recycling MODULES targeting ninety-nine percent recovery of cathode materials, and down in Oz, an Adelaide company called iondrive is working on recycling methods using benign organic solvents, which they say significantly reduces environmental impacts compared to traditional methods.**

**And there are plenty of others vying for market share all over the world. So, you, know, it’s a busy field!**

**So, what have these new Chinese upstarts come up with then, and why do they think it represents a potential advantage over what’s out there right now?**

**Well, the team was essentially looking for ways to minimise the use of strong acids and bases in the hydrometallurgical process.**

**Acid leaching is a nice cheap, simple process with good material recovery efficiency, but it’s quite slow, AND it releases toxic gases and it creates a significant wastewater management problem.**

**Ammonia can be used to do the leaching job as well, but it also has the nasty side effect of choking to death anyone who comes anywhere near the reaction unless they’re wearing the correct safety gear. So that’s not ideal either, is it? Plus, the ammonia method is relatively inefficient, so it doesn’t scale very well to deal with the volume of spent Lithium-ion batteries, or SLIBs, that will be arriving like a Tsunami in the next couple of decades.**

**What you really want is some kind of neutral solution that can persuade the various metals to come out of the black mass without all the nasty side reactions.**

**The team from China’s Central South University and the National Engineering Research Center of Advanced Energy Storage Materials reckon they’ve achieved that using GLYCINE, which is a very common and fairly benign amino acid. The challenge here is to replicate the aggressive ability of hydrogen ions in acids and the very base attributes of ammonia to break down the metal-oxygen bonds that form inside the oxides in battery cathodes.**

**Neutral reactants have been tried before, but they generally lack the energy needed to provoke an efficient reaction and a pretreatment step is required using high temperature processes like chloride roasting and sulphuric acid roasting to do a bit of the initial persuading. That adds a bunch of additional energy requirements into the process and, you know, ‘chloride roasting and sulphuric acid roasting? You don’t really want all that, do you?**

**Glycine, according to the authors of this paper, has dual functionality thanks to these two groups that enable both ligand complexation and pH self-regulation simultaneously.**

**Yeah, so, what’s all that about then?**

**Well, ligands are essentially molecules that can attach to metal ions. They’re useful in recycling because they can grab onto metals like nickel and cobalt and pull them into a solution that can then be recovered. This part of glycine is an amine group that is happy to donate a pair of electrons from its nitrogen. This other part is a carboxylic acid group that does the job of releasing hydrogen ions. Both of those groups are attractive to metals, and that makes glycine perform well as a ligand.**

**The so-called pH self-regulation thing is also very useful. In a normal process the operator would need to monitor the pH level of the reaction and add a bit more acid or a bit more of a base to keep the pH value in the desired range. But glycine can do that itself.**

**If the solution gets too basic then the carboxylic acid group can release more hydrogen ions, or protons, and if it gets too acidic then the amine molecules can pull more protons out. In other words, glycine buffers the pH naturally without needing a bunch of nasty additional chemicals**

**But that’s not the only insight that the Chinese team provide us with.**

**They also describe what they call a ‘solid-solid reduction design, in situ constructed primary battery effect’.**

**And, in plain English, the primary batteries effect refers to a situation where two solid materials – usually two different metals or metal compounds – come into contact with each other and start acting like the parts of a primary, or non-rechargeable, battery. That interaction causes a spontaneous flow of electrons just like a regular battery powering a device. The researchers found they could exploit this phenomenon to speed up the process of breaking down the metals inside the recycled battery, boosting the performance of the glycine, making the process faster and more effective—all without using harsh chemicals.**

**According to the lab test, and yes, I know…lab tests blah blah blah, but anyway, according to the lab tests the whole process can be achieved in just fifteen minutes and in its current iteration it can recover ninety-nine-point-nine percent of the lithium, ninety-six-point-eight percent of the nickel, ninety-two-point-three-five percent of the cobalt and ninety-point-five-nine-percent of the manganese from a spent lithium ion battery.**

**What that potentially means is fast, safe lithium-ion battery recycling in neutral conditions without the environmental and human health hazards of other processes. And although this has so far only been demonstrated in a laboratory, it does look like one of those rare concepts that could quite easily be scaled up to meet the needs of mass throughput.**

**And here’s the thing. Those folks who are still desperately looking for reasons NOT to embrace the transition from internal combustion engine vehicles to electric vehicles are kind of running out of problems to highlight, as safety, range, convenience, charging network proliferation, product choice and even the cost differential between EV and ICE have all been addressed and pretty much resolved in recent years. So, they’re only really left with the rather porous argument about the environmental pollution caused by the mining of metals for the batteries.**

**To be honest that’s already a spurious argument when properly set against the truly mind-boggling levels of environmental pollution that come from the mining, shipping, processing and burning of fossil fuels, but now even that forlorn attempt at naysaying the transport revolution will have to be shelved once the recycling industry kicks into top ger in the coming years.**

**And if processes like this latest one can be employed to improve safety in the workplace and minimise the environmental impacts of processing plants, then we might genuinely be able to claim that electric vehicles are just a bit more sustainable than the outdated and hopelessly inefficient gas guzzlers we currently have to put up with.**

**No doubt there will be plenty of you out there with your own point of view on this topic, so if you’re burning with an uncontrollable desire to share that view right now, the place to do just that is in the comments section below.**

**That’s it for this week though. Thanks, as always to the amazing folks over at Patreon, who make this channel possible and enable me to keep ads and sponsorship messages out of your way.**

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**Most important of all though, thanks very much for watching! Have a great week, and remember to just have a think.**

**See you next week.**