**Well, here I am again coming at you with yet another video about hydrogen, which, if you’ve watched some of my previous offerings on the subject, you’ll know is an element with great potential but also a whole raft of issues and challenges on a practical level.**

**Hydrogen is the most plentiful element in the universe, which is nice. But here on earth it doesn’t tend to float around on its own. It has to be forced away from the other elements it’s reacted with, which currently either means hitting fossil methane gas with high pressure steam to break apart the carbon and hydrogen atoms, which is a process that generates more greenhouse gases than burning diesel, or it has to be separated from oxygen atoms in water via the process of electrolysis, which is much less efficient and currently more than twice as expensive, at about five dollars a kilogram compared to one or to dollars a kilogram for hydrogen from steam reforming methane. Once you’ve got your hydrogen you have to store it somehow for transport and all that sort of stuff. As an energy carrier hydrogen contains a hundred and twenty megajoules in every kilogram, compared to only forty-four megajoules in a kilogram of gasoline. That’s why it’s such an attractive prize. BUT at normal temperature and pressure gasoline is an easily manageable liquid, whereas hydrogen, as the lightest and simplest element in the known universe, is a gas with a very low volumetric energy density. That means hydrogen either has to be compressed to about seven hundred times atmospheric pressure to get it into a manageable size of container, or it has to be cryogenically chilled down to minus two hundred and fifty-three degrees Celsius so that it condenses into a liquid. That’s only twenty degrees above absolute zero. Both those processes need a lot of energy and expensive infrastructure.**

**So, I suppose it’s not surprising that clever science boffins in laboratories all over the world have been trying to develop alternative methods for liberating and storing this potentially transformative element. And now, a couple of research teams reckon they’ve worked out how to store hydrogen safely and more or less indefinitely, as a powder.**

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

**If you’re a regular viewer of the channel, you’ll know that over the years we’ve looked at all sorts of ways of and storing and converting energy, from electrochemical reactions in various battery technologies to thermochemical reactions in energy storage media.**

**Now we’ve got a new term to add to the lexicon… mechanochemistry. It’s a phrase that came to prominence only a few years ago when this paper described how the rather unfortunately titled process of dry ball milling could be used to strip graphite down into graphene.**

**Now a group of research scientists from Deakin University in Australia has embraced this technology and combined it with good old nanotechnology to achieve separation of gases without the need for heat, or light or an electrochemical reaction.**

**Their initial focus was to find a way of simplifying the separation of hydrocarbon gases like alkyne, or olefin, and paraffin from petroleum, which the fossil fuel industry currently achieves in distilleries by cryogenically cooling everything down into a liquid and then reheating the mixture and syphoning off each gas as it evaporates at its own specific boiling point. That’s quite smart science but it’s also very expensive and energy intensive.**

**The process that the Deakin team have developed essentially involves a cylinder containing nanosheets of boron nitride powder and a bunch of steel balls. The breakthrough discovery that the team have identified is that when defects are present at the edges and within the main body of boron nitride nanosheets, they act like a catalyst to accelerate the adsorption of gas. By rotating the cylinder and allowing the steel balls to tumble onto the powder, the researchers have been able to greatly increase the number of these catalytic defects in the material. When a mixture up olefin and paraffin gas is introduced at room temperature and normal atmospheric pressure, the nanoparticles of boron nitride selectively adsorb a much greater quantity of olefin gas over paraffin gas. That means at the end of the process pure paraffin gas can simply be syphoned off and the olefin can be recovered from the born nitride powder via a low-temperature heating process.**

**It’s really very simple indeed and according to the research team, this scalable mechanochemical process offers substantial energy savings over the existing technology.**

**It’s not a particularly quick process. It can take more than twenty hours for olefins to be fully absorbed, but the team found that rotating their cylinder for that length of time only used about thirty-two cents worth of energy. According to the paper the full-scale process is estimated to consume seventy-six point eight kilojoules per second to separate a thousand litres of an olefin-paraffin mixture, which is two orders less than the cryogenic distillation.**

**Now, you know me, I’m not one to arbitrarily promote anything that might be perceived as being advantageous to the fossil fuel industry, but if this method could be scaled up and used in the petrochemical industry then it would displace a process that, according to a report by the Oak Ridge National Laboratory, accounts for as much as fifteen percent of all energy consumption in the United States, and presumably a similarly high tariff at distilleries elsewhere in the world.**

**Technology writer Loz Blain spoke to the papers co-author, Professor Ian Chen, for a recent article that you can find at New Atlas dot com, and I’ll leave a link to that article in the description section below.**

**Chen told Blain that although their research paper focusses on paraffin and olefin, they realised that the process could also be used to absorb and store relatively high quantities of hydrogen gas.**

**“It doesn't require a lot of energy”, Chen explained “and it's safe. Under normal conditions it's quite stable, and the hydrogen won't be released unless it's heated to a couple of hundred degrees.”**

**Even with that heating requirement at the end to liberate the hydrogen from the boron nitride powder, Chen says their initial small-scale experiments with hydrogen suggest that their process would use only about a quarter of the energy needed to compress the gas to seven hundred bar. That can most likely be improved as the system scales up and the operating parameters are optimised. Plus, in relative terms, the more gas you store the less energy you need to release it.**

**Tests indicate that each gram of boron nitride powder stores about as much hydrogen as eleven centilitres or just under four fluid ounces of compressed hydrogen gas, which the team claim to be about double the capacity of other solid state hydrogen storage methods.**

**The boron nitride powder isn’t an infinitely reusable material though of course. It’s pretty stable, but the process of pummelling it with steel balls does mean it loses about one to two percent of its storage capacity on every cycle. The Deakin team are now looking at ways of treating the spent powder to restore its absorption levels. That’s by no means a done deal just yet though, and there’s still quite a bit of work required to prove out an effective process.**

**So, we’re definitely not at the stage where we all need to be getting giddy with excitement just yet. As is so often the case, there will most likely be several years of further research and development before we see this process at industrial scale in the real world.**

**And that probably holds true for another, completely different, powdered hydrogen storage technology that was announced in the very same week as the Deakin paper research paper was published.**

**This one comes from a company called EPRO Advance Technology, or EAT, based in Hong Kong. And it involves storing hydrogen in a powder by not storing hydrogen in a powder at all!**

**Yeah, I know.**

**Now, I am going to share the very brief explanation that the company provides for how the technology works, but I reserve the right to retain a healthy level of journalistic scepticism about this one until it’s been road tested and peer reviewed in the real world because it sounds a little bit too good to be true in my view, and as you good folks are constantly reminding me , if something sounds to good to be true, then it probably is.**

**Anyway, see what you think, and I’ll be interested in your comments and feedback at the end.**

**The company are pitching their technology as the “easiest, safest, and most economical way to generate and deliver hydrogen that the world has ever seen.”**

**So, you know, there’s no shortage of confidence, that’s for sure!**

**What they’ve developed is a material they’re calling ‘SI plus’, which is apparently a very porous version of silicon powder that, when exposed to water, reacts to form Silicon Dioxide or silica, and hydrogen, according to this balanced equation that your chemistry teacher at school would have happily been able to show you, so nothing new there.**

**They don’t say exactly what they do to the silicon to make it super porous, but their promo video suggests it involves the input of electrical energy. The video shows the processed powder being poured into a flask of water and hydrogen bubbling out at the other end to charge up a one-kilowatt fuel cell. They plan to produce a small system for domestic homes that could charge a five-kilowatt fuel cell which would be enough to run domestic appliances. They’re also hoping to break into the global market as an ultra-safe, cost competitive storage and transport medium for hydrogen. It’ll be safe because, as I mentioned earlier, the powder doesn’t actually store anything at all! Just add water at the end, and hey presto, instant hydrogen!**

**They’re not clear what the end user is supposed to do with all the silicon dioxide they’ll be left with. It may not be a problem for anyone living next to a beach, because it’s essentially no more than a component of sand, but not everyone has that luxury do they, so there would need some sort of collection facility which could get pretty cumbersome and expensive.**

**Nevertheless, the company plans to deliver domestic generators into the European market, and commercial generators in Hong Kong at some point in twenty-twenty-three, and they’re apparently talking to the Hong Kong Airport authority about replacing back-up diesel generators and providing a hydrogen refuelling station at Hong Kong International Airport.**

**I’m not going to hold my breath on this particular technology, but there’s no doubt that, along with the high cost of production in the first place, the safe, economical storage and transport of green hydrogen is a major obstacle holding back its mass adoption. So, it’s got to be encouraging to see the development of alternative hydrogen storage solutions like these, and others, like this solid state metal hydride technology from a company called GKN Hydrogen in Germany, which is something we may look at in more detail in a future video.**

**That’s it for this week though. I’m sure many of you have lots to say on this subject, so as always, if you do then feel free to leave your thoughts in the comments section below.**

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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**