**If you’re a human being living in a reasonably developed country, you will, at some point, almost certainly have used a product made by this company.**

**3M has a long history of innovation and risk-taking stretching right back to its inception at the turn of the last century, resulting in a vast range of incredibly useful products, including every day stuff like Scotchgard, Post-It notes and Thinsulate.**

**In December 2022, 3M took what was arguably one of the most momentous and consequential decisions in the company’s history, when it announced plans to stop using PFAS materials by 2025. The full name of PFAS is ‘polyfluoroalkyl substances’, but you probably know them better as ‘Forever Chemicals’ . These things were practically a miracle when they were first cooked up in labs decades ago. They’re resistant to water, heat and grease, which enabled companies like 3M, Dupont and others to use them for all sorts of applications from non-stick cookware, through to stain resistant carpets and firefighting foams. The slight wrinkle that scientists have discovered more recently is not only that PFAS doesn’t break down well in the environment, but also that it doesn’t break down well in the human being. PFAS chemicals have been found in the bloodstreams of people all over the world, even in those who’ve never directly used products that contain them. Once they’re in our systems they can accumulate over time, and they’re now being linked to a number of health problems, including cancer, liver damage, thyroid problems, and decreased fertility.**

**So, not making PFAS chemicals any more would seem like quite a smart move, wouldn’t it? The question, according to our friends in the fossil fuel industry is ‘what are you going to replace PFAS with, so that you can continue to use the millions of different products containing it that make the modern world go round?’ Until very recently that was indeed a pretty-tricky conundrum. But now there’s an increasingly credible answer – trees, which unlike fossil fuels, are renewable and sustainable.**

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

**If you don’t fancy cooking your bacon and eggs on a wooden saucepan, or trying to write a note to a colleague on a thin sheet of bark, then fear not my friends because that’s not what I’m on about here at all.**

**If we dive down into the microscopic structure of a tree, we find that it’s made up of cellulose and hemicellulose, all held together by a gluey substance called lignin. Cellulose is what we make paper and cardboard from, and it’s found in plenty of other products too, including textiles and food packaging. And now a Swedish start-up called Cellfion has developed and commercialised a range of cellulose-based proton exchange membranes, or PEMs. Why is that a good thing? Well, because the vast majority of existing PEMs are made using the PFAS ‘forever chemicals’ I mentioned right at the start of the video. And those PEMs are found in literally billions of devices and machines all over the world.**

**I’ve made the point quite a few times on this channel that some of the greatest breakthroughs on our path to global sustainability won’t be glamorous headline grabbing technologies like twenty-megawatt floating wind turbines the size of the Eifel Tower, or solar panels beaming energy down from low earth orbit. They’ll be the inconspicuous, non-showy workhorses, quietly doing their thing, buried somewhere deep inside the everyday technology we all take for granted. Proton exchange membranes are certainly a perfect example of that! So, what are they, and what do they do?**

**Well, essentially a cation-exchange or Proton-exchange membrane allows selected ions to pass through while blocking the passage of electrons. That’s what makes them so useful as a separator in electrochemical batteries and fuel cells. They’re also used in electrolysers to split water into hydrogen and oxygen. They can be utilised as sensors in industry to detect the presence of specific chemicals and they even play a role in water desalination.**

**PFAS materials have, until recently, been seen as the perfect option for PEMs, at least from a technical point of view anyway. They have high proton conductivity, very good chemical stability, and they’re very durable. Finding a completely different material that eliminates all the nasty consequences of PFAS that I mentioned earlier, and that still works as effectively, has not been an easy challenge. But that’s precisely what the folks at Cellfion reckon they’ve come up with.**

**I caught up with CEO Liam Hardey and Business Developer Alexandra Troulioti via Zoom recently to find out a bit more about how their technology works. Liam explained that their membrane is based on microscopic fibres of nanocellulose known as nanofibrils or CNFs. These things range in size from just a few nanometres up to tens of nanometres in diameter. To give a bit of scale to that, a human hair has a diameter typically around 70 microns, which is 70,000 nanometres. CNFs also have a high aspect ratio. In other words, they have very long length relative to their thickness. Nancellulose itself is apparently about a fifth the weight of steel and, gram for gram, it’s about five times as strong. So that certainly ticks the durability box. And just like PFAS, nanocellulose is a very stable material with extremely low thermal expansion and contraction. Perhaps most important of all though, for the applications we’re looking at today, is the fact that nanocellulose is impermeable to oxygen and a bunch of other gases.**

**Cellfion’s insight and patented USP is a process that, for understandable reasons, is a fairly closely guarded piece of intellectual property, but Liam and Alexanda explained that it’s essentially similar to a papermaking process except that Cellfion modifies the fibres with a carefully developed secret soup of chemical groups, controlling the material properties for each specific application. Then they extract the cellulose nanofibrils from the walls of the wood fibre through mechanical treatments. That produces the individual starting material they’re after. Once the chemical composition is just right** **the mixture is then pressed into membranes that can perform exactly the same ion-exchange function that PFAS materials are used for today.**

**Since the inception of their company in 2021 as a spin off from a research programme atLinköping University in Sweden and KTH Royal Institute of Technology in Sweden, the folks at Cellfion have been working fast. They’re already demonstrating their validated membrane technology to potential commercial partners. The plan is to set up their first pilot production line by 2024 and start upscaling by the following year.**

**As for cost structure? Well, again that’s not being disclosed at this early stage, but to give us a bit of a guide, the Cellfion folks did tell me that the availability of the cellulose they use as their raw material and the fact that it can be purchased on a remarkably non-volatile market, means that Cellfion's process and products are highly scalable within very achievable economic parameters. They also suggested that one ton of pulp derived from any softwood source, provides capacity to produce many thousands of their membranes.**

**In February 2023, the European Chemicals Agency, led by Denmark, Germany, the Netherlands, Norway and Sweden published a proposal for the restriction of around ten thousand different types of PFAS materials. Their report points out that if immediate action is not taken to curb the production of these forever chemicals, then an estimated four-point-four million tonnes of them will end up dumped into the environment by the middle of this century. There’s an awful lot of consultation to get through before a ban comes into force though, not least of which is a comprehensive assessment of the socio-economic impacts of such a shock to the global supply system. The results of that analysis, along with advice from something called the Enforcement Forum looking at the enforceability of the proposed restriction, will then be sent to the European Commission who will consult with the EU Member States to decide on the final legislation.**

**Over in the United States, the Environmental Protection Agency’s 2021 PFAS Strategic Roadmap proposes various steps including addressing PFAS contamination in drinking water, regulating the use of PFAS in specific products, a requirement for companies to disclose the presence of PFAS in their products, and agreeing measures to clean up existing PFAS contamination. New York state has already banned the use of PFAS in food packaging and firefighting foam. California has set stringent standards for residual PFAS levels in drinking water, and several cities, including Washington DC and Seattle, have banned the use of PFAS in carpets and other domestic household products.**

**And despite some significant feet dragging, notably by China, which still produces some types of PFAS that have already been banned completely in the States and Europe, Asian countries are now beginning to address the issue of widespread industrial use of these chemicals. In May 2023, 2,000 delegates from all over the world gathered at a United Nations convention in Geneva to agree on how to add ‘forever chemicals’ to the list of toxic substances that are banned or restricted under the Stokholm Convention of 2001, which is a global treaty protecting human health and the environment from long-lasting chemical pollution.**

**Now, I don’t know about you, but all of that sounds like a bit a bureaucratic nightmare to me! What is unquestionable though is that the whole process will be made immeasurably easier if there are proven, workable and economically viable alternatives to PFAS already in place for manufacturers to seamlessly turn to as and when a ban comes into force , just in the same way that HVAC manufacturers were able to do more than three decades ago when the world got together to ban the CFCs that were destroying our ozone layer. So, products like the membranes being developed at Cellfion will surely play a crucial role in that global transition process.**

**If you’re a company that uses PFAS chemicals and you’re keen to know how to stop using them, then you could do worse than visit chemsec.org, where you can join all these other companies and more, all of whom have made pledges to rid their supply chains of ‘forever chemicals’…forever! You may well have direct personal experience of working with PFAS chemicals or the products they’re used in. If you do, then what’s your take on the situation? Do you think such a radical transition can be achieved or not? Or you may just be a normal consumer like the rest of us and have your own opinion on what you feel is the best way forward. Whatever your view, the place to leave your thoughts is in the comments section below.**

**That’s it for this week though. A big thank you to the Patreon crew, as always, for helping me stay independent and keep ads and sponsorship messages out of my videos. And I must just give a quick shout out to some folks who’ve joined recently with pledges of ten dollars or more a month. They are.**

**Lisa De La Mer**

**Keith Helfrich**

**Jason. S**

**Anthony Luongo**

**Joe Chambers**

**Ryan Massey**

**Dot Sulock**

**Konrad Leffler**

**Norman**

**And**

**Charles Vane**

**And of course, a huge thank you to everyone else whose joined since last time too.**

**If you’d like to get involved with all that, then you can find out all about it at Patreon dot com forward slash just have a think.**

**And you can hugely support me right here on YouTube absolutely for free by subscribing and hitting that like button. It won’t cost you a penny to do that, but you really would be helping us massively, and you’d have my undying gratitude. It’s dead easy to do - you just need to click down there or on that icon there.**

**As always, thanks very much for watching! Have a great week, and**