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Introductory Jingle
Connecting for positive change.

Nikoleta
So welcome everyone to this new episode of The Battery Cafe focusing on advanced materials for batteries. I'm Nicoleta Piperidou from the Clean Energy and Infrastructure Team at Innovate UK KTN hosting today's episode alongside my colleague, Dr. Neelam Mughal. Hi Neelam.

Neelam
Hi, everyone. I'm Neelam and I look after Advanced Materials at KTN. This covers a range of materials for high tech applications such as energy storage and materials for space. Really happy to be here with you today, Nicoletta.

Nikoleta
Fantastic. Thank you, Neelam. Just a brief intro to The Battery Cafe. It is an initiative of the Cross Sector Battery Systems Innovation Network, community funded by Innovate UK KTN and the Faraday Battery Challenge. It aims to open new markets for the battery industry, promote innovation in batteries, and help decarbonise a wide range of end users. If you haven't already, please go check out our online platform at ukbatteriesnetwork.org you will find lots of useful material and all the previous episodes of our Battery Cafe. So today, we're joined by James Baker CEO Graphene at Manchester. Hi, James.

James
Hello, everybody.

Nikoleta
So everyone, make yourselves a coffee and join us. Starting today's episode, James, for those who are not very familiar with this space, what exactly do we mean by advanced materials?

James
So advanced materials are often thought about, today I'm here really representing 2D materials, graphene and other 2D materials and often they're talked about as new materials or advanced materials. But from my view, an advanced material can be any material where you can improve the property or function of it, by adding a new coating, or adding some functionality for that, for example. So it doesn't have to be this new family of two dimensional materials. It can really be any material that we use today in manufacturing of our vehicles, of our batteries, of our structures in the future. And again, it's quite interesting, we're now seeing some traditional materials where we can really improve their functionality through the addition of a new advanced material or a coating to them, to improve the performance of that product.

Neelam

Thanks, James. So you mentioned graphene there, would you like to tell us a little bit more about graphene and its advantages for batteries and how we're already seeing it be used?

James
So certainly. I'm part of the University of Manchester when in 2004, graphene was first isolated using sticky tape and graphite to isolate that single atomic layer of carbon. So as a single atomic layer two dimensional material, graphene has some fantastic properties like mechanical strength, thermal conductivity, large surface area, and they're all properties that can be really suitable for the current and next generation of battery energy storage technologies. So when you look at conductivity, graphene theoretically is the most conductive known material. If we can exploit those properties around the durability of a battery, then clearly, there's an opportunity to improve durability, or charging time for a battery. We also want to try and improve the capacity of our batteries. So again, some of the high surface area, in particular graphene is particularly suitable for increasing surface area and improving capacity. So you're already starting to see graphene as an additive, whether it's graphene in the packaging, graphene in the anode, the cathode or in the substrate or in the membrane. So we're starting to see graphene added to different forms of batteries. As well as looking at new forms of batteries or even super capacitors, we get that rapid charge discharge, where graphene and 2D materials are really starting to play a key role in terms of some of that battery technology.

Nikoleta
Thank you very much. That's all well and good and great to hear about all these advantages, but what would you say are the biggest technical challenges and what about other 2D materials?

James
So challenges, going back to Manchester 2004 to today, 18 years sounds a long time. But for any new material, it can take many years from discovery through to products in the marketplace. And that's partly down to technical challenges, understanding how to make the material, how to use it, how to mix it. So we are still addressing many of those technical challenges around new materials. Today you can buy graphene by the gramme, by the kilogramme by the tonne. So companies have started to scale the manufacture of the raw material itself and again, they're through things like reach registration, so it's approved to use in things like batteries, which is very important. So there are lots of technical challenges that have to be overcome. But the one I'd probably pick out more in terms of commercialising is some of the scale up challenges. How do we scale up these new materials into our batteries, both existing battery technology, but also new battery technology? And it might be in the formulation of the electrode or the production of the electrode, or it could be actually in terms of the integration of that anode and cathode into a pouch cell or into a coin cell to make a battery. So the access to scale up facilities for me is absolutely critical. It's something I know the UK is really looking at, we have the GEIC Graphene Engineering Innovation Centre in Manchester, where we have an energy lab, but also in places like Warwick, where we have increased scale at facilities of battery technology, I think is absolutely critical if we're going to accelerate these new materials into our products of the future. We've talked a lot about graphing, but I'm also now seeing a whole family of other 2D materials over 150 2D materials now being studied at Manchester. So as well as your graphene, we're into, for example, products like NX scenes that are showing great promise for energy storage in the

future. And if I just look at NX scenes as an example, we're starting to scale the production of that material from grams to kilogrammes. Towards the end of this year, we should be towards the one tonne capacity, which will really make those other 2D materials increasingly open for use in energy storage and battery devices in the future. So some exciting times, but still lots of challenges to achieve, both the technical as well as the scale up challenges. Then beyond there, we get into things like disposal. So how do we make sure we do this safely and end of life and we can recycle those materials in the future. So many challenges when you look at the whole lifecycle, and the technical and the scale up at the start. But we also need to address things like sustainability and recyclability, it's important if we're going to commercialise those products in the future.

Nikoleta
Thank you, James. That was excellent. And actually, this reminded me, we recently ran a US UK battery Technology Research and Innovation Online Summit. And it was interesting to learn about the common challenges between the two nations, you've mentioned recycling, and that was pointed out there. Neelam, what else was your key takeout from that activity?

Neelam
So another key area for collaboration between the two countries would be looking at the supply chain of these critical, resilient materials, and recycling as rightly so. And, you know, what are the opportunities there for reusing and finding end of life opportunities for very critical materials and batteries, including graphite? So my question here, maybe James, is what other countries would you say that are pioneers in advanced materials beyond the UK? You know, what lessons can we learn from what's happening abroad?

James
So you can see pockets of innovation around new materials. And if I look at batteries in particular, you know, certainly you've mentioned the USA. So we continue to see some great developments around the USA on advanced materials. Quite interestingly, for me, the USA, are probably a little bit behind when it comes to graphene but they seem to be taking more industry around the broader family of 2D materials. I mean, other pockets that we often talk about are things like South Korea, where you had companies like Samsung in the early days doing an awful lot around electronics, and graphene products and applications. And that leads us probably into China and I don't think you can underestimate the amount of activity coming out of China, often a little bit more difficult to be aware of under control. But certainly we see a lot of batteries and advanced materials, interest and activity from our Chinese universities and industry. Finally, I don't think you can dismiss Europe, you know, with the work around Tesla, for example, if I stay on batteries, and some of the Gigafactories that are starting to spring up around the automotive sector. So I think it is very international, you know, advanced materials, materials go in, whether it's a battery, whether it's a vehicle, an aircraft, or even concrete, you know, advanced materials will increasingly play a role in the future, and you are seeing real pockets of activity. Part of our model is very much a collaboration model, you know, we do collaborate with companies in Brazil, we collaborate quite strongly with our colleagues in UAE, United Arab Emirates, where we're actually based in the GEIC in Manchester, which is called the Masdar Building, which is a part of a partnership with UAE and quite interestingly from my perspective we've now got real interest from UAE around graphene products and applications in their country and that can increasingly offer collaboration opportunities for UK academia and industry. So you have lots

of pockets around the world. I think real hotspots are probably around the US, around Korea, and China. But I think Europe is also very strong around advanced materials.

Nikoleta
Thank you very much, James. And while this is clearly an energy storage, focused podcast, KTN is always keen to promote the right technology for the right solution or opportunity. So I just wondered whether there are any other sectors that you think that graphene would make a big impact in?

James
One area we're seeing graphene playing a big impact is around sustainability, and the drive towards net-zero. So in addition to your energy storage batteries for electric vehicles, if we can lightweight our vehicles, so we can make them lighter weight to use less fuel, less emissions, but also in construction, alone if you look at cement, as one case study, I believe globally, cement contributes towards 8 to 10% of global carbon dioxide emissions around the world. And what we found in construction by adding as little as naught point zero 1% of graphene into concrete, we can reduce the thickness of the slab required by up to 30%. So if we could do that across concrete and reduce the amount of material by 20 to 30%, that would have a global reduction of around 2/3% of CO2 around the world. So renewable, recycled materials, reduction in concrete construction and this drive towards net-zero, I'm seeing graphene and advanced materials playing a real role in supporting our ambitions of lighter aircraft, lighter cars, longer lasting batteries, through to new types of roads and structures that hopefully use less cement and construction materials, all supporting that drive towards net-zero.

Neelam
Thanks a lot, James. So you have highlighted some really exciting commercial opportunities. So you know, watch the space for graphene. But I do have a question about the timescales. Where do you see us in 20 years time with regards to graphene being used in all of these factors you just mentioned?

James
So that's a really big question, I think it depends on the area you look at, what you're finding already though, is where there is a relatively easy certification or verification. So training shoes, paints, coatings, where you don't have to certify a new product. You're actually seeing graphene starting to play a key role in industry today. You can buy training shoes, you can buy jackets, you can buy clothing, you can take paint from your hardware store for anti-corrosion coating as an example. So already you are seeing graphene appearing in everyday life, Ford in America has graphene in the foam in their engine bay, over 5 million cars on the road from Ford with graphene foam in the engine bay. Over the next 10 years, though, I think we're going to see an increase in more sophisticated products. We're starting to exploit the more unique features of graphene and 2D materials. So it's in your batteries or your super capacitors. Already, we're seeing some hybrid pseudo capacitors being trialled by clients in the UK, we were integrating a battery in a super capacitor like a hybrid solution. And they're finding the way into early prototypes and early demonstrators. So yeah, I think you're gonna start seeing an increase in graphene playing a role in existing products, the more exciting one 10/20 years. Water Filtration is one that I can see making a real difference, if we could take a graphene membrane that we could allow water to pass

through, but could block contamination or salt to get drinking water through a simple filter. Again, that really has the ability to transform the way we currently have water around the world today. Probably initially, you're not going to go for pure drinking water. But for example, I see people in your house taking rainwater and being able to recycle or reuse that for washing or for irrigation. So we start to reuse some of our materials and increase in amount. So this whole circular economy, I think is going to be quite driven by graphene 2D materials, advanced materials, but also be able to use recycled materials. So some great work is coming out of the US and the UK. For example, we could take plastic, your waste bottles, you could chop that plastic up and reuse that plastic into a graphitic material that you might be able to mix with your concrete. So again, this circular economy, I think you're gonna see increasingly over the next 10/20 years, and it will open the doors for this recycling or reuse of existing materials, to our roads, into our structures and into our everyday life.

Nikoleta
Thank you very much. And we've covered so much ground in this short period of time looking at graphene for so many applications, looking at other countries, etc, etc. But if we were to leave the energy storage audience, just with one key takeaway from today, what would it be?

James
I think the key thing I really like to promote is engagement. We've developed a business model in Manchester that we call make or break or fail fast and learn. Batteries aren't easy. They are complex, they're complex integrated systems. But with facilities like the GEIC, like the catapults in the UK, the ability to integrate a new material and to rapidly test that, to see if you could improve the performance, and then do that spiral development, we're not going to create a new battery overnight. But by innovating, by bringing together the best of the supply chain academia with industry, and engaging, for me, we can bring these new forms of energy storage. So I think the takeaway message is if you're not looking at new materials, or you're not looking at engaging with academia or the catapults, you know, for me just take that time to see what's taking place. We have some great researchers around the UK, we have some great facilities and capabilities, supported by Innovate UK, the KTN ability to do rapid programmes and prototyping to experiment, and to bring those new ideas and innovations to market. I think there's never been a better time to be able to do that. But you need to engage to start that process off.

Nikoleta
Thank you so much, James. That was fantastic, thank you. Thank you Neelam as well, thank you all for listening. We hope you enjoyed this discussion as much as we did. Don't forget to visit our online hub at ukbatteriesnetwork.org and register to receive our news and updates and participate in the networking area of the hub. Our next episode will focus on Scaleup, looking at how investment is helping companies to grow and the role for our investment readiness programme. Bye for now.

Outro Jingle
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