Battery materials

Nanoramic's role in advancing sustainable and PFAS-free battery manufacturing

Sustainable solutions for increased performance and reduced cost

Pam Poulin, Market Development Manager at Thermo Fisher Scientific, and **Dr. Julian Renpenning** conducted this interview with Christian Dietrich, Director of Business Development at Nanoramic Laboratories.

Nanoramic Laboratories introduction

With a focus on improving battery performance and sustainability, Nanoramic Laboratories is advancing battery technology and manufacturing. The company's Neocarbonix technology addresses critical battery material issues and represents a significant step forward in electrode design and manufacturing. This interview with Dr. Christian Dietrich, Director of Business Development at Nanoramic Laboratories, delves into the company's innovative approach to battery technology. We explore Nanoramic's evolution from supercapacitor to advanced battery development, examining the technical aspects of their Neocarbonix (NX) electrode technology and its implications for the future of green, sustainable and NMP- & PFAS-free battery production.

Tell us a little about Nanoramic Laboratories and how you got started?

Nanoramic was spun-out from MIT in 2009 following on work on carbon materials. Located near Boston, the company processes lightweight carbon materials in versatile ways to utilize their superior electronic and thermal properties. Nanoramic has successfully applied their technology in thermal interface and energy storage applications and brought them on the market. I joined Nanoramic in 2022 prior to an assignment in the automotive industry when we just started to accelerate the adoption of NX into the EV industry market.

What were your original intentions for NX technology in 2009, and how has it changed since then?

When we started working on NX technology in early 2009, we were really focused on making better supercapacitors—ones that could not only perform well, but also handle high temperatures. You see, most energy storage devices operate up to about 80°C. But with the help of Neocarbonix technology, we were able to push that up to 300°C. That was a big deal for us. Since then, we have continued to work on this technology, finding new ways to use it and improve it.

So, what's special about Neocarbonix technology? Why is it so important that it can withstand high temperatures?

Conventional electrodes rely on organic polymers that act like glue. Instead, Neocarbonix forms a lightweight 3D carbon scaffold structure in the electrodes with the same functionality. Such NX structures have not only better heat compatibility, but also conduct electrons efficiently improving power performance. This combination of heat resistance and better conductivity is what sets our technology apart.

How has the focus of Nanoramic shifted from supercapacitors to batteries in 2019? What was the reason for this shift?

The shift began with the rise of vehicle electrification. We realized we could transfer our core innovations from our supercapacitor work into Lithium-ion batteries, initially, to improve power performance. Since then, we have learned there are a wide range of additional benefits. Electrodes of ultracapacitors and Li-ion batteries are similar, both use polymer binders to "glue" active materials together and are manufactured with the same type of equipment. At the same time the supercapacitor company Maxwell was acquired by Tesla **(reference)**.

Our experience with supercapacitors, which use only hard carbon (the same as in Sony's original LIB anode), made it easy for us to switch to graphite-silicon anodes for batteries. This was because both could be processed with water-based solutions.

The cathode was more challenging because its active material degrades in contact with water. While NMP (N-methyl-2-pyrrolidone), which is used in the industry to dissolve PVDF (polyvinylidene fluoride), is compatible with NX technology, we have looked at other, more auspicious options to improve handling safety.

What has been the impact of GM's investment in Nanoramic? How has this partnership shaped your direction?

We are excited to work closely with General Motors to enhance the Neocarbonix technology and commercialize it onto their Ultium battery platform for EV lithium-ion batteries. Our technology is not limited to passenger EV applications, we are also actively working with our customers worldwide on applications in heavy duty, stationary storage, mobile devices, drones & eVTOL and power tools. However, the strategic partnership we formed with General Motors in 2023 has helped us achieve our goal of improving sustainability, performance, and cost benefits by combining our expertise with GM's industry knowledge to advance our technology.

Overall, GM's investment and partnership has helped us refine our solution for EV battery applications and gave us a clearer path to bring our technology to market.

As you state on your website, your battery technology especially addresses some sustainability concerns. Can you tell us more about this, especially when it comes to PFAS-free and NMP-free materials?

Sustainability is a big issue in battery manufacturing, and with our technology we are trying to address it from several angles. First, our Neocarbonix electrodes are PFAS-free, which is a key sustainability feature. It replaces the commonly used PVDF in cathode electrodes. This is significant because recently, there has been increased attention on PFAS in lithium-ion batteries, highlighting the importance of PFAS-free alternatives **(reference)**.

PVDF is only soluble in a limited range of solvents, which come with their own drawbacks, such as NMP. Here, our NX technology offers more freedom in solvent selection. We have implemented a green solvent that is safer and less corrosive than NMP but maintains the same coating parameters and can be used with existing Gigafactory manufacturing equipment. Replacing NMP is becoming a critical concern for factory workers in the US, so eliminating it addresses an important safety issue.

A second aspect of NMP replacement is cost and energy savings. Energy consumption of 25% from powder to cell, and up to 75% in the electrode manufacturing process can be saved. Without PFAS, our NX electrodes are also easier to recycle at end-of-life. We have worked with partners like RecycLiCo to validate this improvement in battery recycling processes **(reference)**.

These advancements make our technology more sustainable and safer. They also maintain performance and compatibility with existing manufacturing processes.

Talking about security. What are the health risks associated with NMP and PFAS and how are they regulated in the EU and US?

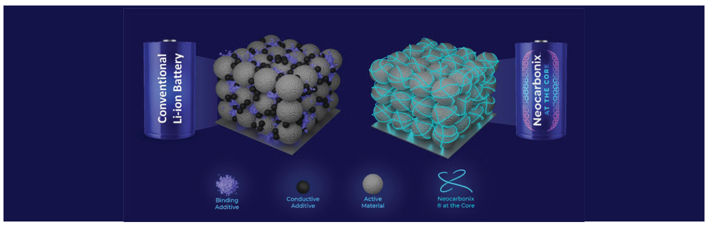
There is ongoing research and regulatory scrutiny of the health risks associated with NMP and PFAS also known as "Forever Chemicals". For NMP the European Chemicals Agency (ECHA) **(reference)** and the U.S. Environmental Protection Agency (EPA **(reference)** have expressed their concerns. EPA found that "NMP presents unreasonable risk to the health of workers for all occupational uses".

PFAS chemicals due to their persistence in the environment, have been associated with a range of health issues **(reference)**. There is growing concern about their presence in various industries, including the production of electric vehicle batteries. This leads to a supply chain risk for these materials.

From a regulatory perspective, both the EU and the US are taking steps to address these chemicals. The ECHA has implemented measures to restrict the use of NMP, while the EPA is working on regulations to limit exposure to PFAS. It's important to note that the regulatory landscape is evolving as new research emerges.

Can you explain a little more about how your electrode technology eliminates the need for potentially hazardous chemical solvents and fluorinated binders in battery manufacturing?

Our NX technology addresses the historical use of hazardous materials in battery manufacturing. While traditional lithium-ion batteries used PVDF in both anodes and cathodes, the industry has since replaced it in anodes with more sustainable, water-soluble alternatives. However, cathodes remained a challenge due to the reactivity of active materials with water and the lack of alternatives by material suppliers.



Neocarbonix is bridging this gap and offers an alternative for battery manufacturers to replace PVDF binder in their cathodes. While NX technology is compatible with NMP, we have focused early on developing safer, non-aqueous solvent alternatives for our customers.

The technology's flexibility in solvent choice allows us to create more environmentally friendly manufacturing processes without compromising battery performance or production efficiency. This adaptability is key to meeting evolving safety and environmental standards in battery manufacturing.

How exactly does your technology contribute to energy savings in the process and to a more sustainable manufacturing process?

Evaporating and recovering NMP solvent during the conventional wet-coating manufacturing step is one of the dominating energy drivers in battery production. By using low-boiling-point solvents, our NX technology improves the energy efficiency and sustainability of battery manufacturing. Third-party simulations show that we can reduce energy consumption in electrode manufacturing by up to 75%. For a typical Gigafactory this could reduce CO_2 emissions by approximately half a million metric tons per year. We achieve these improvements without requiring major equipment changes.

Can you explain the 3D carbon binding structure and its advantages over conventional plastic fluorinated binders used in Li-ion batteries?

Traditional binders simply act as an adhesive, holding particles in place and attaching them to the current collector. However, their insulating nature requires additional conductive additives for electron flow. In contrast, NX forms a carbon scaffold structure that encapsulates the active material particles resulting in the same functionality as a conventional binder.

This unique structure serves a dual purpose, providing both electronic percolation and structural integrity. While PVDF is essentially "dead weight" in batteries, our NX binder is multifunctional. It not only binds the electrode materials, but also reduces electrode resistance, improving battery performance. This dual role of binding and improving conductivity allows us to create more efficient batteries while eliminating fluorinated compounds.

What kind of performance improvements does Neocarbonix offer over conventional Li-ion batteries, particularly in terms of energy density and charge time?

The NX structure changes the way battery manufacturers can design electrodes. Its dual function as a binder and conductive additive reduces the weight of the electrode. The scaffold structure allows the integration of expanding materials, such as silicon, while maintaining structural integrity. Higher electronic percolation allows for thicker electrode designs, resulting in smaller batteries. Overall, NX can improve cell energy density by 30–50% while still enabling fast charging in less than 15 minutes. This is significant because conventional LiBs typically face a trade-off between energy density and fast charge performance. Our technology addresses both simultaneously.

Can you explain how thicker electrode packs could also help reduce the cost of making batteries?

Well, thicker electrode layers reduce cost in several ways. In a lithium-ion battery, we have several layers of active coatings and passive components such as current collectors and separators. By increasing the thickness of the electrodes, we can reduce the number of layers by about 30%. This saves a lot of material and even reduces the volume of the battery.

It also increases the throughput of all manufacturing units—coating, calendaring, slitting, stacking, and so on. This improvement not only reduces operating costs, but also the capital cost of new factories. In essence, thicker electrodes allow us to produce more batteries more efficiently, reducing costs across the board.

You offer a lot of relevant benefits for battery manufacturing. So, what are the main challenges in the replacement of both the binder and the solvent in the battery manufacturing process?

Tstandards for a long time, with extensive experience and training built around them. The real hurdle is getting people to think outside the box and embrace new technologies. It's more about overcoming mental barriers and established practices than technical limitations.

Why do you think no other company has achieved this dual replacement?

The primary focus of battery manufacturers has been on scaling up production, with a secondary focus on improving and adopting new innovations and processes. Today, faced with overproduction and competition from Asia, cell manufacturers have begun to shift their priorities. We're now seeing increased activity in both raw materials and manufacturing improvements as companies try to gain a competitive edge.

In summary, how does Neocarbonix contribute to the reduction of the carbon footprint and the improvement of the sustainability of battery manufacturing?

Neocarbonix improves sustainability in three ways. First, it eliminates fluorinated polymers such as PVDF and PTFE, which have much higher CO_2 equivalents. Second, its design efficiency reduces the carbon footprint per unit of cell energy. Finally, its use of low-boiling-point solvents reduces coating power consumption by up to 75%, resulting in an overall 25% reduction in cell manufacturing energy.

And you say that your Neocarbonix technology is compatible with existing equipment and processes used to manufacture batteries?

Yes, Neocarbonix is fully compatible with existing equipment. It can be used in current Gigafactories worldwide without any changes to manufacturing processes or machinery.

So, what is the impact of your technology on the future of electric vehicles and renewable energy storage?

Our technology addresses key challenges in electric mobility. As the industry has reduced the use of cobalt in batteries, our focus is on increasing battery efficiency while further reducing reliance on critical materials. This approach aims to make electric mobility more affordable and accessible to everyone, supporting the broader transition to sustainable transportation and energy storage.

Do you have any success stories or case studies that you can share where your technology has made a significant impact?

We have worked successfully with several OEMs and battery manufacturers. One notable example is GM, which invested in our company following successful technology evaluation. While we can't disclose specifics about other customers, this partnership with a major automotive company demonstrates the potential impact of our technology.

Looking ahead, what do you see as the biggest challenges and opportunities in the sustainable battery technology sector?

The main challenge and opportunity lie in cost reduction. While electric mobility is more sustainable than internal combustion engines, it needs to become more affordable. Increasing battery cell efficiency is key to making electric vehicles accessible to a broader market, driving the transition to sustainable transportation.

As a last question, what are the next major milestones or developments Nanoramic is working towards in the coming years?

Well, our focus is on scaling up production to meet global demand. We have already shipped prototype cells and electrodes to partners, and now we are expanding our manufacturing capabilities. While we have numerous commercial opportunities, we are strategically targeting a select group of high-impact customers to accelerate the global adoption of Neocarbonix. Our goal is ambitious, but realistic—within three years, you could find our PFAS-free binder in your next mobile device or EV battery.

Contact us for more information on our chemicals for battery applications

For more information about chemicals for materials research and development, visit:
thermofisher.com/battery-chemicals