Battery technology: Indian players double down on sodium-ion chemistry as China tightens lithium-ion stranglehold

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A super-fast charging sodium-ion (Na-ion) battery that can charge up to 80 per cent in just six minutes and claims to last over 3,000 charge cycles, nearly comparable with the more ubiquitous lithium-ion batteries. This is a breakthrough claimed by a research team at the Bengaluru-based Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), an autonomous institute of the Department of Science and Technology, and is being touted as yet another promising step in India's efforts at nurturing an alternative to the lithium-ion chemistry — the most common element in battery manufacturing where China has a virtual stranglehold. Beijing controls the global lithium-ion battery supply chain as well as the world's lithium refining capacity used for battery storage and electric cars, and now has two of the biggest li-ion battery makers — CATL and BYD.

Sodium-ion offers promise

Developed by a JNCASR team led by Prof. Premkumar Senguttuvan and Ph.D. scholar Biplab Patra, the new battery is based on a 'NASICON-type' chemistry, a class of polyanionic materials with a known structure in electrochemical materials, but with a significantly enhanced performance claim using novel material engineering. Unlike conventional sodium-ion batteries that suffer from sluggish charging and short lifespans, this new battery uses a smart mix of chemistry and nanotechnology to demonstrate a significantly lower charge time and more charge cycles.

In an earlier interaction with The Indian Express, Principal Scientific Advisor to the Government of India, Ajay Kumar Sood had stressed on the need for India to look beyond the lithium chemistry for batteries and how sodium ion was already an option. "Multiple technologies (is the way forward)… In the case of EVs, I don't think that lithium chemistry (for batteries) is the end of the world… Other electro chemistries have to be tried, and are being tried… Solid, solid state batteries are the ultimate, in my view, because they'll be the safest, and energy density will be the highest, but there you still have some R&D issues, so it's still not commercial yet… But that's where we should work. Fully solid state batteries, where the electrolyte is also solid. But sodium ion batteries are already an option. It's happening…"

Multiple players

There is more promising work in the sodium ion battery tech that is happening in India. In February this year, Pune-based KPIT Technologies and Trentar Energy Solutions Pvt Ltd, a company targeting the electrical mobility and energy storage space, announced a collaboration on sodium-ion battery technology. Under this, KPIT said it will transfer its new sodium-ion battery technology — which it claims has an extended lifespan (80 per cent capacity retention over 3,000-6,000 cycles), and faster charging capability than lithium batteries — to Trentar Energy Solutions. The latter will operationalise and commercialise the technology further. Earlier, in May 2023, scientists at the Indian Institute of Technology Bombay claimed a breakthrough in developing sodium-ion batteries by addressing the challenges of air-water instability and structural-cum-electrochemical instability in cathode materials.

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While lithium is the more common element being used in rechargeable battery manufacturing, the stranglehold of China in this sector is a cause for worry, especially given Beijing's willingness to weaponise its dominance over particular technologies. Its Li-ion dominance notwithstanding, Chinese companies are also stepping up their play in the sodium ion chemistry. CATL, the world's biggest battery maker that supplies Li-ion batteries to Tesla and GM, has said it will mass-produce by the end of 2025 its patented 'Naxtra' sodium-ion battery packs that would enable an electric vehicle to travel up to 500 km on a single charge.

Pros and cons of sodium chemistry

Given that lithium-ion batteries are made of scarce and expensive elements such as cobalt, nickel, copper and lithium, technology companies worldwide have been looking for alternatives. Sodium offers multiple advantages: it is way more abundant than lithium and can be extracted from seawater at relatively lower costs, unlike lithium, where availability is concentrated in a few countries and mining includes hard-rock excavations in regions other than the Li-triangle comprising Argentina, Bolivia and Chile; and sodium is more environmentally friendly and can be transported at zero volt, making it safer, unlike lithium, which is less environmentally friendly and must be always stored with a minimum charge, increasing fire risks. Also, a sodium-ion battery uses aluminum, which is cheaper than copper used in the lithium-ion battery tech. Sodium-ion batteries also have a higher operating temperature range and are hence safer, given that these can be used in more extreme temperatures without the risk of thermal runaway.

But the sodium chemistry has its problems too: given that this battery technology is still in its nascent stage, and very few companies operate in this segment, leading to higher costs. Sodium-ion based batteries have limitations of flexibility as they cannot be turned into various shapes like prismatic, cylindrical, and these are less energy dense and have less storage capacity compared to lithium-based batteries. Sodium-ion batteries also typically have a much lower cycle life as compared to the cycle life of commercial lithium iron phosphate batteries, which could be upwards of 8,000 times.

Tech tweaks

The team at JNCASR engineered a novel material for the anode and optimised it in three critical ways — shrinking the particles to nanoscale, wrapping them in a thin carbon coat, and improving the anode material by adding a small amount of aluminium. These tweaks,the scientists say, made sodium ions move faster and more safely, enabling both speed and durability.

Beyond just cost, these sodium-ion batteries could potentially power everything from electric vehicles and solar grids to drones and rural homes, making clean energy accessible where it's needed the most, a Department of Science and Technology statement said. The technology has been tested and validated through high-end methods, including electrochemical cycling and quantum simulations. What makes it especially exciting is that it not only supports rapid charging but also avoids the fire and degradation risks of traditional batteries.

While more development is needed before these batteries hit the market, the new formulation marks a continuing step forward in domestic research and development.