If Lithium is not the future of car batteries, what is?

A look at two battery chemistries vying with lithium to power our automobiles.

At the end of May, we looked at three lithium battery companies poised to revolutionize the automotive and aviation industries. This spawned a raft of questions from readers about a multitude of other battery chemistries, and which ones have a serious shot at dethroning lithium as the automotive battery king. First, a few words about predictions. Whether this quote came from legendary physicist Niels Bohr, or an old Danish proverb, the wisdom it contains rings true:

"Prediction is very difficult, especially about the future."

So, please take the following with a large pinch of salt.

Actually, salt is a good place to start! Remember China's **Contemporary Amperex Technology Co. Limited, (CATL**) and their announcement of a new condensed battery that has up to twice the energy output of equivalent-sized lithium-ion cells?[(1)] Well, they **are also launching a hybrid sodium-ion/lithium-ion battery pack for automotive use this year!**[(2)]

Sodium-ion batteries operate in a very similar fashion to lithium-ion batteries; however, they have several advantages over the latter. Sodium-ion batteries rely on hard carbon anodes and sodium/metal cathodes that do not require precious metals such as nickel, cobalt, chromium, or vanadium. No precious metals means avoiding many of the worst human and environmental impacts from battery mining and production.[(3)] Also, sodium is abundant worldwide and doesn't rely invasive and carbon-intensive mining practices. And, sodium batteries can operate in greater temperature ranges than their lithium-ion counterparts.[(4)]

This is all good news, but sodium-ion batteries are not as energy dense as lithium-ion batteries. They currently provide only 120 to 160 Watt-hours per kilogram (Wh/kg) of battery pack.[(4)] This is roughly half the energy density of the best conventional lithium-ion batteries[(5)] and only one-third of the energy density of CATLs most advanced lithium batteries.[(6)] So why would anyone want this seemingly inferior battery in their vehicle? Simple, cost!

Sodium-ion batteries are roughly half the price ($77 per kilowatt hour(kWh)) of their conventional lithium-ion counterparts ($151 per kWh).[(7)] CATL and other Chinese manufacturers, such as BYD Co. Ltd., understand that there is a large segment of the worldwide automotive market to whom cost is the driving factor for vehicle purchases. For these consumers, lower-range, lower- cost vehicles are an ideal fit, especially for those living in urban areas. Additionally, many industry observers see the intermingled use of lithium and sodium-ion batteries in battery packs - such as those CATL is proposing - as being a hedge against the peak prices that lithium is currently demanding.[(8)]

It should also be noted that this is only the second step in sodium-ion's commercialization journey and these batteries will likely improve over time. First launched by CATL in 2021, sodium-ion batteries must compete with lithium-ion batteries that have been in development for over two decades, a sizable head start. But, if sodium-ion cells can reach an energy density of 200 Wh/kg in this or the coming years, their future in the lower-cost end of the vehicle market may be very bright indeed.

So, what else is close? **Australia's Graphene Manufacturing Group (GMG) has produced a graphene aluminum-ion battery, commercializing research done by the University of Queensland.** Like the technology being relied on by US company Lyten, GMG's battery requires no precious metals for its cathode, and replaces lithium with aluminum in the anode. The battery can also operate over larger temperature ranges and the technology is lighter and cheaper than lithium. The latter is thanks to the large-scale industrial production of aluminum worldwide. Also, unlike sodium-ion batteries, energy density does not seem to be an issue. In December 2022, GMG's CEO, Craig Nicol, announced that their battery had achieved an energy density of 290 Wh/kg. This is roughly equivalent to conventional lithium-ion batteries.[(9)] And, all of this is possible even though GMG is not yet harnessing all the aluminum ions released in the electrochemical reaction in its batteries. If GMG resolves that issue, the energy density of their batteries may multiply by two to three times and that would be truly revolutionary!

Again, the aluminum-ion battery currently only has the same energy density as conventional lithium-ion batteries, so why are people excited about it? GMG has claimed that its batteries can charge at rates up to 70 times faster than lithium-ion with no battery degradation due to heat stress. Imagine a Tesla or EV that could charge to 300 miles of range in one to two minutes? That would pretty much end every argument regarding range anxiety and the convenience of fossil fuels.

Unfortunately, GMG is not producing its batteries at commercial scale just yet. In December 2022, Mr. Nicol expected that GMG would go into full- scale manufacturing of its coin cell battery (a watch size offering) in 2024. However, a recent $6 million investment by Australian mining giant, Rio Tinto, may delay this substantially. Under the Rio Tinto agreement, GMG's need to produce pouch-cell batteries (a multilayer battery in about the size of a typical printer page in an insulating bag or pouch) for testing in mining vehicles by 2025.[(10)] This has certainly fast tracked the company's efforts to produce a vehicle-grade battery which, when finished, could be used in any automotive application. It will be interesting to monitor the next few years of development for this very promising technology.

Conclusions

I selected these two battery chemistries because of how close they are to going into actual vehicles. There are others - such as magnesium-ion batteries - that are showing great promise at the laboratory scale but none that I believe are as far down the road to commercialization. Since both CATL and BYD will put their sodium-ion batteries in cars this year, and GMG in heavy equipment within the next two years, I think it won't be long before lithium-ion has serious

competitors in fueling the automotive future. This is good news for all of us and good news for those most directly impacted by current battery mining and production.

About the Author:

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