Future Publishing LLC

May 2022| Volume 01 | Issue 01 | Pages 28-29

Journal homepage: https://fupubco.com/futech

Future Technology

https://doi.org/10.55670/fpll.futech.1.1.5

Open Access Journal

News & Views

Alternatives to lithium-ion batteries in electric vehicles

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As of 2022, there have been new developments on batteries that use sodium instead of lithium. These batteries are known as sodium-sulfur batteries. They use sodium as the negative electrode and sulfur as the positive electrode to store and discharge the electricity.

Ten years ago, there were not many electric vehicles driving on the roads, but in 2021 over six million battery electric vehicles were sold [1]. The increase in demand for battery electric vehicles calls for a large need for improvements in the technology for these vehicles. Lithium-ion batteries have made exceptional progress since they were first developed in the mid 1900's. These developments are not satisfactory to today's standards for the environment. Scientists and engineers have deployed various alternatives to lithium-ion batteries. A number of these alternatives can store more energy or have a longer lifetime. Additionally, many of them can mitigate CO_2 emissions and be considerably more easily attainable. Environmentally, it is known that lithium is not the leading option for batteries. The extraction of lithium can lead to deforestation and a substantial increase in CO_2 in the atmosphere. Lithium batteries have also been found to cause fires in landfills when not disposed of properly. As of 2022, there have been new developments at The University of Texas at Austin on batteries that use sodium instead of lithium [2]. These batteries are known as sodium-sulfur batteries. Sodium-based batteries were first developed by General Motors in the late 1900s, but these batteries did not have an extensive lifetime. They use sodium as the negative electrode and sulfur as the positive electrode to store and discharge the electricity [1]. Like lithium-ion, these batteries can be used for many things other than just electric vehicles. Experiments at the University of Texas were done on the electrolyte inside the batteries. This electrolyte affects the sulfur in a way that it will dissolve. If this electrolyte is not the right substance, it will lead to a material loss known as shuttling [3]. The loss of material would lead to a shorter lifetime and an unstable overall performance. In the previous sodium-sulfur batteries, the sulfur always had this issue with shuttling, explaining why the batteries were never able to be sold in high demand. Sodium is not a cause of the increasing CO_2 emissions in the atmosphere. Expanding the extraction of these materials could lower the emissions of CO_2 even though it will still release greenhouse gasses such as SO_2. In addition, alternatives of sulfur and sodium in the batteries would aid in the decrease in the price of batteries. Lithium prices are at an all-time high in the current year of 2022. Underlying materials such as cobalt are a cause of this increase. Lithium-ion batteries use other materials, which are not abundant resources like sodium, causing a price increase [2].

Nickel, manganese, and cobalt are used in most lithium-ion batteries in electric vehicles. However, other automakers, such as Tesla and Ford, are going to employ lithium iron phosphate (LFP) batteries in at least some of their vehicles, which are popular in China. These LFP batteries, however, cannot store as much energy per pound as lithium-ion batteries, but they're far cheaper and last much longer. Tesla intends to use LFP batteries in electric vehicles with shorter ranges and lower prices. Ford intends to utilize them in some fleet-oriented trucks offered under the Ion Boost Pro name. Tesla equipped with these batteries can only travel roughly 270 miles on a single charge, compared to 358 miles for equivalent models equipped with nickel and cobalt batteries. When the temperature dips below freezing, LFP batteries lose some of their power and take longer to charge [4]. Tesla is leading the way in shifting lithium-ion battery technology away from nickel-based chemistry and toward LFP. The adoption of LFP will go a long way toward making electric vehicles more affordable. They are less expensive, have a lower energy density, and a shorter (but acceptable) range than nickel-based lithium-ion batteries, which will continue to be utilized in more expensive electric cars with longer range requirements [5]. On the other hand, Tesla's next-generation battery known as "4680" is going to be implemented in their Model Y crossovers; the reason why it seems popular is due to the distinctive honeycomb construction which will be able to provide 16 percent more range in its pursuit. Furthermore, General Motors' Ultium battery cell requires 70% less cobalt than the Chevrolet Bolt electric hatchback's cells [4]. The large-format, pouch-style cells of Ultium batteries are unique in the market because they may be stacked vertically or horizontally inside the battery pack. This helps engineers optimize the storage and placement of battery energy for each vehicle design. Energy options range from 50 to 200 kilowatt-hours, allowing for a GM-estimated range of up to 450 miles on a single charge and 0-60 mph acceleration in under three seconds. Level 2 and DC rapid charging are built into GM's future Ultium-powered EVs. Most will feature 400-volt battery packs and fast-charging capabilities of up to 200 kW, while GM's truck platform will have 800-volt battery packs and 350-kW fast-charging capabilities [6]. Solid-state batteries lack a liquid electrolyte, making them lighter, storing more energy, and charging more quickly; moreover, they are less prone to catch fire, requiring less cooling equipment. Volkswagen and BMW have both invested in and are implementing this technology. Solid Power, the industryleading producer of all solid-state batteries for electric vehicles has announced a $130 million Series B investment round led by the BMW Group, Ford Motor Company and Volta Energy Technologies. Ford and the BMW Group have also extended their existing cooperative development agreements with Solid Power to ensure that all solid-state batteries for future electric vehicles are secure. The company however has also reinstated that they can manufacture all solid-state batteries using existing lithium-ion battery manufacturing infrastructure. QuantumScape, an ambitious Silicon Valley start-up, has stated started the same project planning to commercialize solid-state batteries by 2024 [7].

Toyota is planning to use its first solid-state battery in an electric vehicle by 2030, and other automakers are quickly following suit, forming collaborations with battery producers all around the world.Rapid charging of batteries, improving battery range, developing equitable charging infrastructure, and addressing battery end-of-life options are critical next steps in the complex challenges of vehicle electrification, and sales forecasts now always seem to include the word exponential, but if battery technology fails to make the assumed improvements.

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