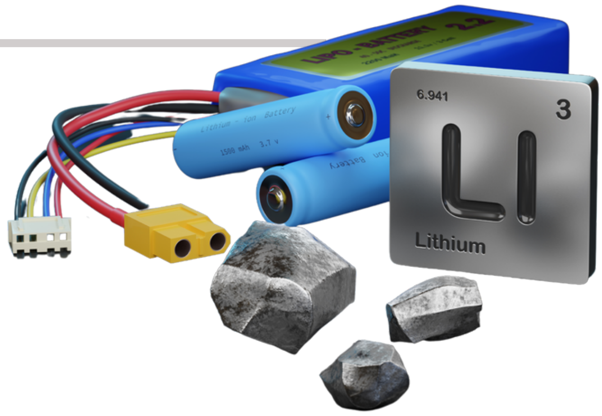
Can Solid-State Batteries Eventually Replace LITHIUM-ION IN EVS?



DR. ANJALI SINGH

RESEARCH SCIENTIST, STRATEGIC STUDIES SECTOR, CENTER FOR STUDY OF SCIENCE, TECHNOLOGY AND POLICY (CSTEP)

The ongoing transition from fossil fuel to green fuel is a giant step that every country is willing to take irrespective of its challenges—in a bid to achieve the net-zero emissions goals by 2050. Large-scale electric vehicle (EV) adoption is one of the ways of achieving these ambitious goals. However, the challenges associated with conventional lithium-ion battery (LiB) technology—a key component of EVs— threaten to slow down the adoption of EVs at a mass level.

Currently, LiBs are beset by limited energy density, shorter lifespans, and safety issues, which can derail the green-fuel transition process. EVs require safe, lightweight, fast-charging, and durable batteries, in order that the end users to accept them. LiBs lack these features due to the presence of liquid electrolytes (the chemical that allows lithium-ion flow between the cathode and anode terminals of a battery). On the other hand, solid-state batteries (SSBs), which are made of solid ceramic material (instead of liquid electrolytes), are lighter and safer as compared to conventional LIBs.

Solid electrolyte offers better conductivity than liquid ones, resulting in a 25% to 30% enhancement in power and energy density. Further, one-third of the EV weight comes from LiB, which can be reduced significantly by shifting to lightweight SSBs. Also, SSBs can be charged six times faster than LIBs.

In terms of material demand, SSBs require 35% more lithium as compared to LiBs, but lesser cobalt and graphite. Cobalt is a critical raw material (CRM), which is used in large quantities in manufacturing conventional LiBs. The near monopoly of the Democratic Republic of Congo region over cobalt mining is a concern for its supply and pricing. A shift to SSB will reduce cell-manufacturing industries' dependency on cobalt by 45%. Currently, the two well-known chemistries used in EVs are nickel cobalt manganese (NMC) and lithium iron phosphate (LFP). Due to the huge cost reduction (owing to the elimination of cobalt use) offered by LFP-SSBs, they are being promoted by leading automobile companies.

This year, some southern states of India witnessed a series of explosions in electric two-wheelers during peak summers. One of the factors responsible for these explosions is the liquid electrolyte used in LiBs. These batteries can swell due to temperature variation or even leak from mechanical stress, thus becoming fire hazards. In fact, poor safety is the most worrisome aspect of using LiBs. Conversely, SSBs have excellent safety, which is their biggest advantage. Moreover, SSBs can withstand extreme weather conditions (-20 °C to 80 °C), making them ideal for tropical countries like India.

SSBs have shown great potential in early research and will be a technology to watch out for in the future. However, despite the lower cost, better safety, and longer running range, the success of SSB will depend on a broad range of other factors such as the future EV-industry demand and the manufacturers' ability to overcome the initial manufacturing cost. Also, the mass production of SSBs and finding suitable materials for use as electrolytes will be some of the major challenges in the context of their commercialization. Given the rapid increase in battery demand, SSBs along with LIBs can be a great asset.