Chemicals

The state of solid-state battery innovation

Heather Platt, PhD shares insights on the chemistry of solid-state batteries and what the future could hold for this technology

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The what and why of solid-state batteries

Heather Platt has spent her career exploring battery chemistry and how to make a better battery. Today, her focus is on expanding development of solid-state batteries. All **batteries** consist of an **anode**, a **cathode**, and an **electrolyte**, which is the component that transfers ions back and forth between the anode and cathode to cause the battery to charge and discharge. In solid-state battery cells, Heather noted, "You can use solid electrolytes instead of liquid electrolytes."

The advantages, according to Platt, are, "Solid-state can enable the higher energy electrode active materials, silicon and NMC in particular, and have a significant advantage in how they're made." When asked to expand on the manufacturing advantages of solid-state battery technology, she explained that with liquid electrolyte batteries, "Your cell is in its can or in its pouch, but then you have to spend potentially 2 days putting it through the right temperature and a very specific slow charge and discharge. So solid-state being able to take that piece out would be transformative in terms of cost."

When asked about any other advantages of all-solid-state battery cells, Heather added that, "You can use less flammable **solvents**." In the end she says, "You can have a safer cell that can be manufactured in a shorter time."

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Solid electrolytes—not an oxymoron

To many chemists, the terms solid-state and electrolyte might seem like an oxymoron given that electrochemistry is typically taught in the context of solutions. Platt explained that solid electrolytes tend to fall into two different categories, polymeric or ceramic and glass-ceramic.

"The polymeric type is closer to the classic liquid electrolyte where you have your cations and anions dissolved in solution, in solvation spheres, and they're moving around in response to changes in the polarity of the cell and what's going on with the electrodes." These polymers are typically materials like polyethylene oxide or polyacrylonitrile. Platt explained that these polymers, "need hetero atoms like oxygen, nitrogen or sulfur in the polymer chain frequently enough to allow ions like lithium to hop from one hetero atom to the next." These polymeric solid-state electrolytes do have some solvent, but it's far less than that of a traditional lithium-ion battery.

Ceramic and glass-ceramic electrolytes are more rigid and rely on conductivity of cations via channel-like structures in the materials. Heather points out that these electrolytes are interesting in that, "You're not going to have the anions moving around because they're fixed in your solid structure." Platt likens these materials and structures to playgrounds with features that children can crawl through. She says, "If you get it right, you have enough of these 'slides' going through your ceramic, and then lithium ions have lots of places to go and they can move very easily." She goes on to add, "What's tricky and has taken some number of decades to work out is what specific structures have enough of these channels or these 'slides' to get the same level of ionic conductivity that you can get with a liquid electrolyte."

Real and here to stay

While some still think of solid-state batteries in the future tense, Platt assures us, "There are polymer solid-state batteries in the market right now." She tells us that the automotive industry is embracing sulfide-based solid-state batteries and shares the following examples. "One automaker is currently using this technology in buses, which is a nice use case because it's a little bit more of a controlled charging environment. I'll also note that another automaker has a prototype vehicle with a sulfide-based solid-state pack ready for demonstration at the Tokyo Olympics."

On being asked about her comment on controlled charging, she offered, "These cells have to be charged in a very specific way, but certainly at least one of the big automotive OEMs is going to put a solid-state battery pack out at some point." To this point, she added, "**Solid Power Inc.** has a licensing agreement with a major automaker and has announced that they are on track to be producing enough sulfide solid electrolyte for 800,000 vehicles a year by 2028. So that's pretty definitive. Those are real numbers, based on real progress."

On the reasons Platt says that the electric vehicle (EV) industry is keen on solid-state batteries, she reminds us of her earlier points about these cells having higher energy, manufacturing process advantages, and safety benefits. On the aspect of safety she noted, "When you have a safer cell that you're putting it into a vehicle, you don't have to do the same things regarding engineering safety controls. I think solid-state could be transformative from a design and production standpoint."

Bringing Chemistry to Life

For a deeper dive into this discussion and Heather Platt's work, check out her interview on the **Bringing Chemistry to Life** podcast. There, we learn more about her background and get into much more detail on battery chemistry and where this field of research is headed.

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