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Synthesis of Nanosized Cubic Lithium Lanthanum Zirconate (LLZO) Fast Ion Conductor

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Lithium lanthanum zirconate (Li7La3Zr2O12, LLZO) is a promising fast ion conductor for Li-ions, with the potential to greatly enhance the energy density and safety of future Li-ion batteries. Many advantages can be obtained by reducing the size of this material to nanometric dimensions. These include but are not limited to: (1) the ability to stabilize the highly conducting cubic phase without the need for extrinsic dopants; (2) enhanced densification and sintering properties; and (3) lower temperature and lower cost preparation methods. However, current methods to obtain nanostructured LLZO are challenging. Most LLZO is synthesized through solid state reactions, typically requiring high temperatures, repeated heat treatments, ball milling or other mixing methods, as well as carefully controlled addition of extrinsic dopants to stabilize the cubic phase at room temperature. In some cases, dopants used in these processes can form impurity phases, particularly at interfaces and grain boundaries, resulting in reduced overall conductivity. Researchers at Arizona State University have developed a rapid, simple, and inexpensive method to synthesize nanocrystals of LLZO, with the desired cubic crystal structure and without need for extrinsic dopants. This is accomplished by first intimately mixing salts of lithium, lanthanum, and zirconium with salts of a composition suitable to form a molten reaction medium. Next, the mixture is heated to the desired temperature for the desired time, after which reaction products are obtained by simple washing methods with water. The resultant product is a phase-pure, highly crystalline powder of cubic LLZO.

This technology is covered by U.S. Pat. No. 11,053,134. Potential Applications:

- Li-ion batteries
- Solid-state electrolytes

Benefits and Advantages:

- Able to generate large amounts of material from inexpensive precursors in as little as one intermediate-to-high-temperature (700-1000 °C) step
- Reduced lithium volatilization
- Reduced energy usage
- No use of extrinsic dopants
- Lower temperature processing may enable easier and less costly fabrication such as roll-to-roll processing