Application of plate-like Li_6PS_5Cl synthesized by liquid-phase synthesis to sheet-type electrodes for all-solid-state lithium batteries

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Abstract

All-solid-state lithium batteries employing sulfide solid electrolytes have emerged as promising next-generation batteries for large-scale energy storage applications in terms of safety and high energy density. Among the sulfide-based solid electrolytes, Li_6PS_5X (X = Cl, Br, I) with agyrodite structure synthesized by planetary milling exhibits rather high lithium ion conductivity of $10^{-2} \sim 10^{-3}$ S cm^{-1} at room temperature. Unfortunately, the planetary milling process has the disadvantage, in producing such solid electrolyte with large and round shape particles. Recently, the sulfide-based solid electrolytes have been synthesized not the mechanical milling process but liquid-phase process, which facilitates synthesis of nanosized solid electrolyte particles. It is important to reduce the particle size of the solid electrolyte, so that promote intimate contact with the active material in the composite cathode. Furthermore, solution process is performed in order to overcome this issue that it is difficult to prepare the composite cathode with large contact area between the solid constituents. The solution process has the advantages to prepare the composite cathode with low porosities, so that promote favorable ionic contacts.

In this study, nanosized plate-like Li_6PS_5Cl was, for the first time, successfully prepared by the liquid-phase process. Not only ethyl acetate was employed as a solvent containing the ester group since it has appropriate boiling point (77.1 °C) but also electrochemical and structural evaluation of all-solid-state lithium batteries using the plate-like Li_6PS_5Cl solid electrolyte was performed after solution process for the composite cathode.