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Systematic investigation of sensitivity of sulfide-based solid electrolytes for lithium-ion batteries towards humidity

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All-solid-state lithium-ion batteries (ASSLIBs) attract huge interest of researchers and battery manufacturers since they are the most promising candidates for future safe energy storage devices with high energy density for electric transport [1]. However, an important obstacle for wide commercialization of sulphide-based solid electrolytes (SSEs) for LIBs is their extremely high reactivity with traces of humidity leading to toxic H_2S evolution. Therefore, a deep understanding of reactivity of SSEs with water is a key factor to optimise intrinsic characteristics of SSEs as well as a production process of ASSLIBs ensuring its safety and reliability. Very limited amount of literature data is available on the topic [2, 3].

In this work, reactions between SSEs and water were investigated with high precision using a home-made test assembly. Commercially available SSEs, such as Li_3PS_4 , $\text{Li}_7\text{P}_3\text{S}_{11}$, $\text{Li}_{10}\text{GeP}_2\text{S}_{12}$, $\text{Li}_6\text{PS}_5\text{Cl}$ and $\text{Li}_6\text{PS}_5\text{Br}$ were investigated at different scales (from few milligrams to 1g). The developed test assembly is based on gas flow-through cell for the analysis of SSE powders and pellets and continuous H_2S measurements thanks to ultra-sensitive laser detection equipment. Specific attention was paid to reproducibility of the results. The levels of humidity were chosen to mimic a dry room atmosphere. A strong relationship was found between the composition of SSEs, their surface area and reactivity towards humidity. Passivation phenomena were observed in some cases upon exposure to H_2O . Additional advanced characterisation methods helped to understand the differences in reactivity of SSEs with water.

Literature:

[1] C. Wu et al., Nano Energy 2021, 87, 106081. [2] P. Lu et al., Adv. Mater. 2021, 33, 2100921. [3] T. Ohtomo et al., J.Mater. Sci. 2013, 48, 4137.