Interfacial layers to enable recyclability of solid-state lithium batteries

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All-solid-state batteries are promising energy storage devices due to their high energy density and light weight. The potential massive production and lack of recycling methods necessitate the development of strategies to address the problem of spent batteries. Current implemented recycling methods are designed for conventional liquid electrolyte batteries and require the use of organic solvents or high-temperature furnaces, which are not environmentally friendly. Here, we proposed an architectural design for recyclable all-solid-sate lithium batteries by introducing interfacial layers at electrode interfaces. Flexible lithium perchlorate doped polypropylene carbonate (PPC-$LiClO_4$) thin-films improve contacts between Li metal and $Li_7La_3Zr_2O_{12}$ (LLZO)-based composite electrolytes, LLZO–PPC–$LiClO_4$, thus lowering interfacial resistances. In addition, polymer-salt layers serve as sacrificial layers to enable clean separation of electrodes and solid-state electrolytes. Recovered battery components demonstrate the retention of crystalline structures of ceramic materials. Full cells incorporated with recycled components shows modest degradation in cycling performance suggesting the preservation of electrochemical properties in recycled components. We provide insights on the design of recyclable all-solid-state lithium batteries to fulfill a long-term and sustainable battery recycling strategy.