Bio-sourced Alternatives for Lithium-Silicon Anodes (BALSA)

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The **BALSA** project aims to develop a bio-based Li-ion battery (LIB) anode and quasi-solid-state electrolyte, in which most of the active and supporting materials are derived from biological sources. The project combines mesoporous Si derived from barley husks, a cellulose-based carbon nanofiber aerogel as a free-standing support, and a bio-derived quasi-solid-state composite electrolyte containing a poly(ionic liquid) scaffold, bio-based fillers, and ionic liquid additives.

To date, the **BALSA** project has made significant progress along multiple directions of incorporating bio-based materials as LIB active and supporting materials. Firstly, the synthesis and development of mesoporous Si from barley husks has been optimized for control of the specific surface area and pore size as well as increasing the scale of production to 6 grams per week. Half cell testing showed stable cycling capacity between 1000 and 1200 mAh g^{-1} for more than 100 cycles while electrochemical dilatometry revealed reduction in mesoporous Si electrode expansion compared to a Si nanoparticle–based anode. New production processes have been developed for pyrolyzing cellulosic nanofiber into carbon nanofibers and successfully implementing them into high weight percent silicon composite anodes. Multiple types of quasi-solid-state electrolytes using bio-based SiO_2 additives have demonstrated the ability to extend the electrochemical stability window from 4.5 V up to 5.2 V and enhance ionic conductivity up to 1.19 mS cm^{-1} at 25 °C. LCA has identified bio-SiO_2 magnesiothermic reduction and Cu current collectors as major sources of emissions and used a prospective analysis to estimate the impacts of scaled-up industrial production. In conclusion, significant strides have been made in incorporating bio-based materials and tuning their properties for better performance. Many practical challenges remain, but these results indicate the viability of bio-based materials and their worthiness of future investment.

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