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Interface effects in polymer-based hybrid electrolytes for all-solid-state lithium-ion batteries

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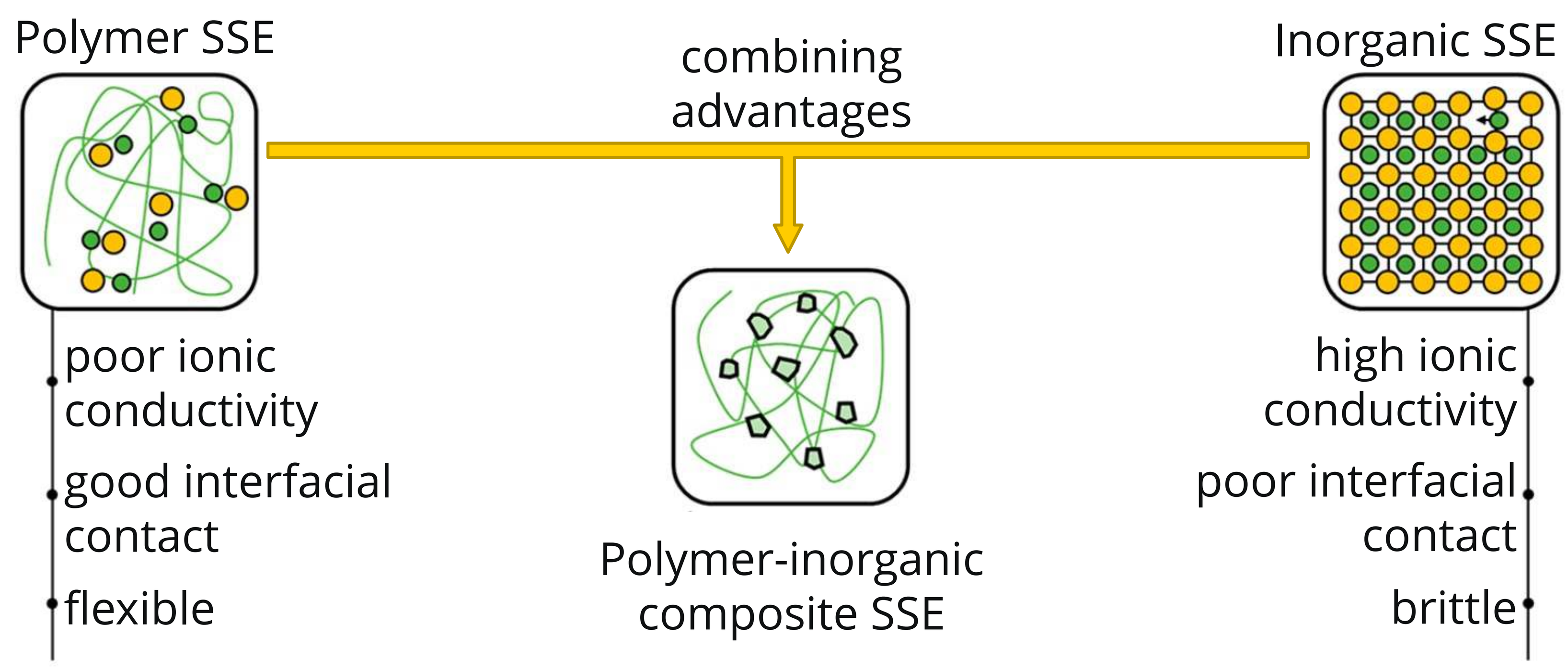
Summary

The goal of this project is to investigate the effects of interfacial reactions on the properties of nanocomposite and hybrid solid electrolytes for batteries, and to develop a detailed understanding of the nature of the interface interactions. Emphasis will be placed on the ionic conductivity and mechanical properties of the interface layers. For this purpose, new but also already known Li-compounds will be used in combination with polymers and inorganic fillers to synthesize polymer-based hybrid solid electrolytes. The fundamental knowledge is crucial to developing new electrolytes with tailor-made properties for applications in all-solid-state Li-ion batteries.

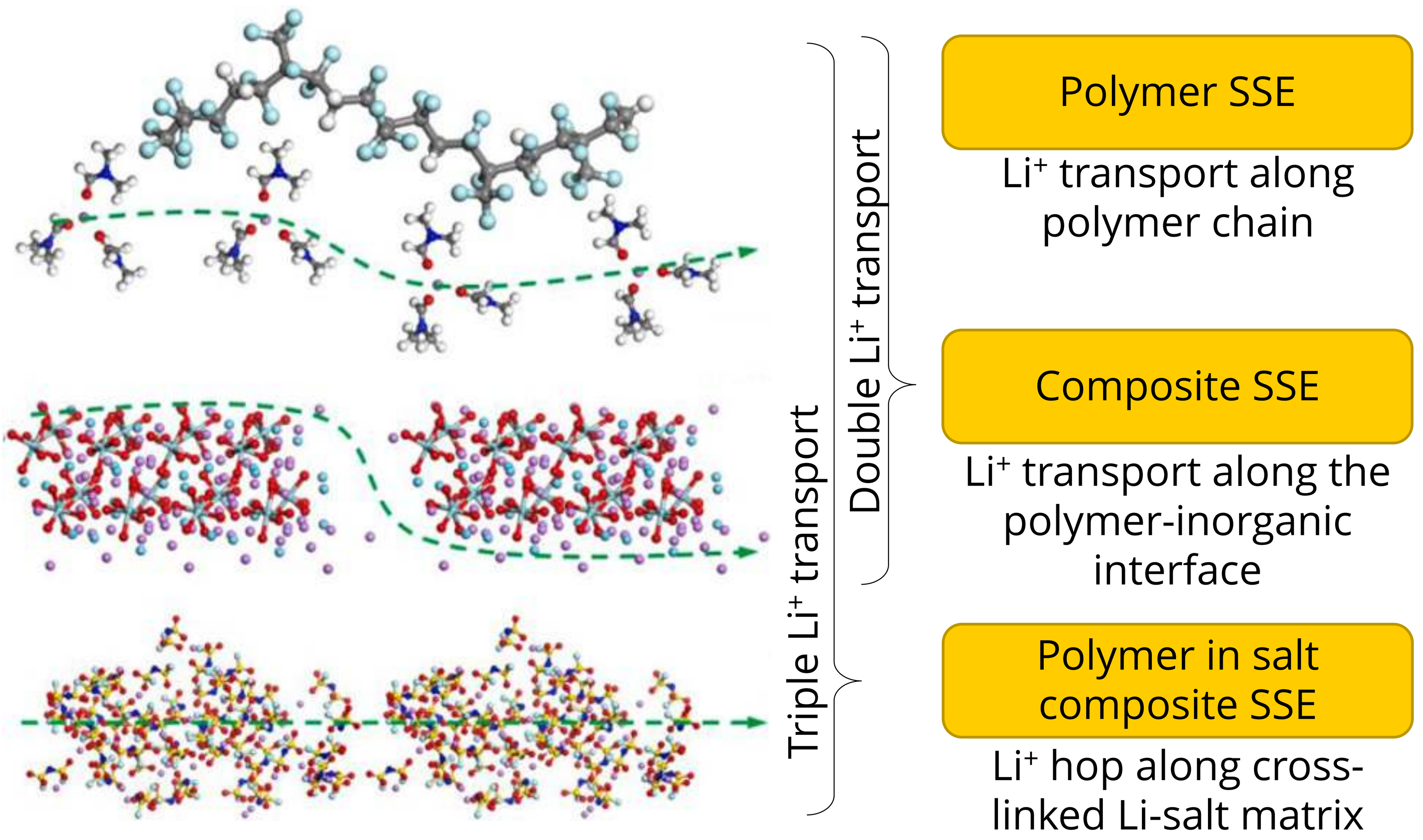
Introduction

Researchers have been focusing on the development of novel Lithium-ion conductive solid electrolytes for decades. These materials are intended to replace the flammable and therefore unsafe liquid electrolytes used in conventional Li-ion batteries. Generally, there are two types of solid-state electrolytes (SSE): inorganic solid electrolytes (such as $Li_{0.348}La_{0.55}TiO_3$) that can have, for example, high Li-ion conductivity but poor interfacial compatibility with the electrodes, and on the other hand there are elastic polymer electrolytes (such as PEO based) which possess good interfacial compatibilities with the electrodes, but often poor ionic conductivity especially at room temperature. Here we aim to combine these two types of electrolytes to form polymer-inorganic composite SSE with advantageous synergistic properties[1,2].

Classification of solid-state electrolytes[3]

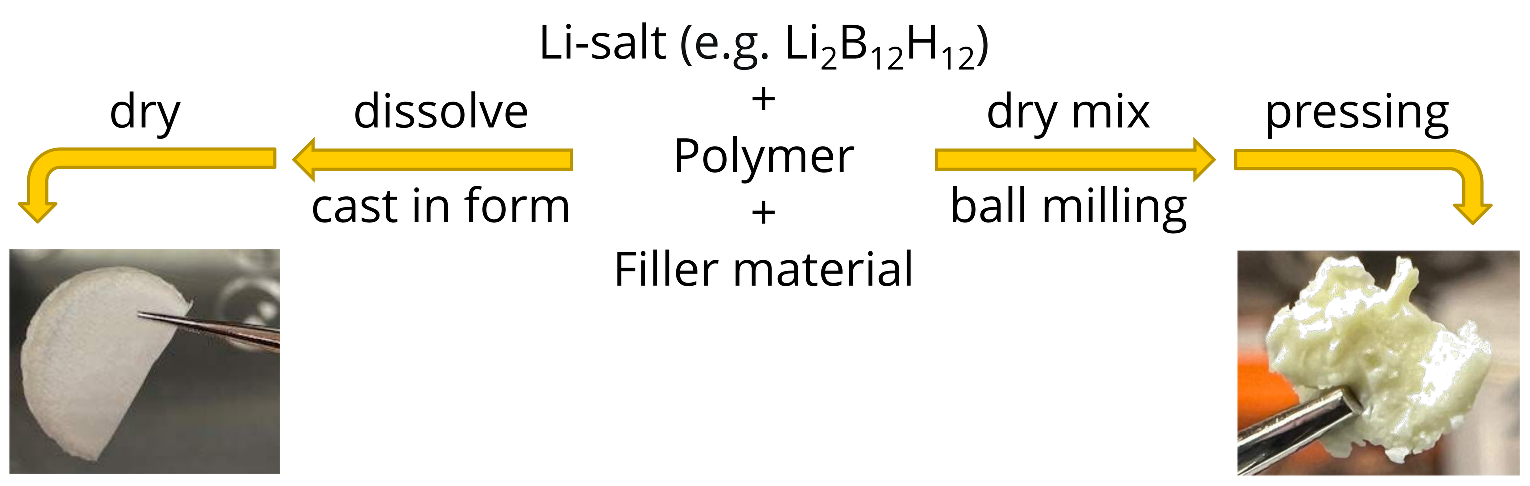


Polymer in salt composite electrolytes[4]



Enhanced Li^+ conductivity through 3 different Li^+ transport paths.

Synthesis approaches



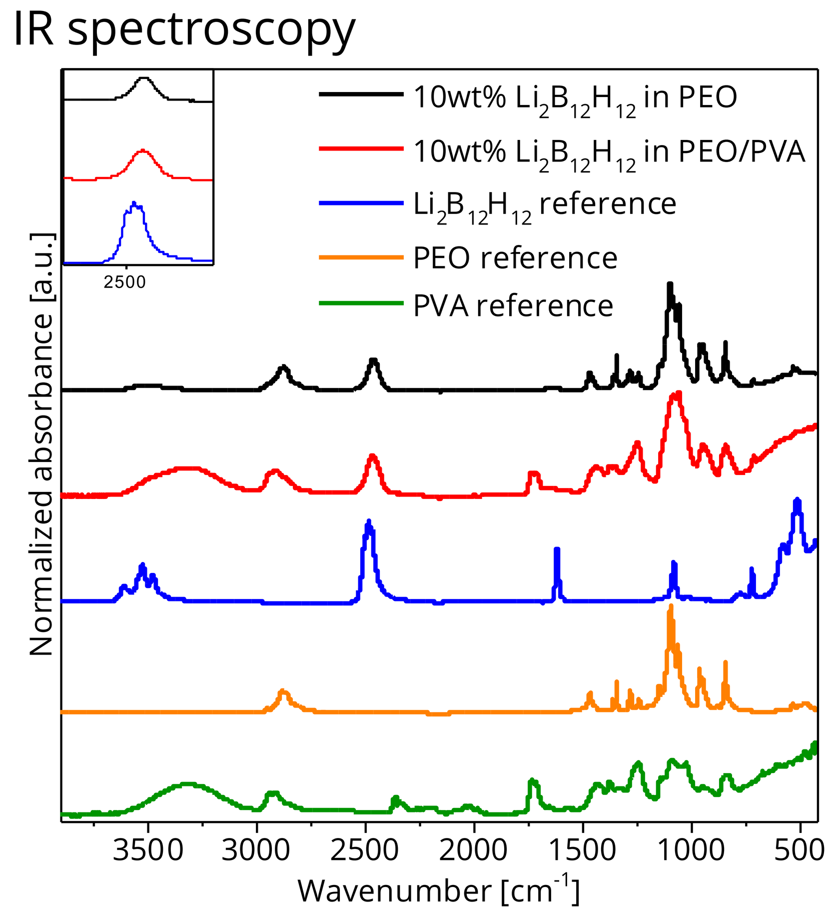
- \+ intact polymer chain
- \+ homogenous film
- − solvent residue in SSE

- \+ solvent free method
- − break polymer chain?
- − less homogenous?

BatteryNL DUTCH BATTERY MATERIALS

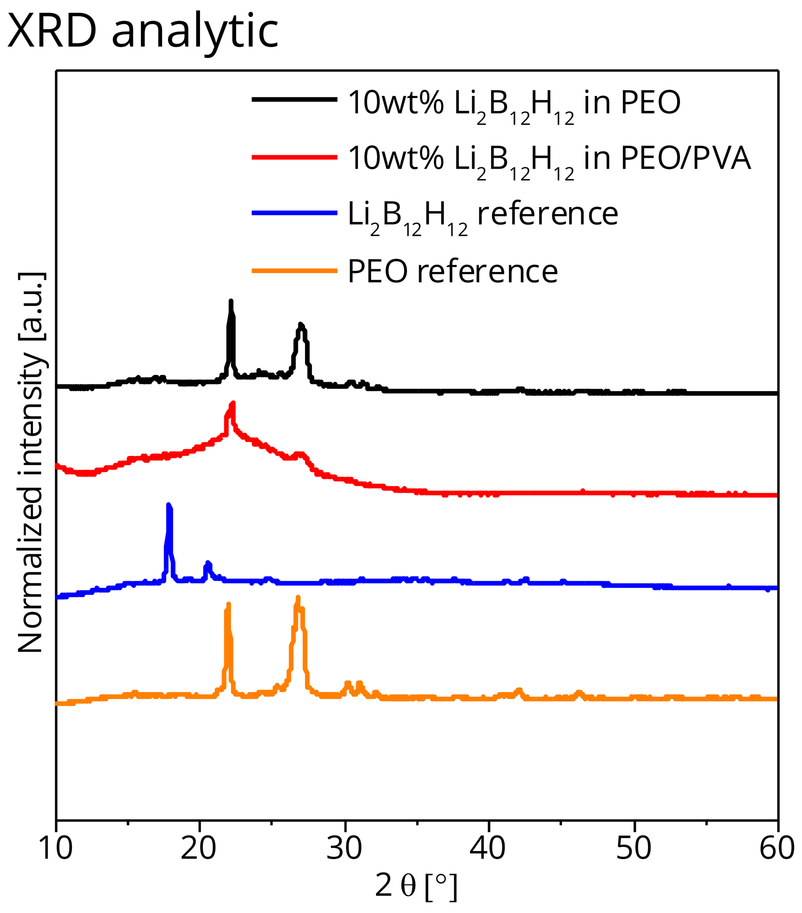
Polymer blending Approach (preliminary results)

IR spectroscopy



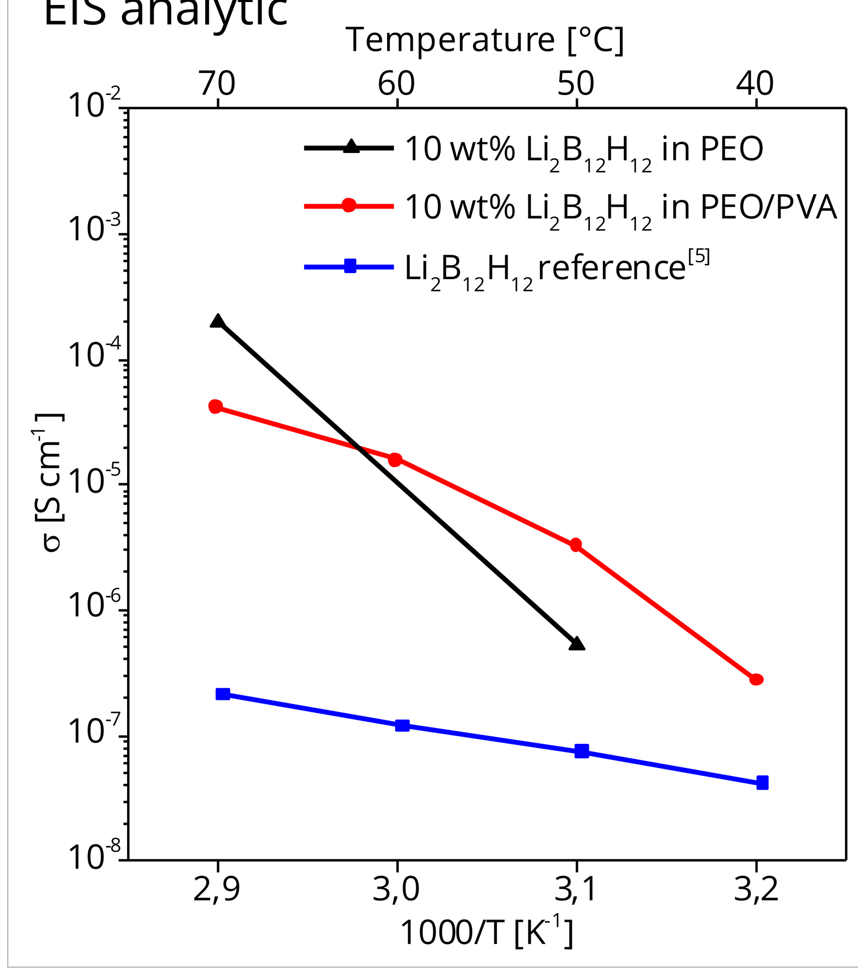
- B-H stretch downshifted
- Polymer and Li^+-ion interaction

XRD analytic



- reduced crystallinity through polymer blending
- $Li_2B_{12}H_{12}$ is dissolved, peaks are not visible

EIS analytic



- dissolving $Li_2B_{12}H_{12}$ in a polymer matrix leads to improved conductivity
- higher conductivity in blended polymer at 50 °C
- At elevated temperatures higher conductivity in pure (melted) PEO

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