Advanced materials and design rules for interface engineering towards a new generation of Li-ion batteries

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Motivation

Lithium-ion batteries play an essential role in the use of electrical energy for portable applications and electrical vehicles in order to improve both autonomy and safety. The main aspects to be improved in the next years are their performance (capacity and power), safety and cost, as well as to reduce their environmental impact.

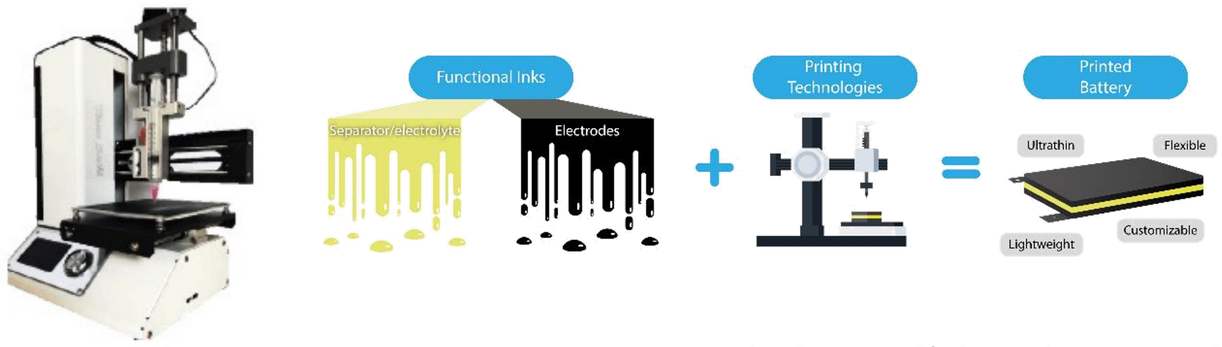
Objectives

In this project we aim to:

1. Develop solid-state Li-ion batteries (SSBs) with focus on interface engineering and advanced processing and characterization techniques;
2. In-situ investigation of battery interfaces combining electro-chemical fatigue tests and in-situ microstructural damage assessment methods for electrode–electrolyte interfaces.

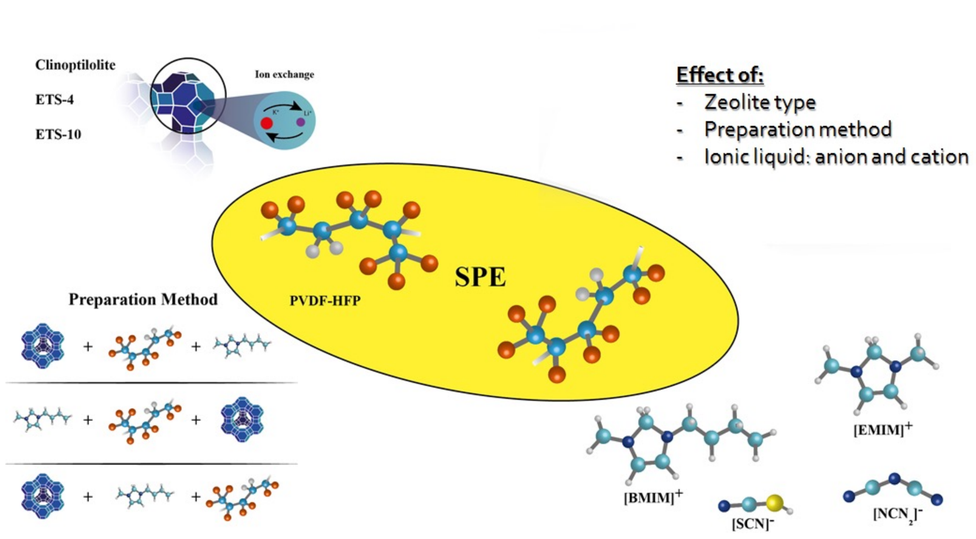
Research

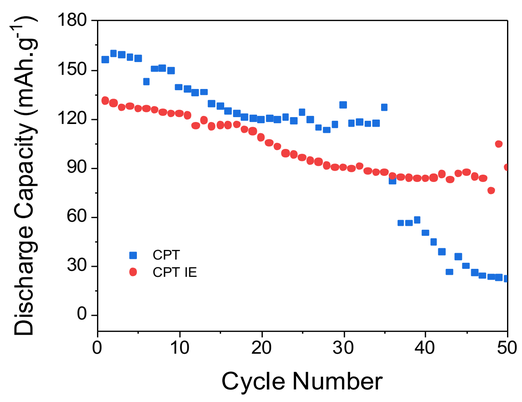
Sample Manufacturing @UMinho:
Electrodes based on different active materials and solid polymer electrolytes:



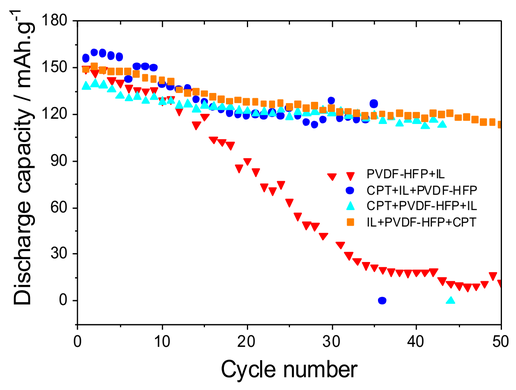
Cathode samples (e.g. $Li_xMn_2O_4$, Li_xFePO_4, $Li_xNi_{0.8}Co_{0.15}Al_{0.05}O_2$, $Li_xMn_{1.5}Ni_{0.5}O_4$,) and solid polymer electrolyte samples are fabricated by standard fabrication processes and direct ink writing printing technique. Then they are subject to electrochemical fatigue tests.

Three-component approach for solid polymer electrolytes based on zeolites and ionic liquids:



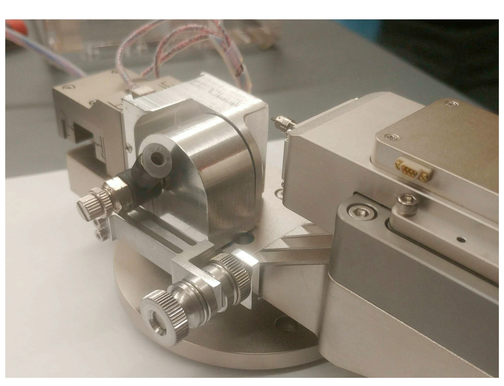


Ion exchange process of the zeolites allows to improve cycling stability



Both solid polymer electrolyte components and preparation method allow to improve battery performance.

Microstructure characterization and Picoindentation @MIT



Multi-field mapping methods developed in the Taşan group allow to investigate the underlying physical mechanisms of microstructural transformation that leads to fracture, as well as interface effects, essential to properly understand and tune battery performance.

References

[1] S. Wei et al., Nat. Mater., 19:11, 1175–1181, 2020. [2] S. Wei and C. C. Taşan, Acta Mater., 200, 992–1007, 2020. [3] D. Miranda et al., Energy, 172, 68-78, 2019. [4] Cameron and Taşan, Sci. Rep., 9: 1, 1–6, 2019.

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