Functional Thin Films in the Manufacture of Batteries

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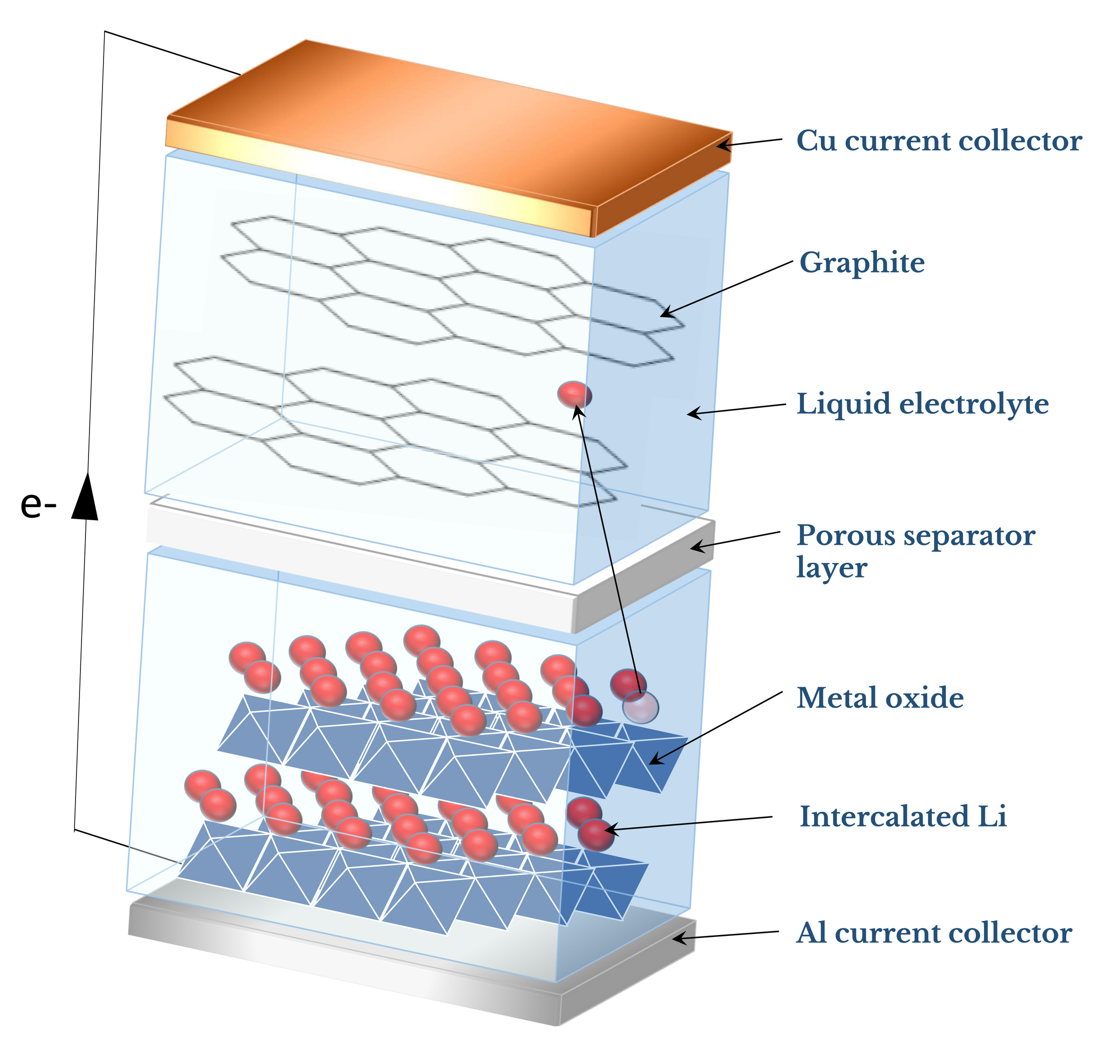
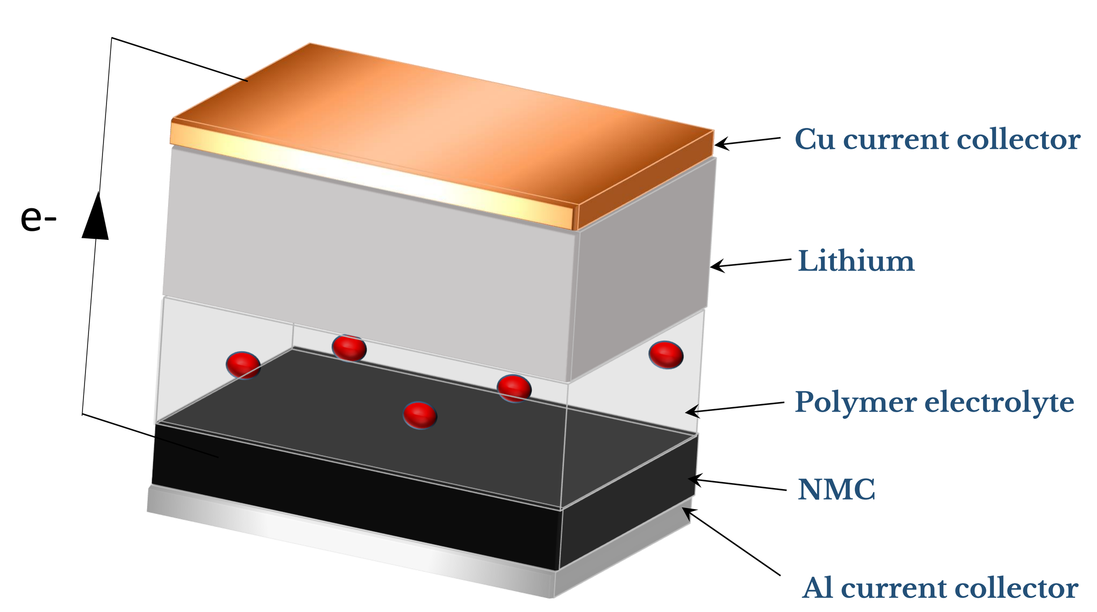
Differences between Lithium-Ion and Lithium-Polymer Batteries

'Conventional' Li-ion battery



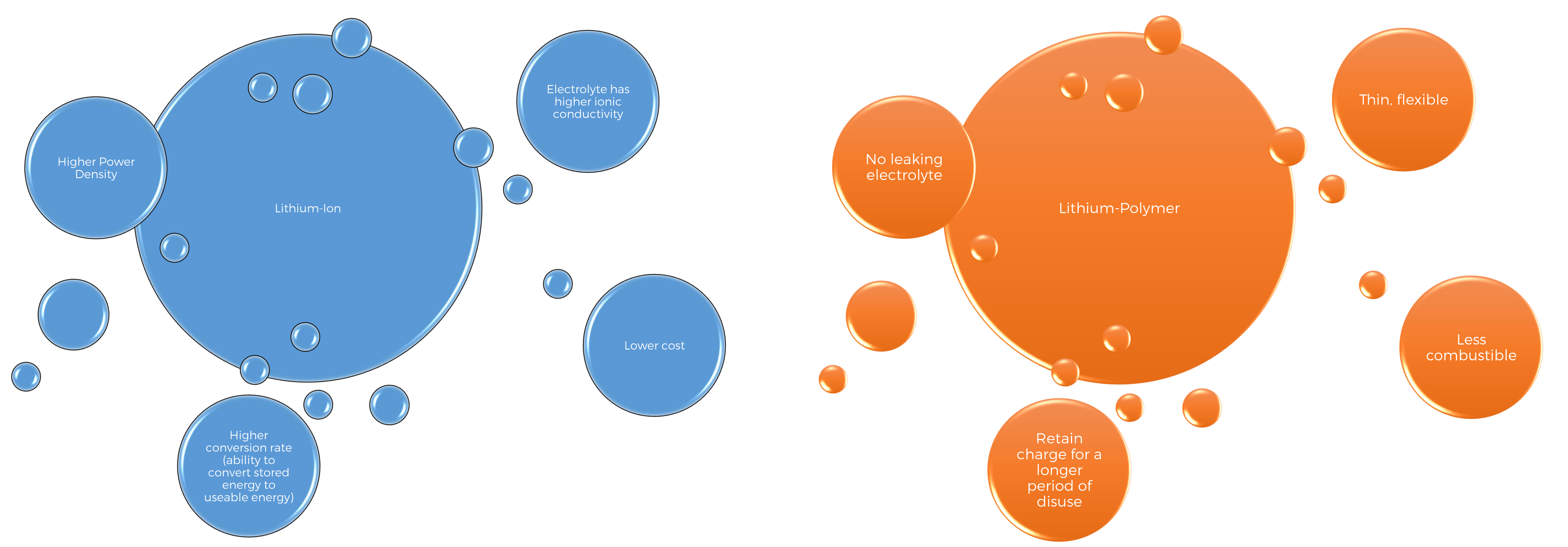
- As the battery is charged, electrons move from the Al current collector to the Cu current collector
- Li+ ions move from the metal oxide layer to the graphite layer in order to maintain charge neutrality
- A solid, porous separator keeps the two electrodes apart and prevents short circuit
- The flow of charge is reversed when the battery discharges, providing an electrical current to the connected circuit

Lithium Polymer Battery



- Instead of a liquid electrolyte, Li+ ions travel across a solid polymer electrolyte
- No separator is required due to the solid nature of the electrolyte layer- the two electrode layers are effectively separated
- NMC is Lithium Nickel Manganese Oxide, which provides a source of Li ions at the cathode

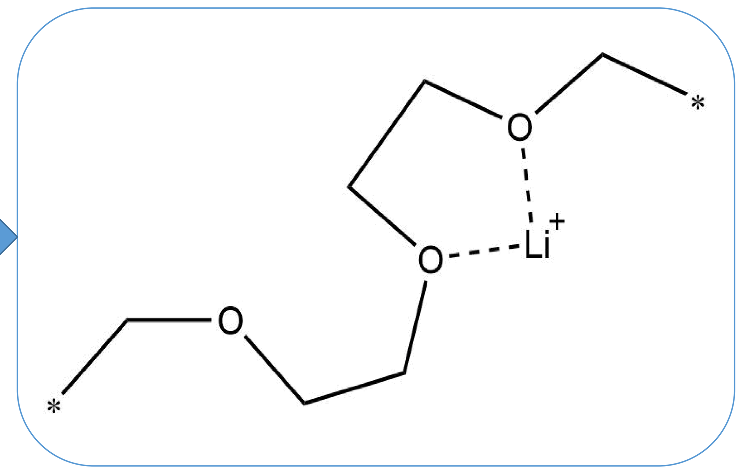
Lithium-Ion vs. Lithium-Polymer

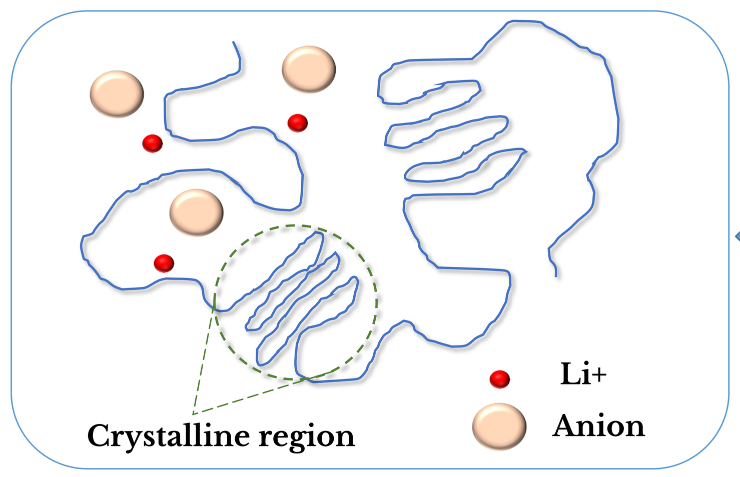


Formulating an effective electrolyte layer

Requirements: mechanical robustness, high ionic conductivity, low electronic conductivity

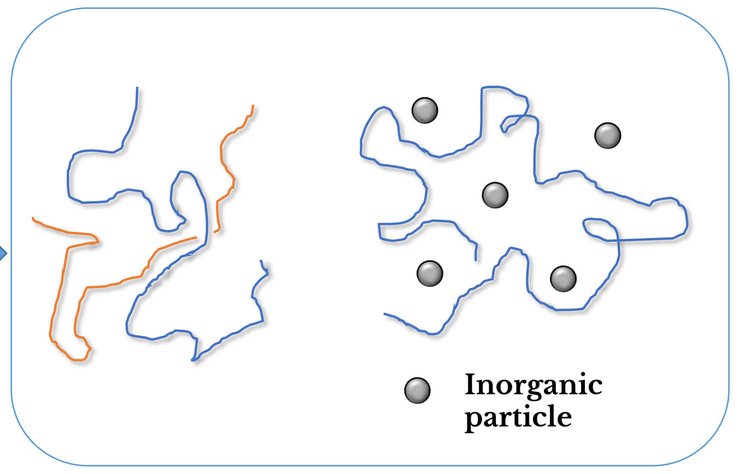
- The first polymer electrolyte widely studied for Li batteries was polyethylene oxide (PEO)
- The electrolyte consists of a Li salt dissolved in a PEO matrix
- Li+ forms a complex between the electron-donating O atoms in the chain; ion conduction is by transfer of the Li+ between complexing sites





- Ion conduction occurs only within the amorphous regions of the polymer.
- To suppress crystallinity, a Li salt with a larger anion can be incorporated into the electrolyte.
- PEO mixed with $LiClO_4$ gives conductivities between 10^{-8} to 10^{-6} S cm^{-1}, while PEO with $Li(CF_3SO_2)_2N$ (LTFSI) gives conductivities between 10^{-5} to 10^{-4} S cm^{-1}

- Other methods for the suppression of the formation of crystalline regions within the polymer include:
  - The addition of low molecular-weight additives
  - Blending a second polymer with the PEO
  - Adding inorganic particles into the polymer matrix



Characterisation Techniques

Technique	Use
SEM-EDX	Structural information Cross sectional analysis of the interfaces Elemental analysis
XPS	Elemental analysis
EIS (Electrochemical Impedance Spectroscopy)	Ionic conductivity
Archimedes' method	Density analysis
Galvanostatic polarisation	Electrical conductivity
FIB-SIMS	Surface degradation
Raman spectroscopy	Presence of chemical groups
FT-IR spectroscopy	Presence of chemical groups
LIBS (Laser-Induced Breakdown Spectroscopy)	Elemental analysis

References

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2. Lee, A., Koo, Y. (2019). The Effect of Active Material, Conductive Additives, and Binder in a Cathode Composite Electrode on Battery Performance. Energies, 12(4), 658. doi:10.3390/en12040658

Acknowledgements

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