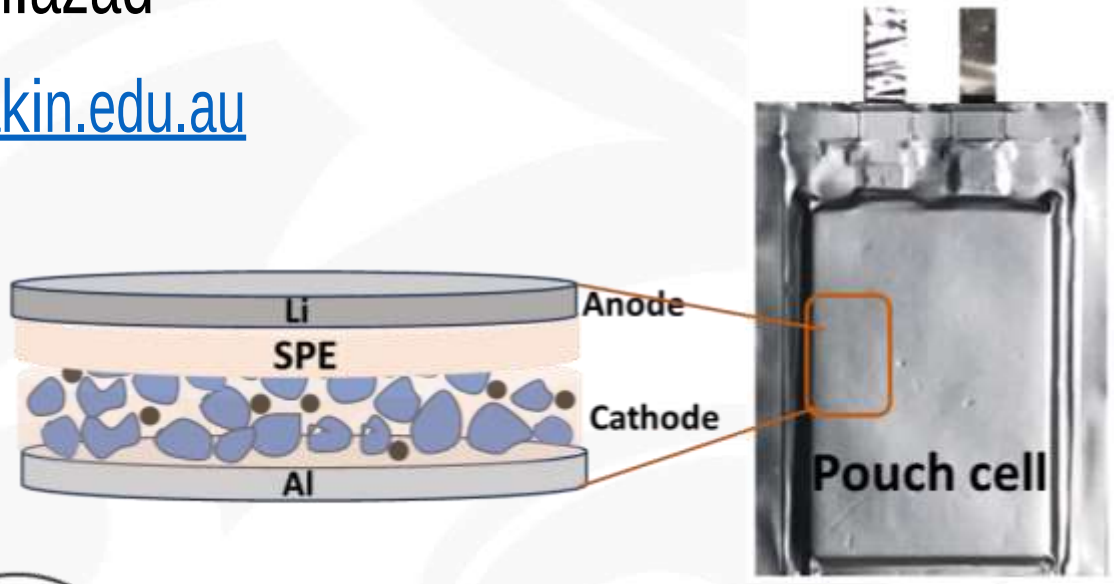
Novel Solid-State Electrolytes for High Voltage Lithium and Sodium-Metal Batteries

Faezeh Makhlooghiazad

f.makhlooghiazad@deakin.edu.au

The Institute for Frontier Materials,
Deakin University,
Melbourne
Australia



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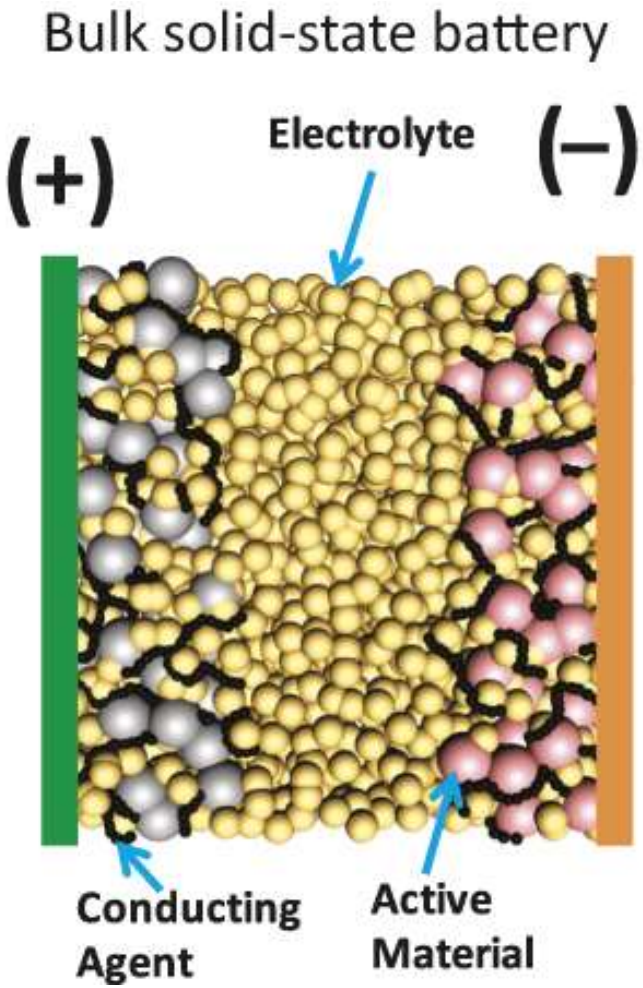
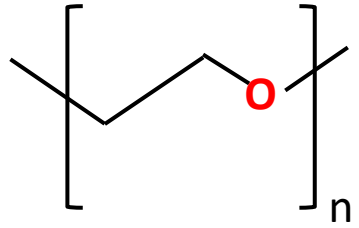
Electrolytes for battery applications

Liquid electrolytes — **Ionic liquids**

Solid electrolytes — **OIPCs**, **Polymers**, **Zwitterions** — **Composites**



- High ionic conductivity
- Chemical stability with electronically conductive additives
- Good mechanical properties
- Thermally & electrochemically stable
- Chemical stability with alkali metals



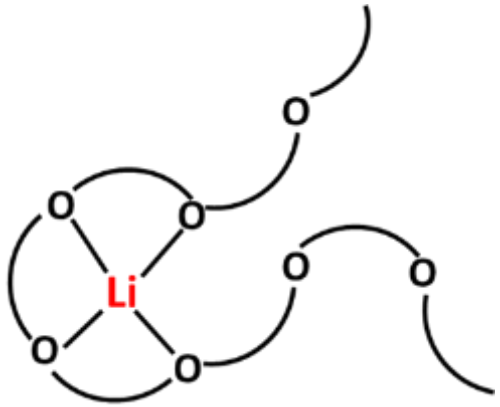
PEO
Poly(ethylene oxide)

Bluebus & Bluecar by Bollore' *(www.bluecar.fr)*

30 kWh, driving ranges of up to **250 km**

- ✓ Chain flexibility
- ✓ Low Tg
- ✓ great solubility for conductive Li salts

- ×Poor anodic stability
- × High degree of crystallisation
- × Low ionic conductivity at RT
- × Low Li transference number

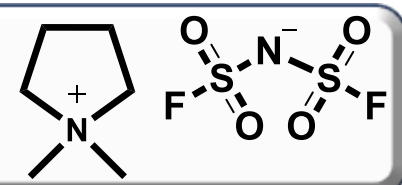


Approaches to increase ionic conductivity

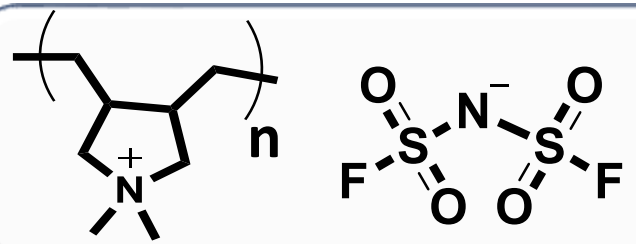
Adding plasticizers

Organic solvents
Flammable, Volatile

Ionic liquids
Safe



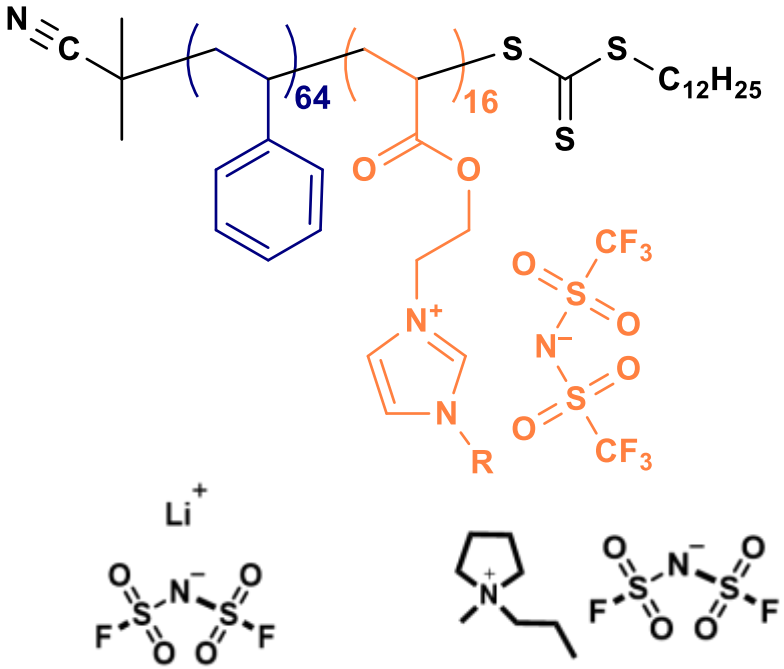
Polymerised ionic liquids

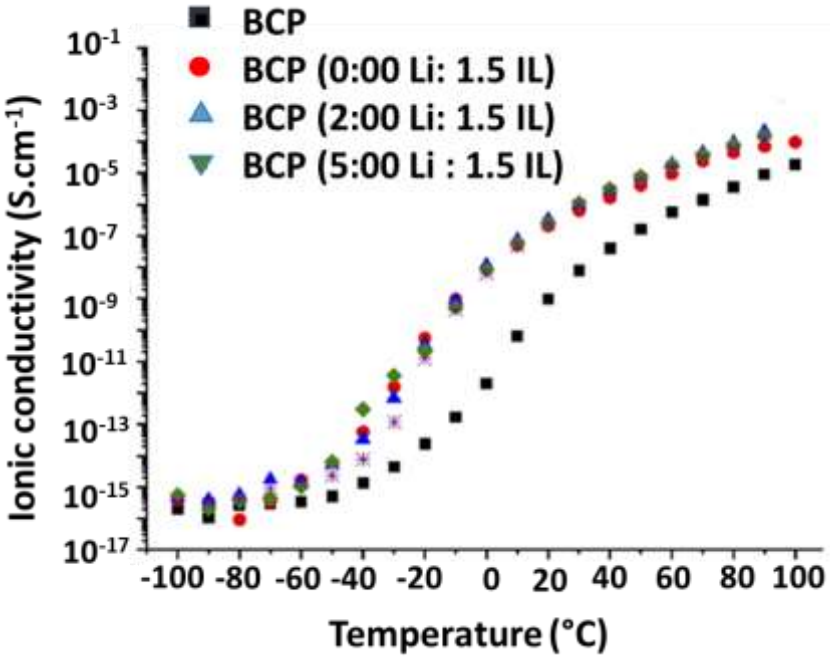


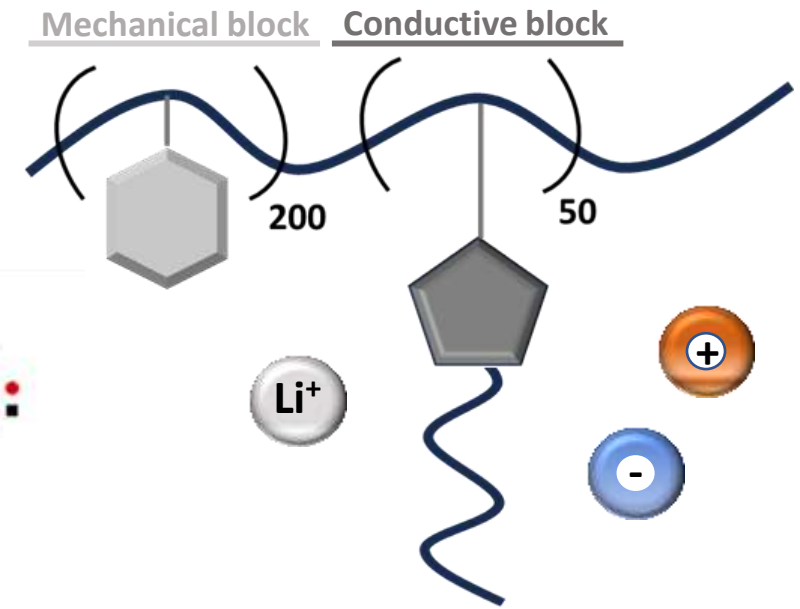
Challenge

Mechanical integrity & ionic conductivity

Block Copolymer Electrolytes







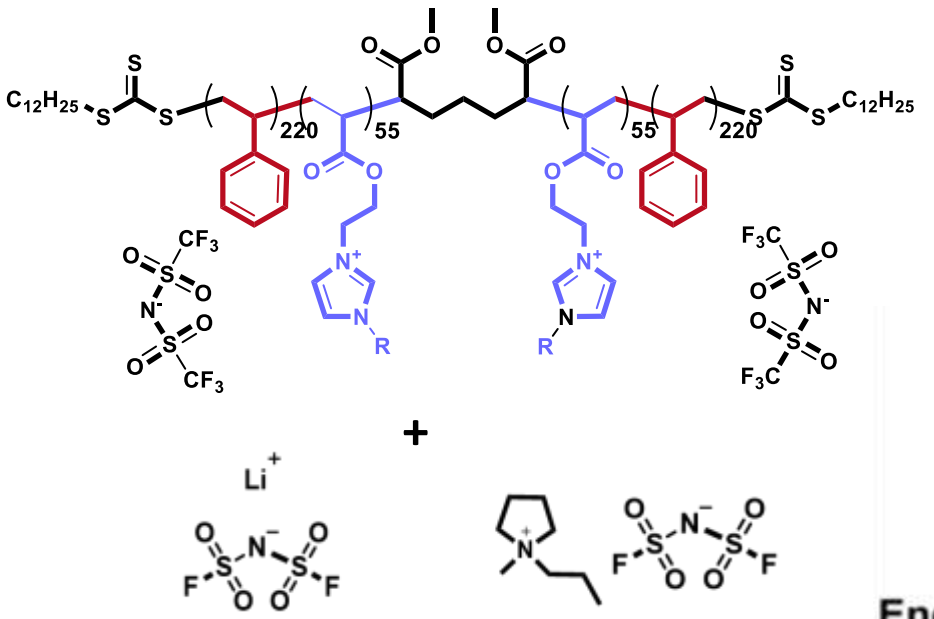
Optimum composition

1:00 **BCP** : 2:00 **LiFSI** : 1.5 **IL**

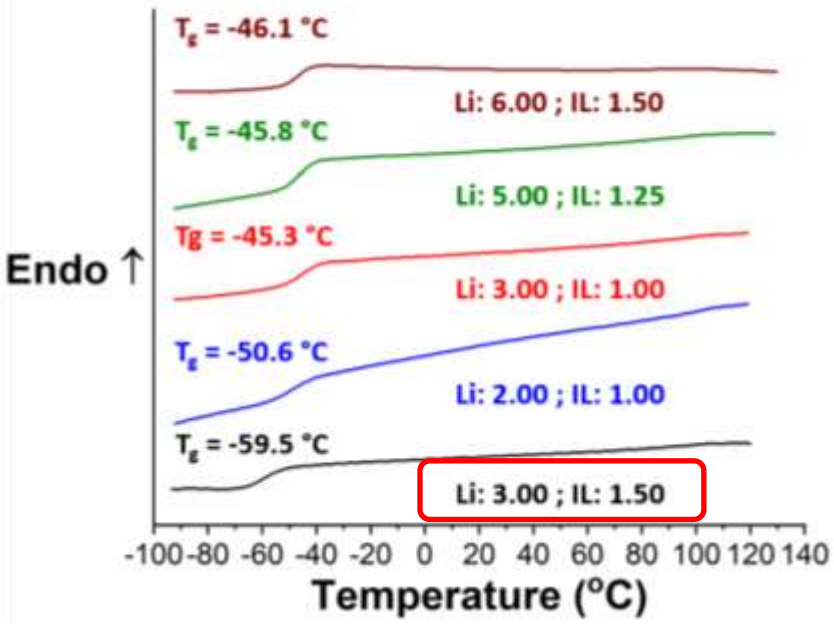
Higher loadings of **salt** and **IL**

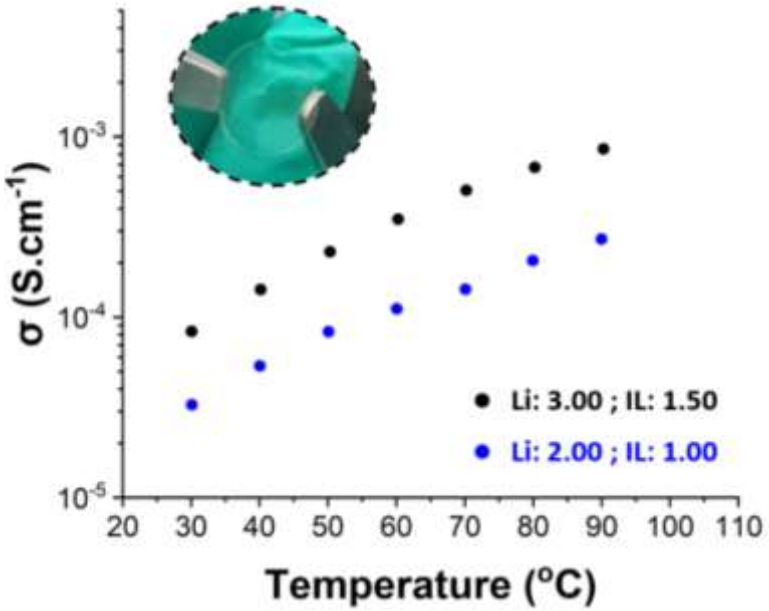
↳ Higher ionic conductivity & better performance

TriBlock Copolymer Electrolytes

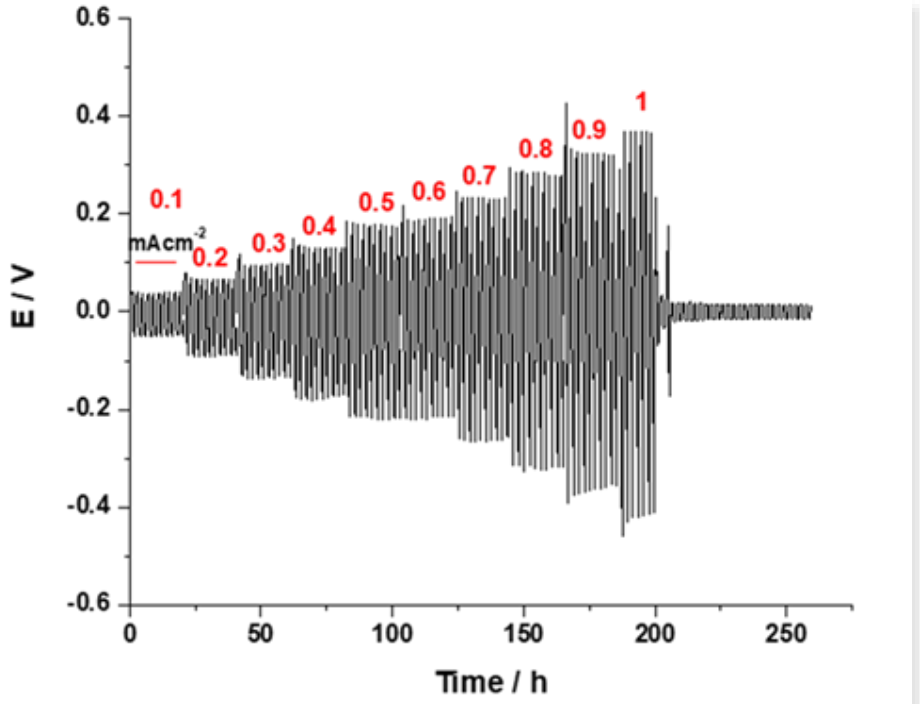


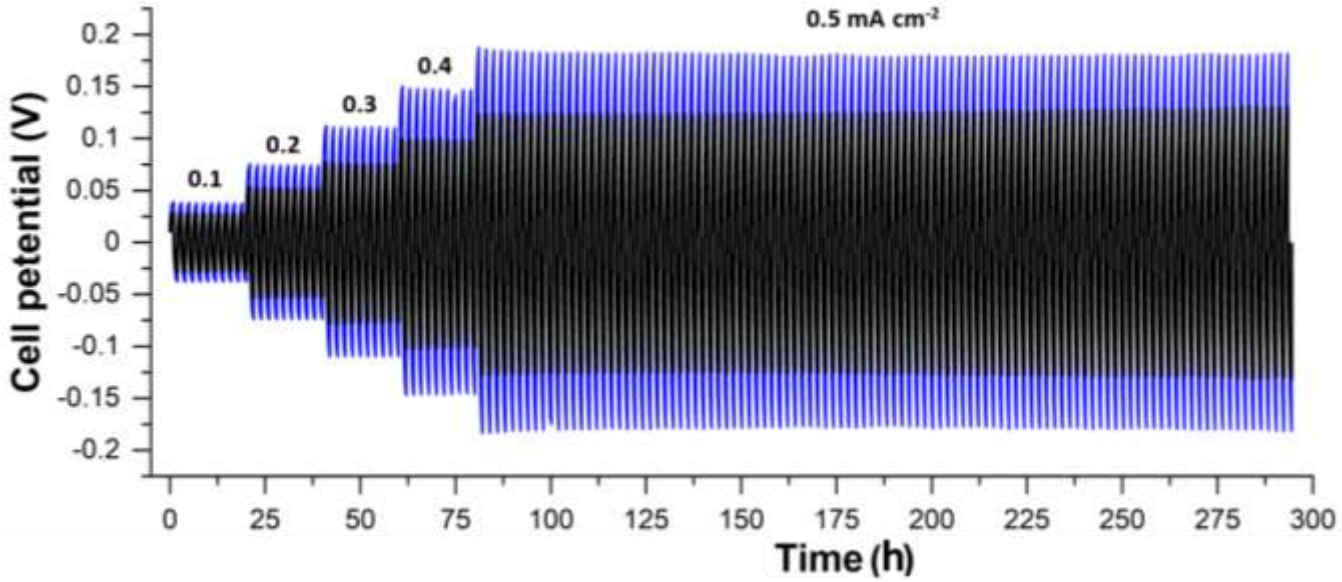
- Additional mechanical block To improve the mechanical properties of the SPE
- To maintain mechanical properties at higher LiFSI and IL concentrations to support higher current densities in Li metal cycling.

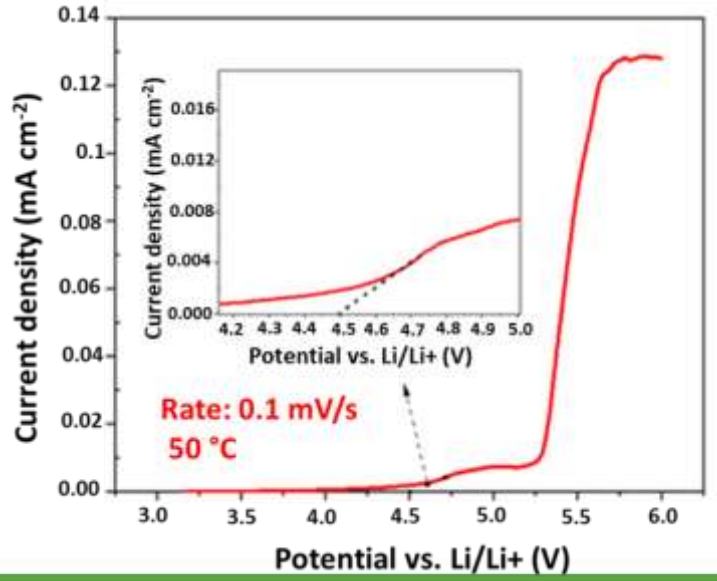




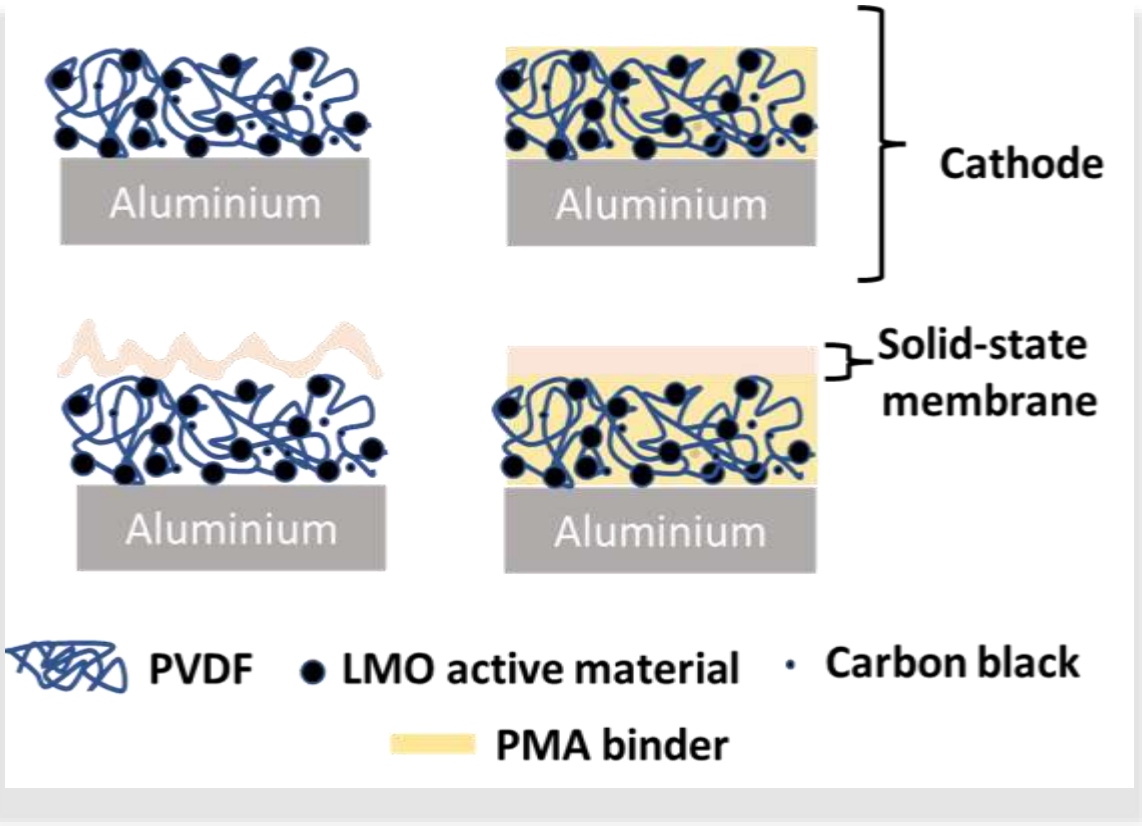
TriBlock Copolymer Electrolytes-Electrochemical properties





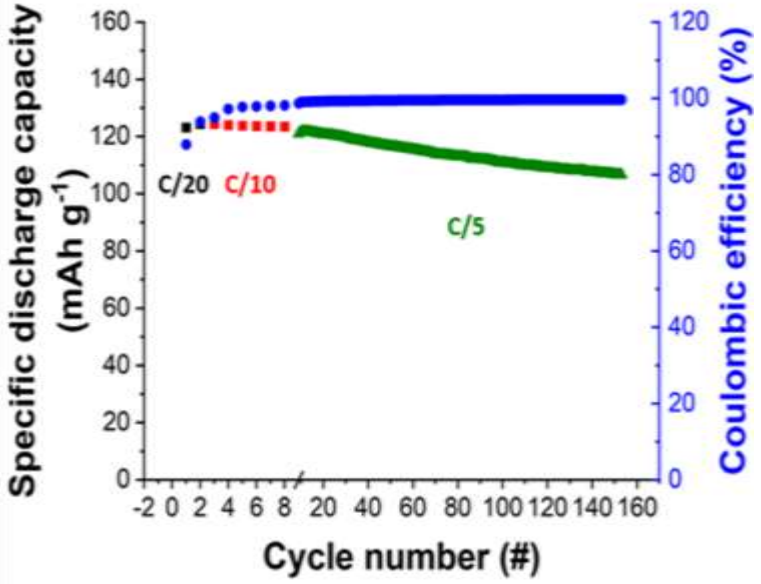


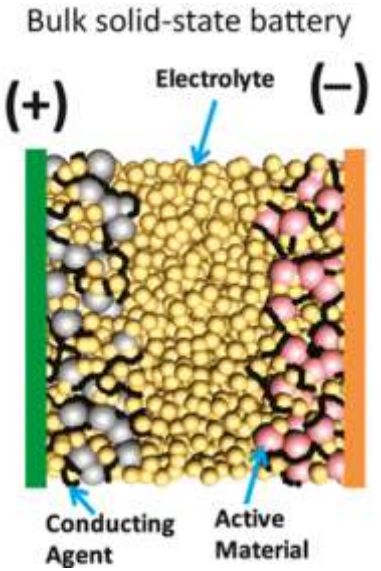
All-solid-state Li metal battery

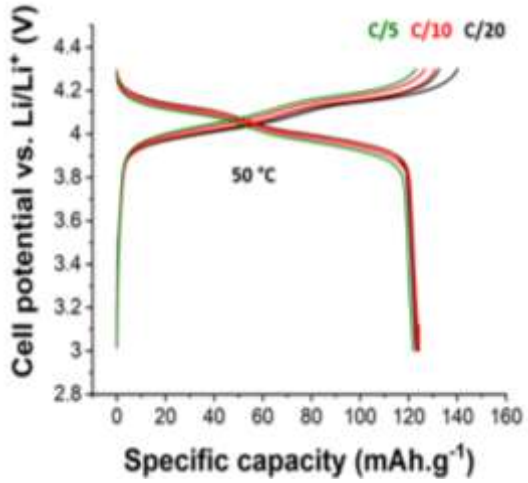


60wt% LMO / 30 wt% SPE / 5wt% PVDF / 5wt% C-black

Li | SPE | $LiMn_2O_4$ (LMO)

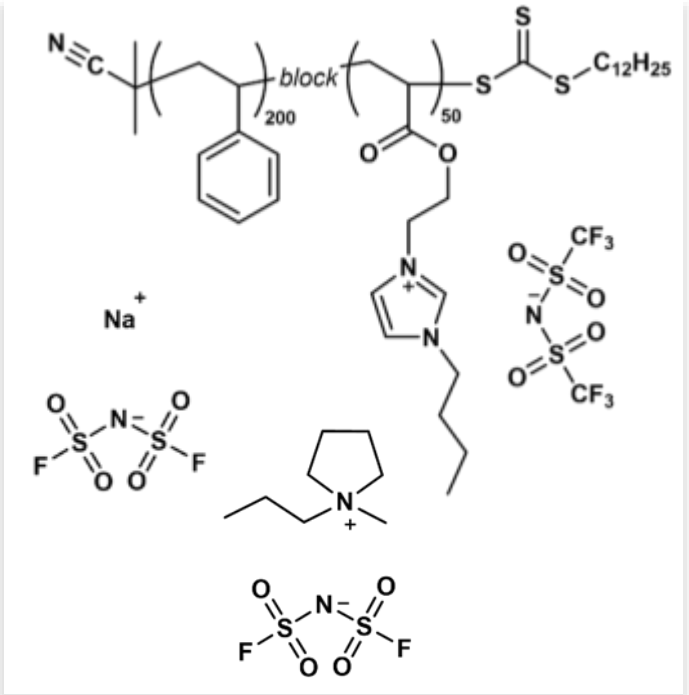


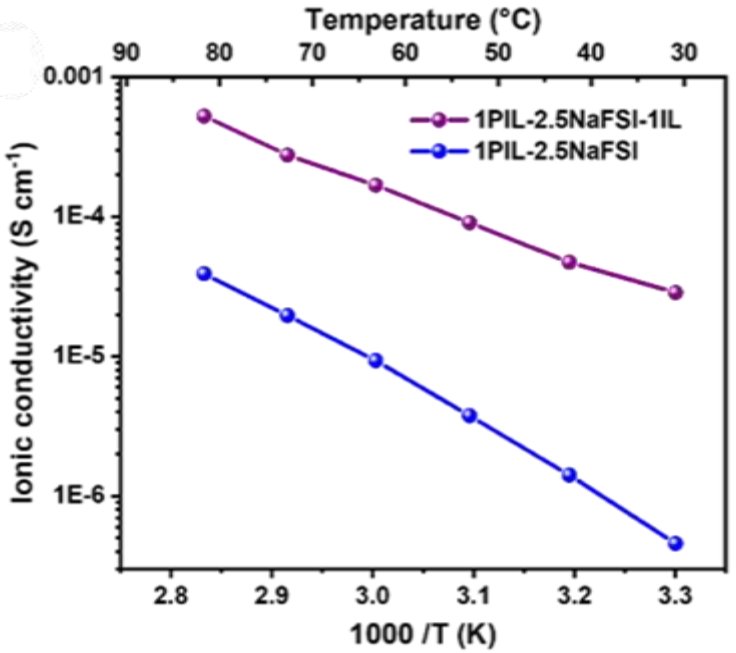




Battery Research and Innovation Hub

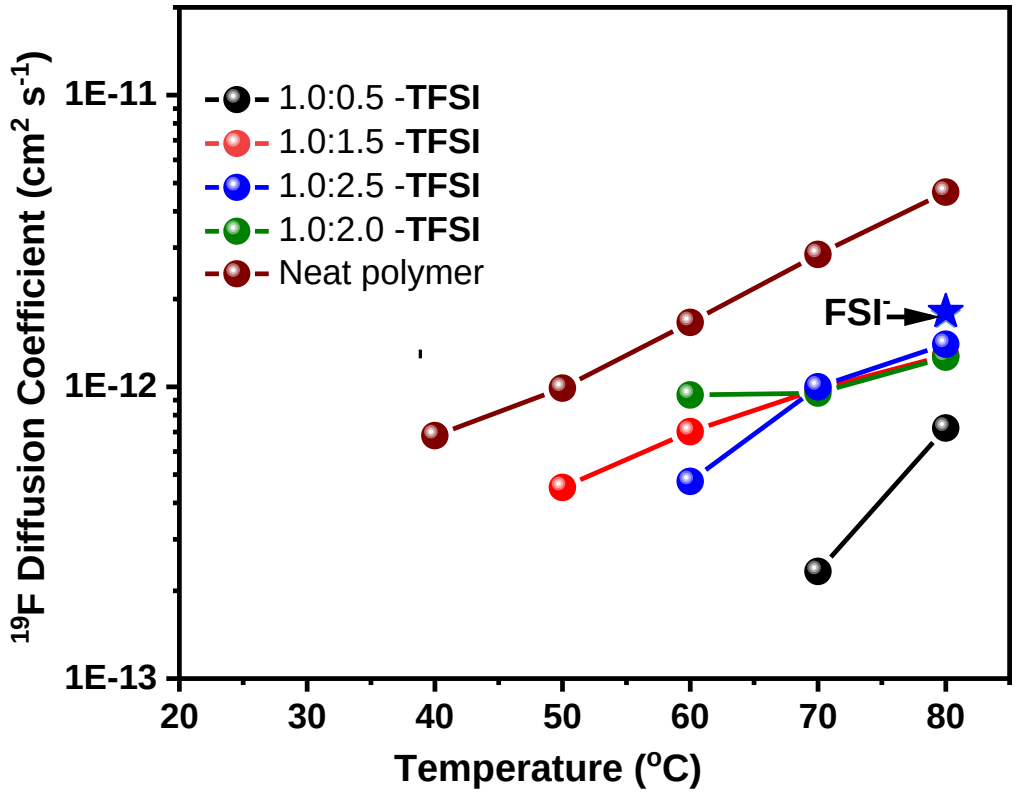
Block Copolymer Electrolytes in Na devices

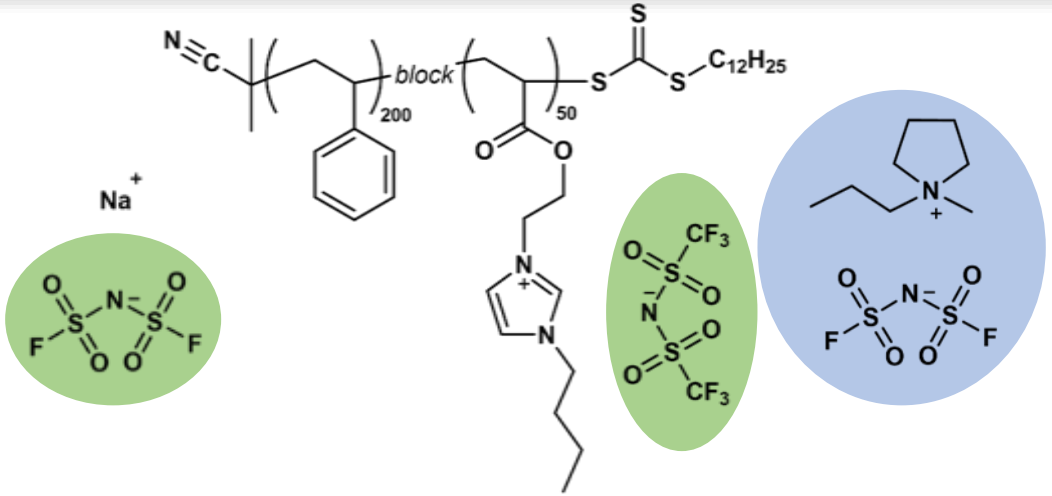


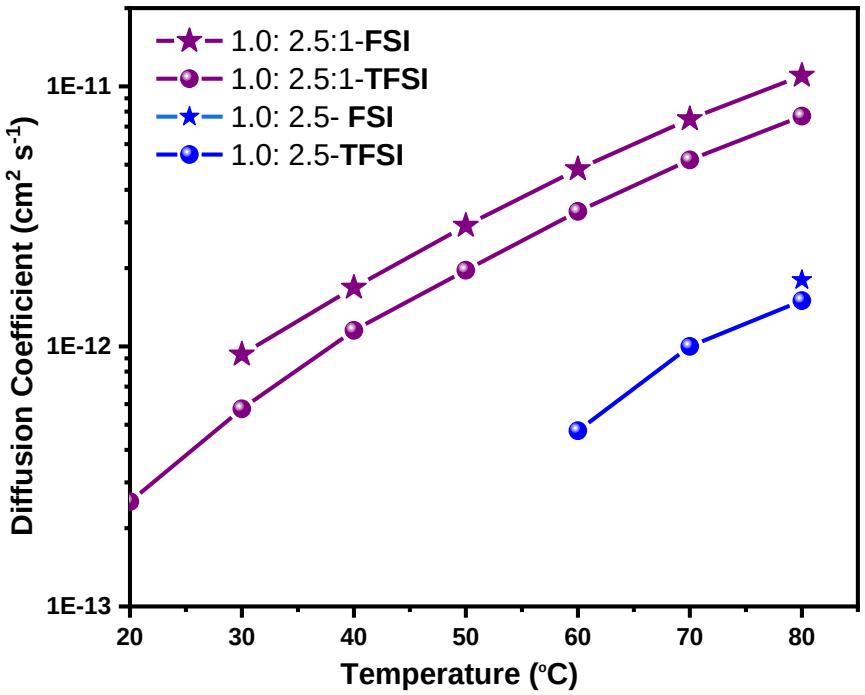


PIL:NaFSI: IL molar ratio	T_g (°C) Onset	ΔT_g (°C)	Conductivity at 70 °C (S cm^{-1})
1.0:**0.5**:0.0	-11	15	1.8 x 10^{-6}
1.0:**1.5**:0.0	-19	16	6.6 x 10^{-6}
1.0:**2.0**:0.0	-19	16	5.3 x 10^{-6}
1.0:**2.5**:0.0	-23	15	2 x 10^{-5}
1.0:**3.0**:0.0	-21	14	2.1 x 10^{-5}
1.0:2.5:1.0	-43	28	**2.8 E-04**

Block Copolymer Electrolytes in Na devices; Ion diffusions and correlations

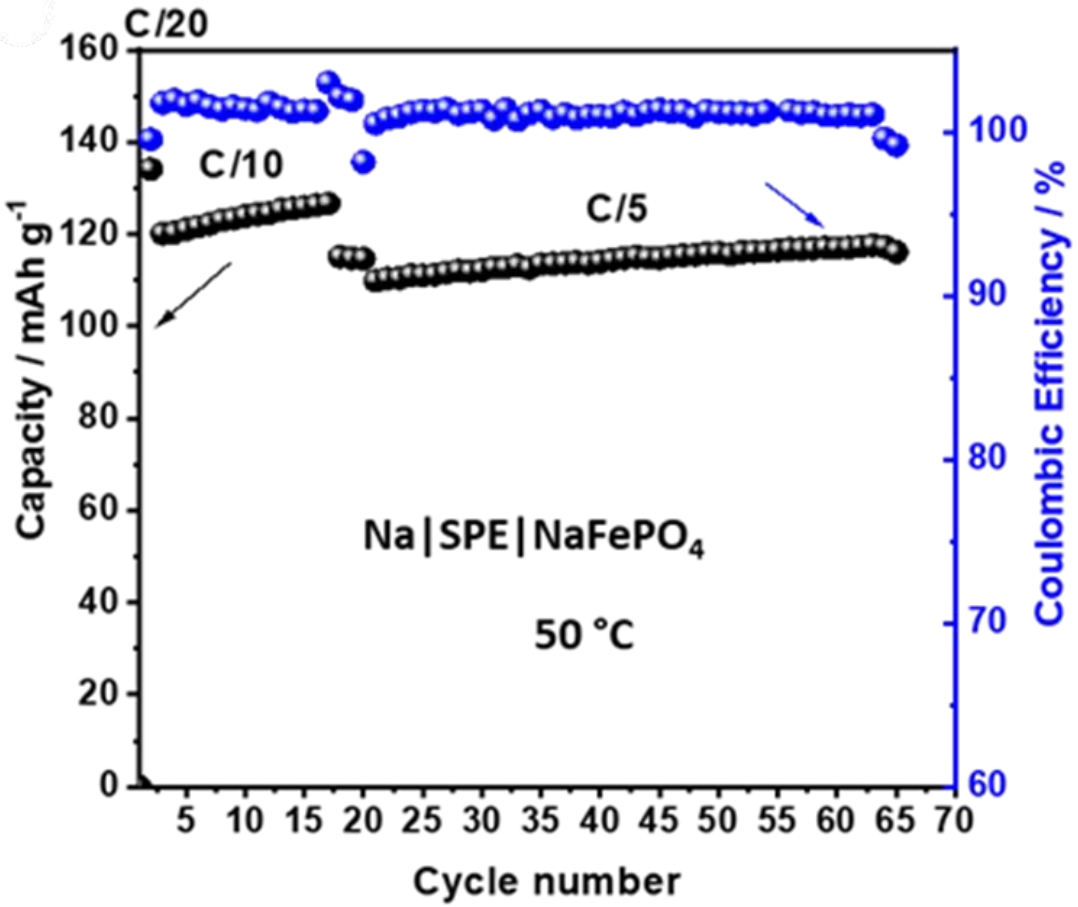






Dani Kourati poster #25

All-solid-state Na metal battery

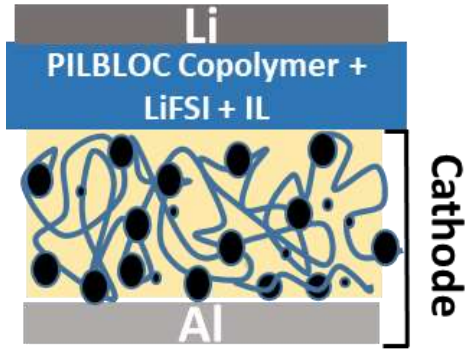


- An initial discharge capacity of 134 at C/20 and 120 and 115 mAh g^{-1} at C/10 and C/5 at 50 °C.
- Demonstrating favourable charge–discharge performance, maintaining a capacity of 117 mAh g^{-1} for 60 cycles at C/5 at 50 °C which is similar than the initial capacity,
- Exhibiting a high coulombic efficiency of 99.5% at the end of 60 cycles.

Conclusion

- Diblock and triblock polymer electrolytes with high mechanical stability and ionic conductivity
- Promising materials for high-voltage solid-state lithium and sodium-metal batteries

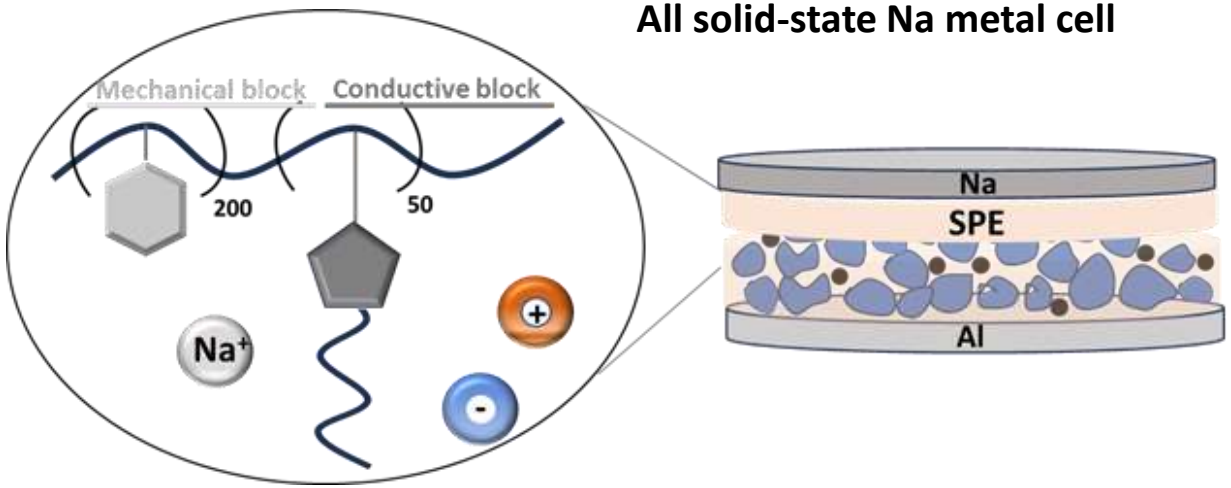
All solid-state Li metal cell



PVDF LMO active material

PMA binder Carbon black

All solid-state Na metal cell



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