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New lithium salts derived from naphthalene: toward carbonate-based single-ion polymer electrolytes

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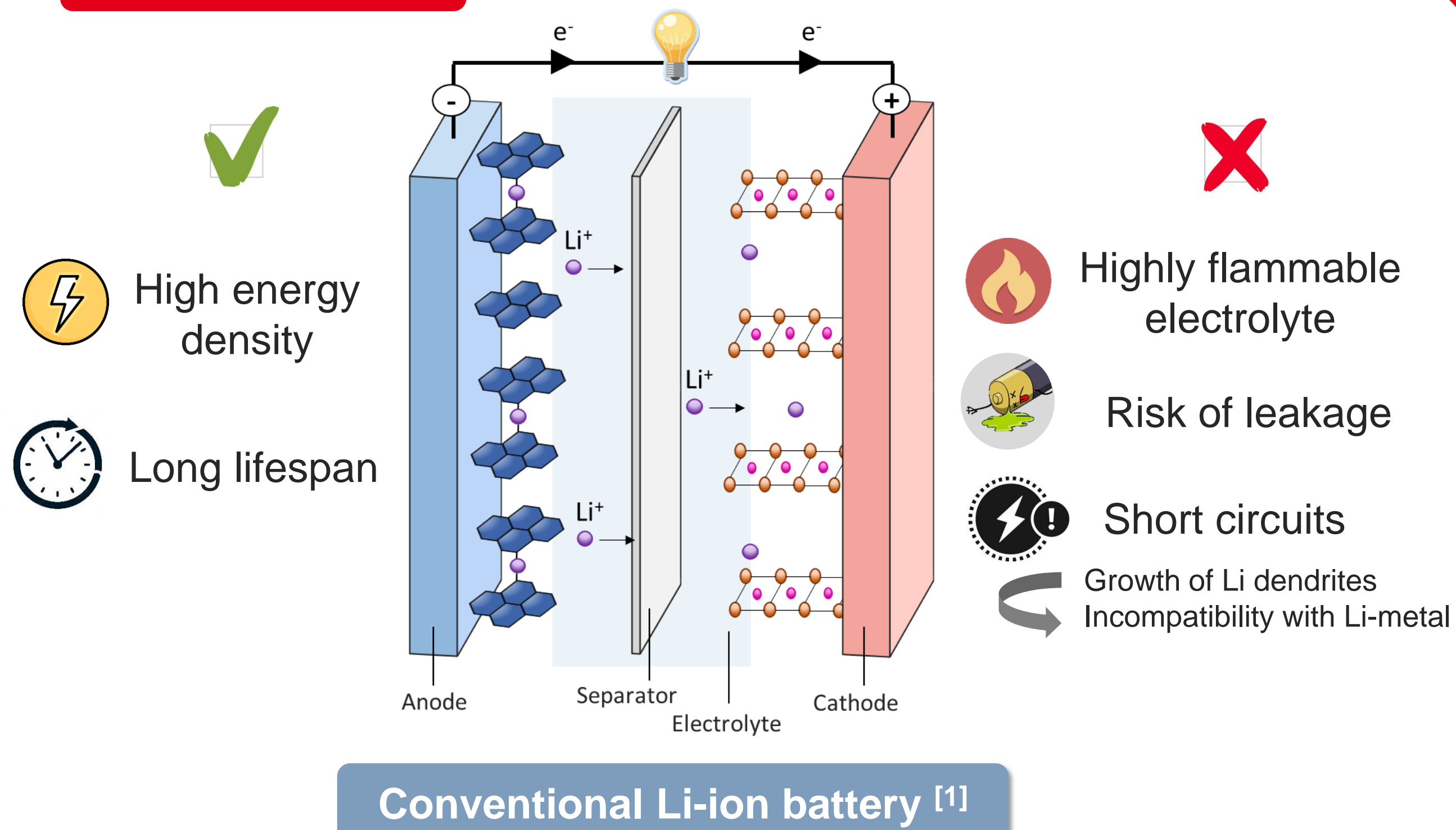
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Context



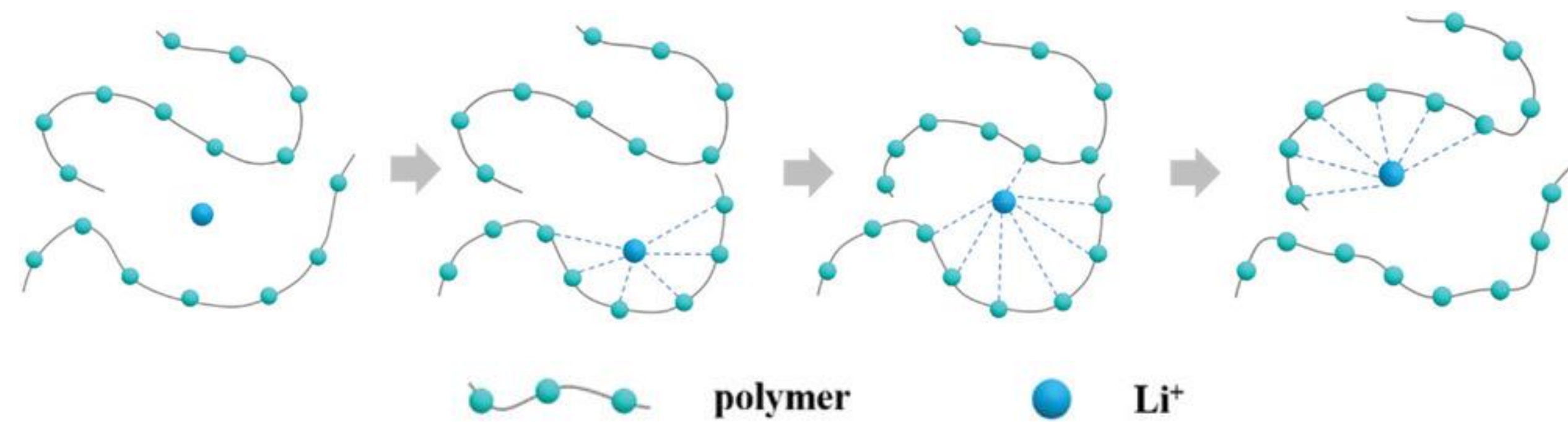
Strategy: substitution of liquid electrolytes with solid materials

3 different classes of solid electrolytes: oxides, sulfides, and **polymers**

Strengths	Weaknesses
<ul style="list-style-type: none"> Lightweight Interface properties with active materials Adaptation to electrode volume changes Easy to process 	<ul style="list-style-type: none"> Ionic conductivity at room temperature Mechanical properties

State-of-the art: PEO-like polymer electrolytes

- Dissolution of lithium salts in a polymer matrix
- Conductivity via the **segmental motion of polymer chains and diffusion** [2]



❖ PEO ELECTROLYTES [3,4]

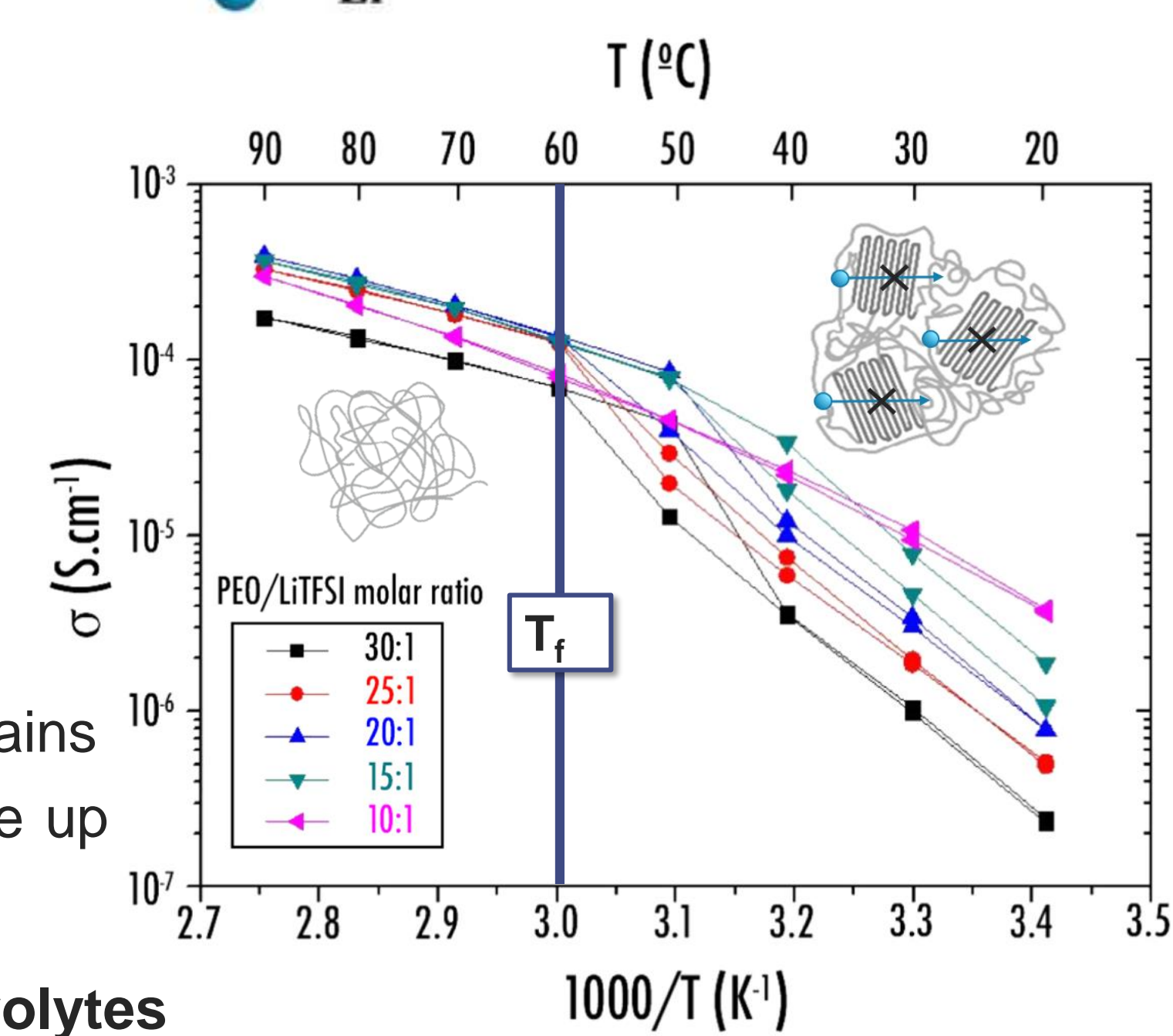
Strengths

- Ionic conductivity about 1 mS.cm⁻¹ at 80°C
- Low glass-transition temperature ($T_g = -60^\circ\text{C}$)

Weaknesses

- Non-conductive crystalline phases ($T_f = 60^\circ\text{C}$)
- Strong interactions between Li⁺ and polymer chains
- Limited to low voltage cathode materials (stable up to 4V vs .Li⁺/Li₀)

➔ Study of other families of polymer electrolytes



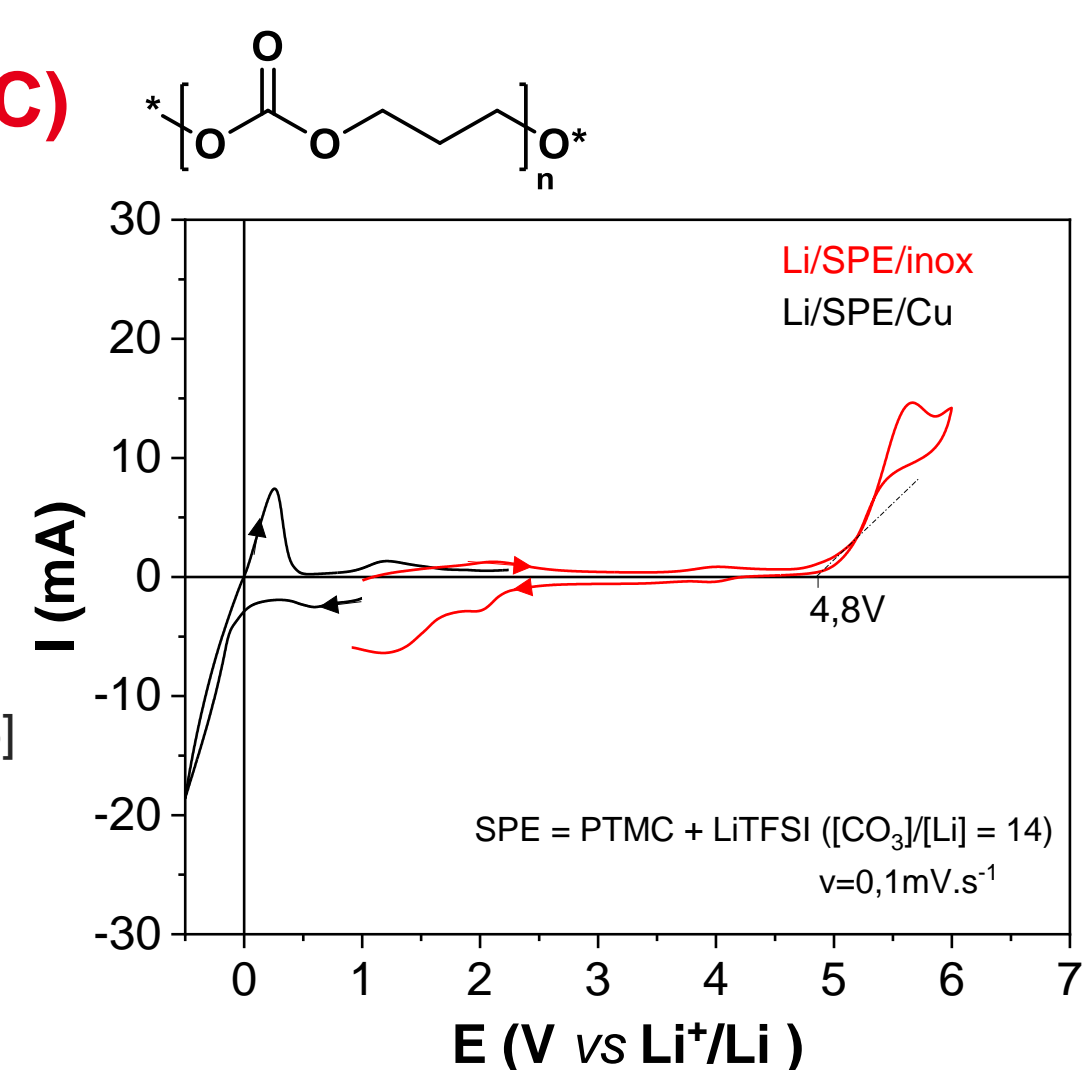
Objectives

- Development of **stable high voltage polymer electrolytes** for high energy density batteries
- **Single-ion polycarbonate** synthesis (PTMC derivative) by covalently **grafting Li⁺ counter-ions** on polymer chains
- Synthesis and electrochemical characterization of **new model salts**

High voltage polymer electrolyte

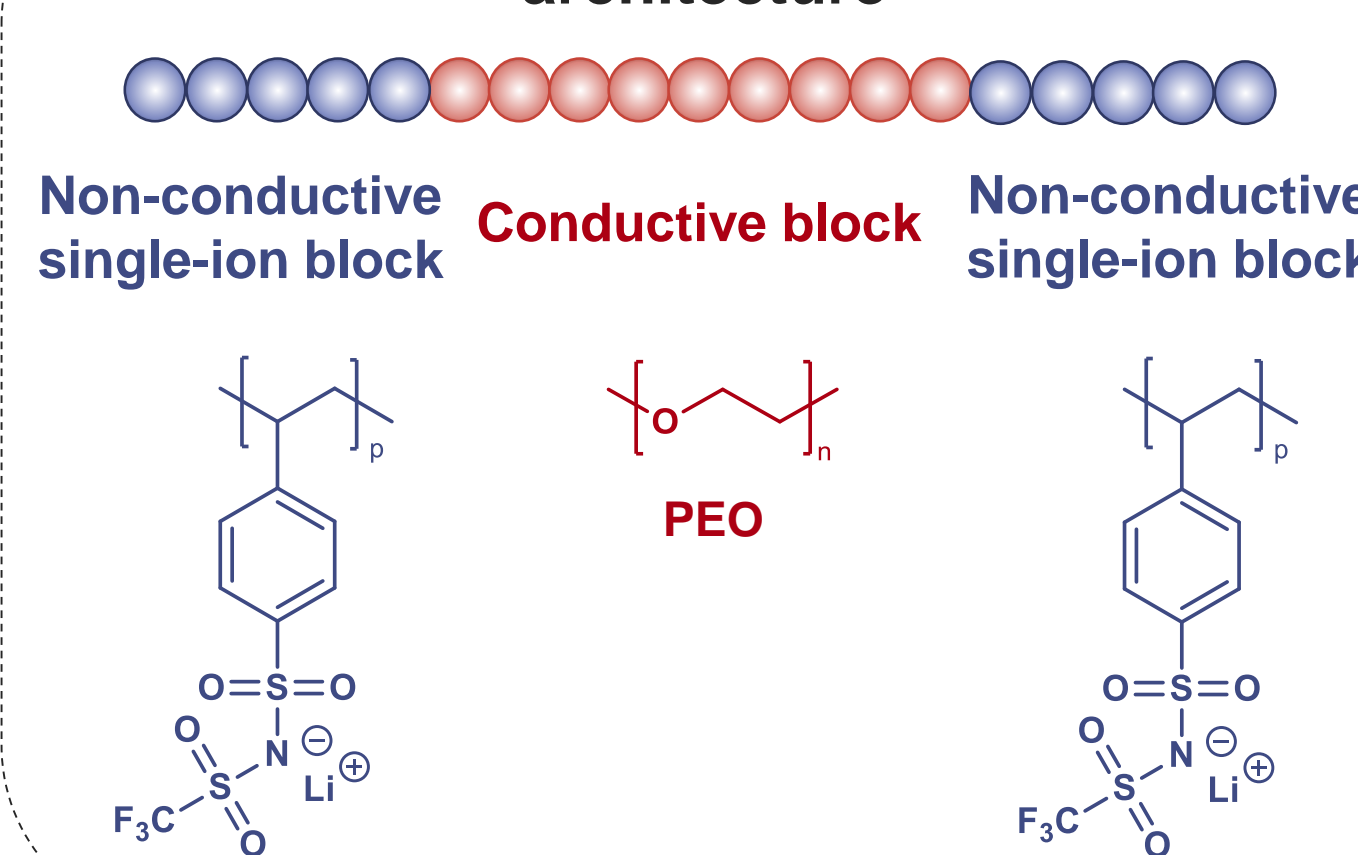
❖ POLY(TRIMETHYLENE CARBONATE) (PTMC)

- Amorphous polymer: $T_g = -20^\circ\text{C}$ [5]
- Ionic conductivity is **mainly due to Li⁺ mobility**
→ $t_{\text{Li}^+} \approx 0,8$ [6]
- **Electrochemical stability up to 4.8V** vs. Li⁺/Li₀ [5]
→ High voltage cathode compatibility

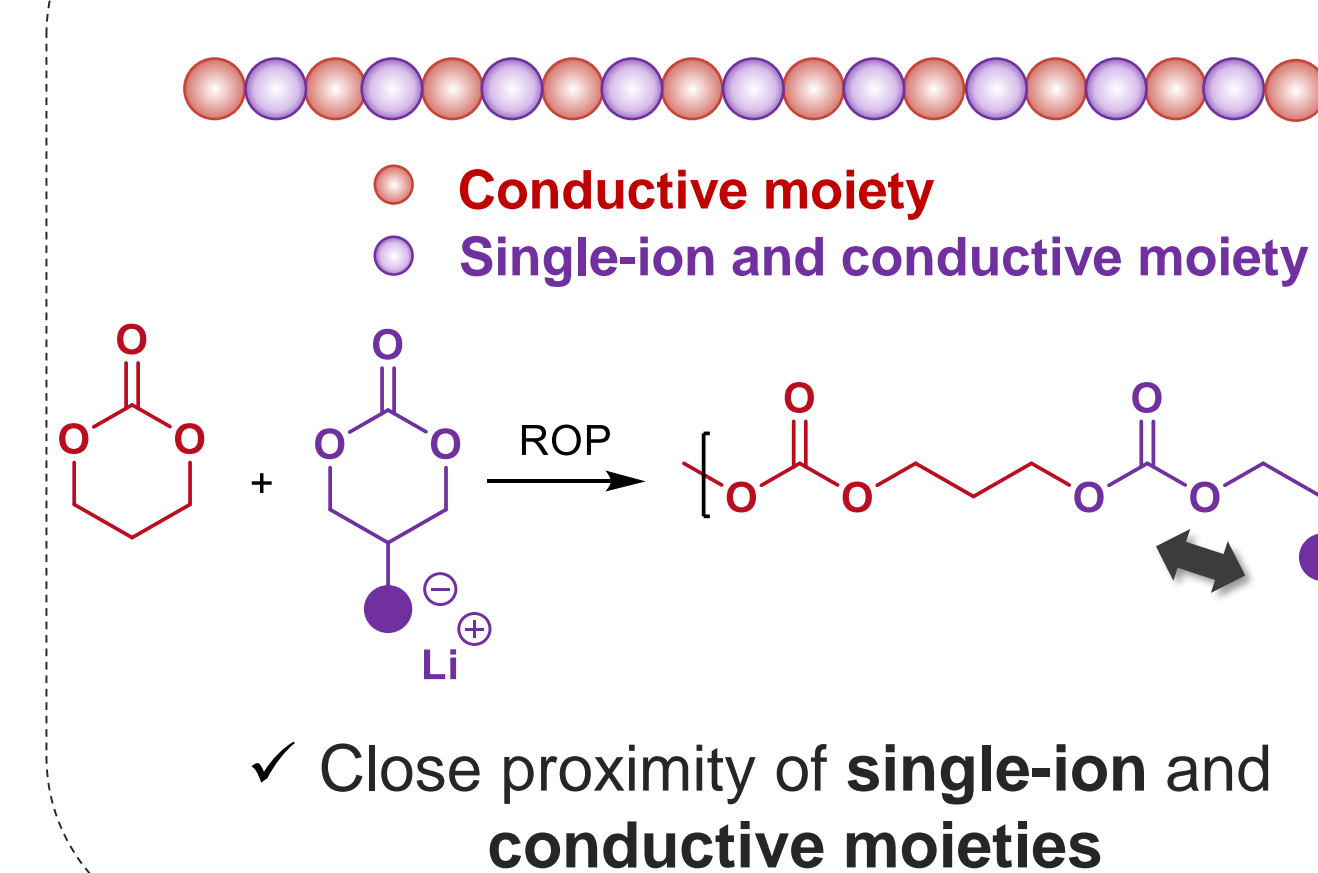


Carbonate-based single-ion polymer electrolytes

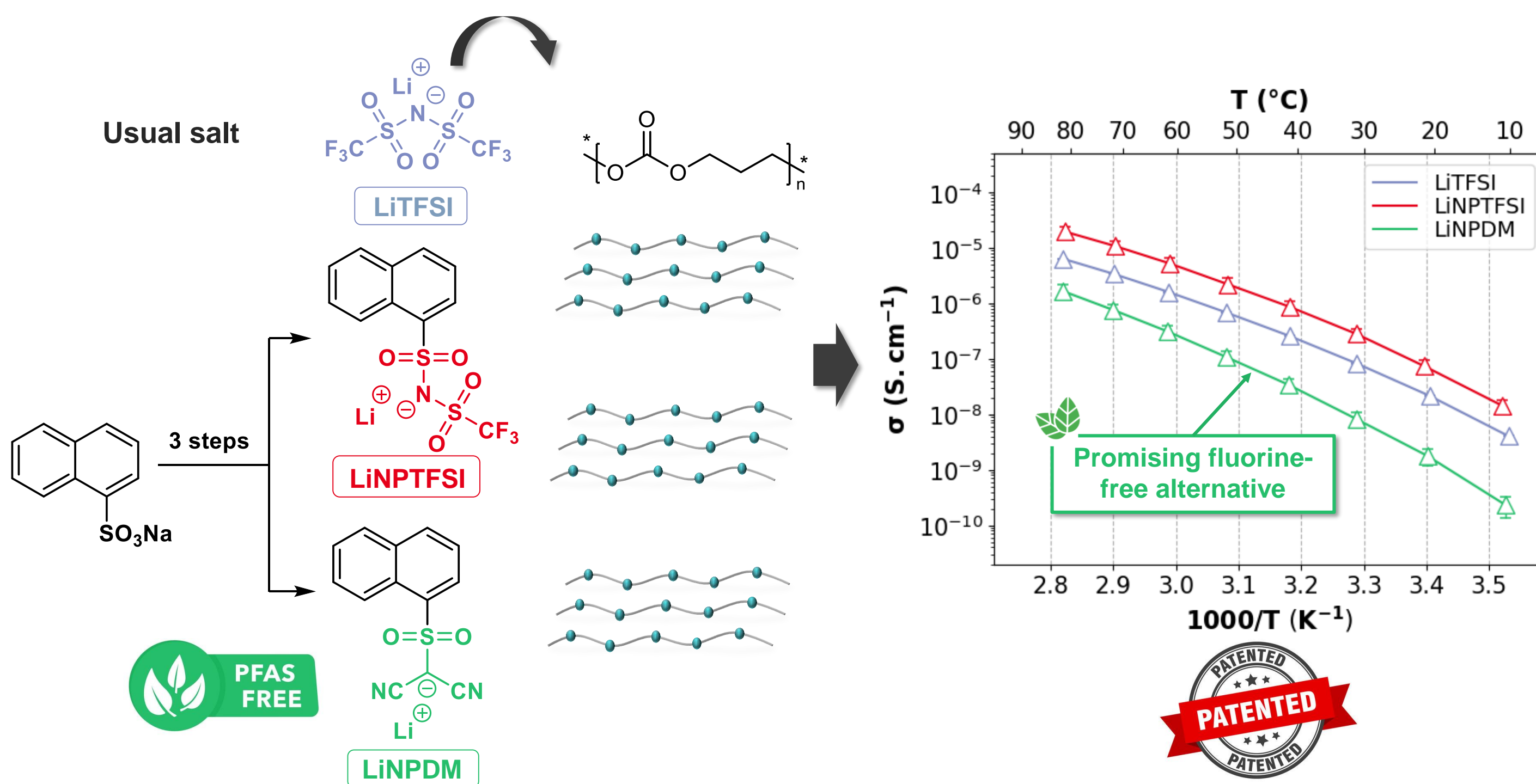
Classic single-ion polymer architecture [7]



This work

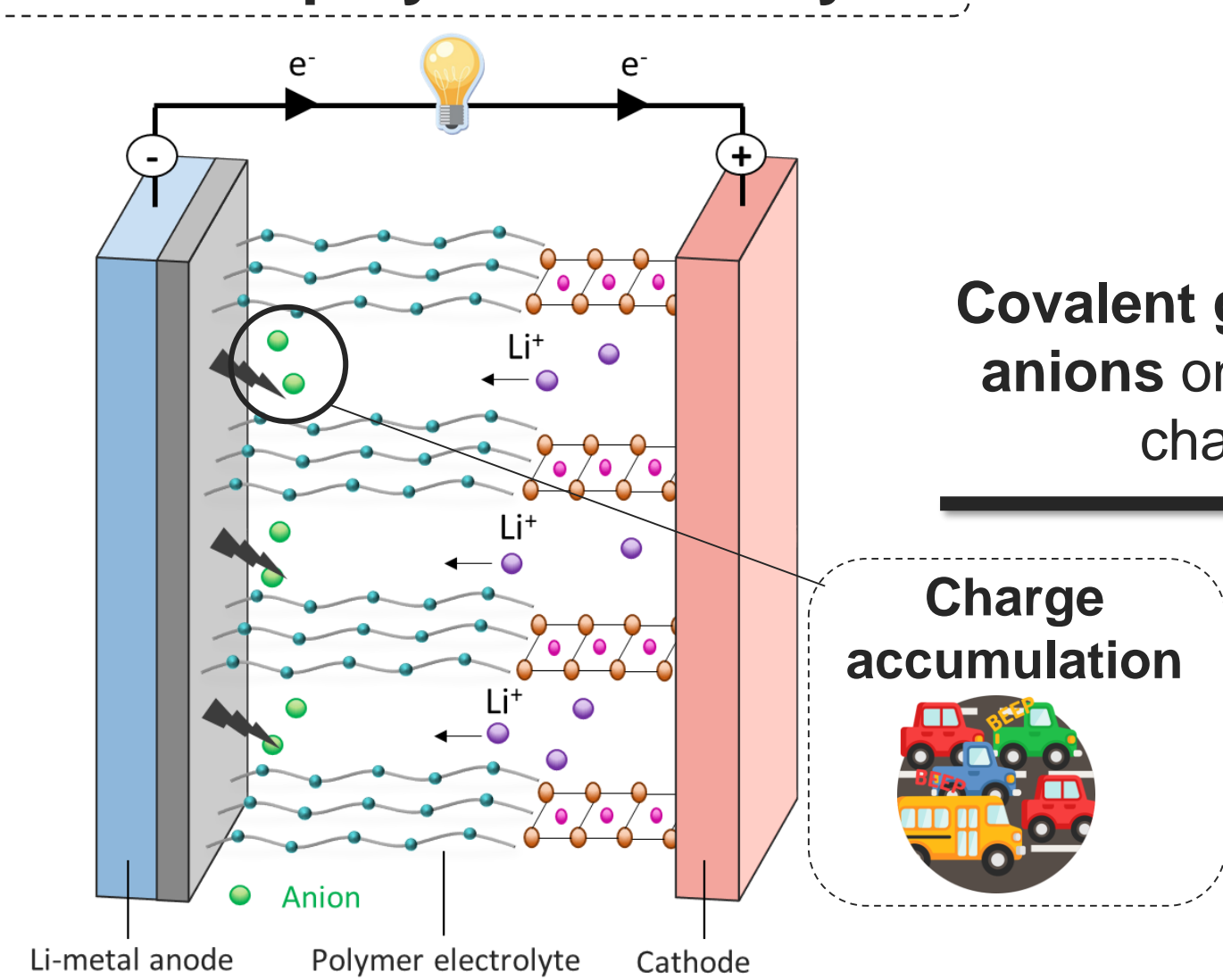


❖ ELECTROCHEMICAL CHARACTERIZATION OF NEW LITHIUM SALTS

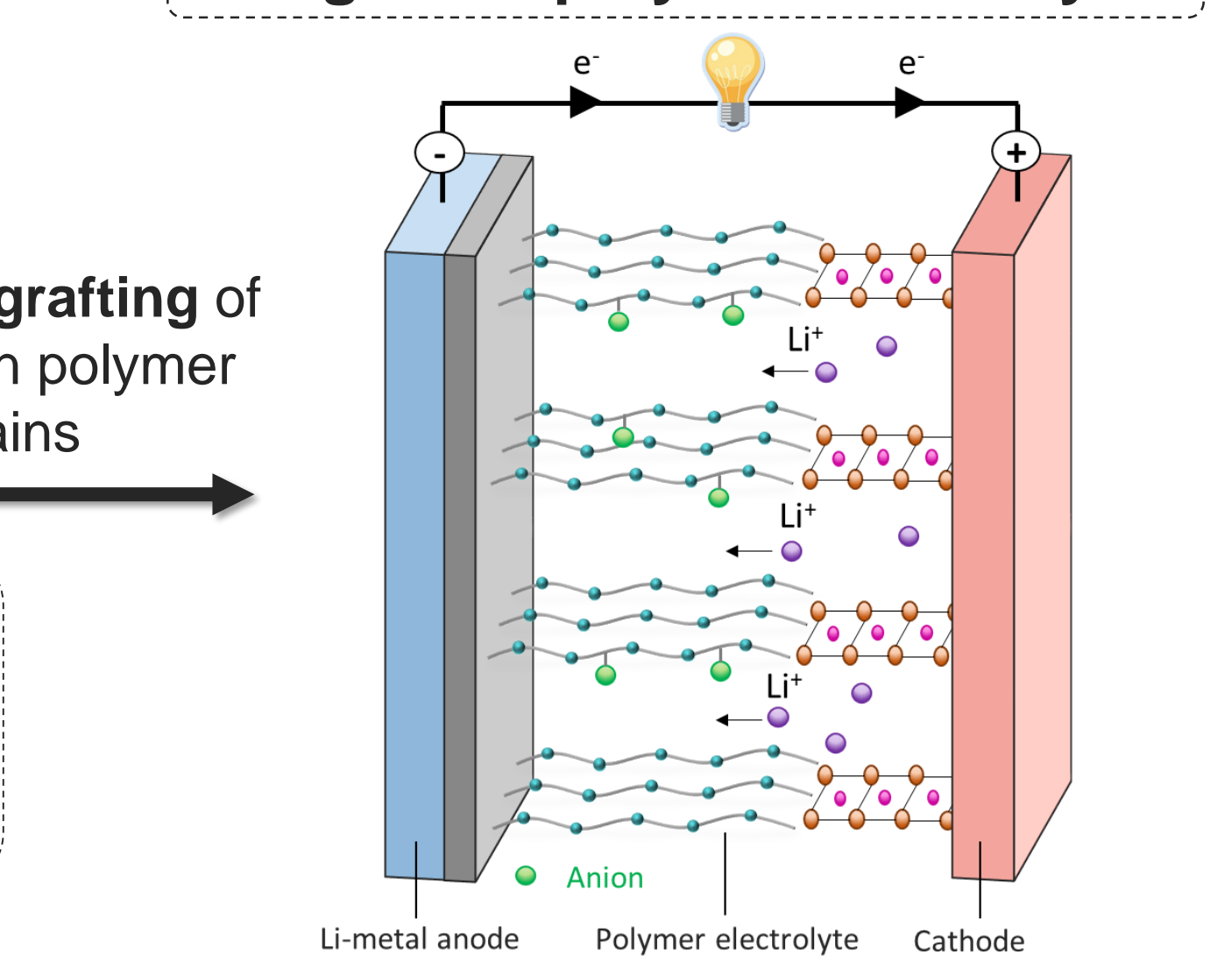


Single-ion polymer strategy

Classic polymer electrolyte



Single-ion polymer electrolyte



Covalent grafting of anions on polymer chains

Charge accumulation

✓ Only Li⁺ ions move via the segmental motion of polymer chains ($t_{\text{Li}^+} \approx 1$) [6]

Conclusions and perspectives

- Preparation of **new polymer electrolyte systems** with weakly coordinating lithium salts derived from naphthalene and electrochemical characterizations
- Development of a **versatile synthesis method** for single-ion functionalized cyclic carbonate monomers
- Study of the **copolymerization** of cyclic carbonate monomers and single-ion functionalized cyclic carbonate monomers

References

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[6] M. Irfan, *et al. J. Power Sources* **2021**, 486, 229378.

[7] R. Bouchet, *et al. Nature Mater* **2013**, 12 (5), 452–457.