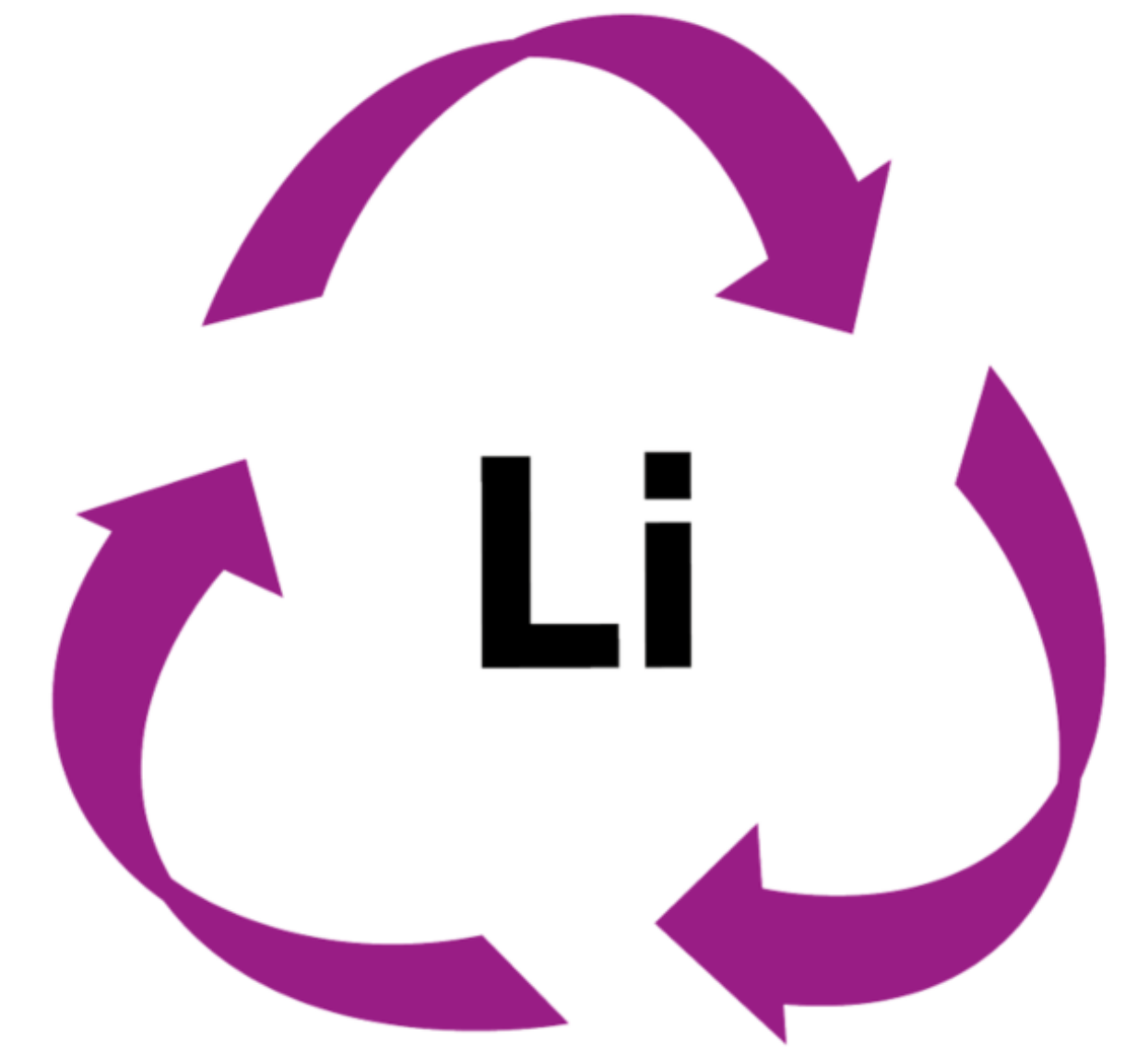


# Lithium Extraction via Ion-Selective Ceramic Membranes: Smart separation technology for the efficient recovering and refinement of Lithium



Evonik's lithium-selective ceramic membranes enable a sustainable and efficient electrochemical process for recovering high-purity LiOH from lithium-containing process water.

## Innovative solutions needed to meet the rising Li-demand



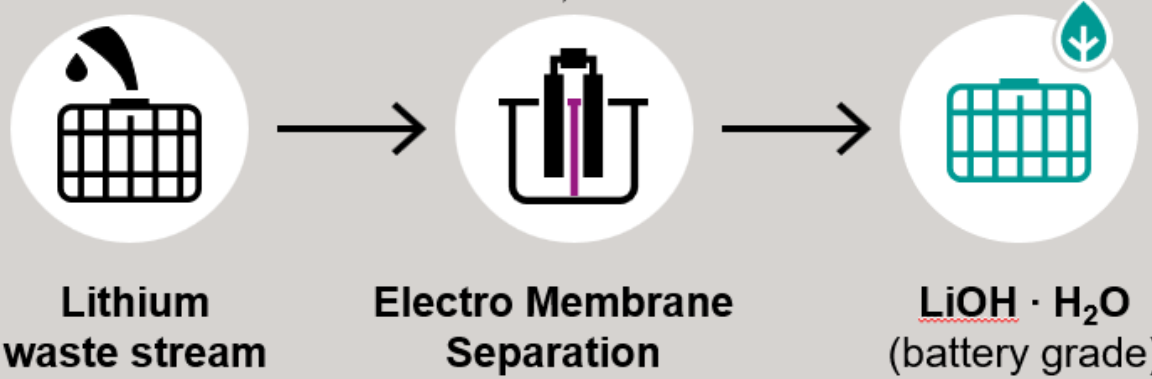
Challenge

- Rising demand for **lithium** in e-mobility drives interest in sustainable production and a closed lithium circular economy.
- Battery recycling & mining industry is intensively seeking for new **cost-effective technologies** to recover Lithium.

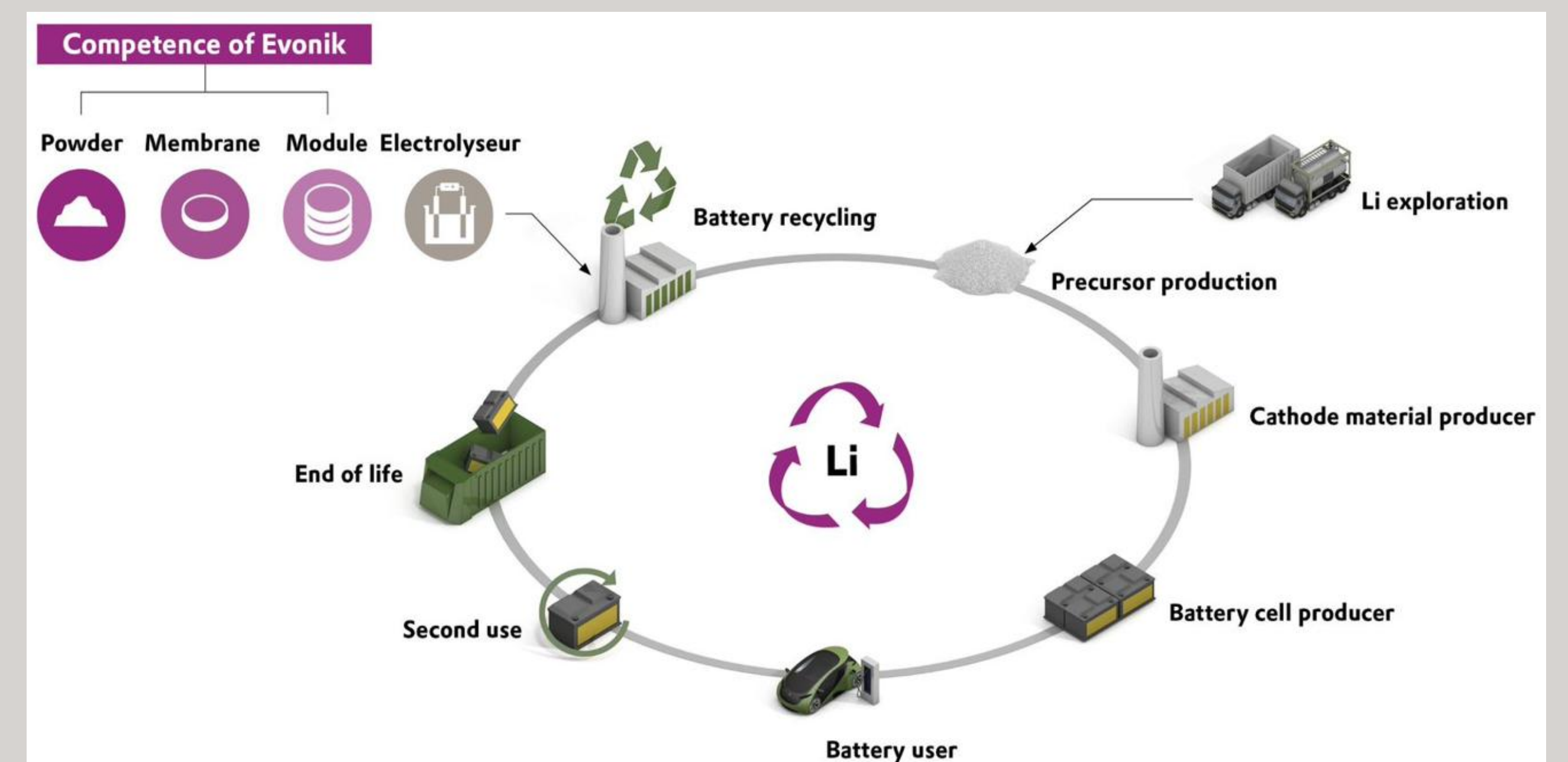


Solution

- A **permselective ceramic membrane** useable for **electrochemical separation of lithium** in a resource friendly and cost competitive way.

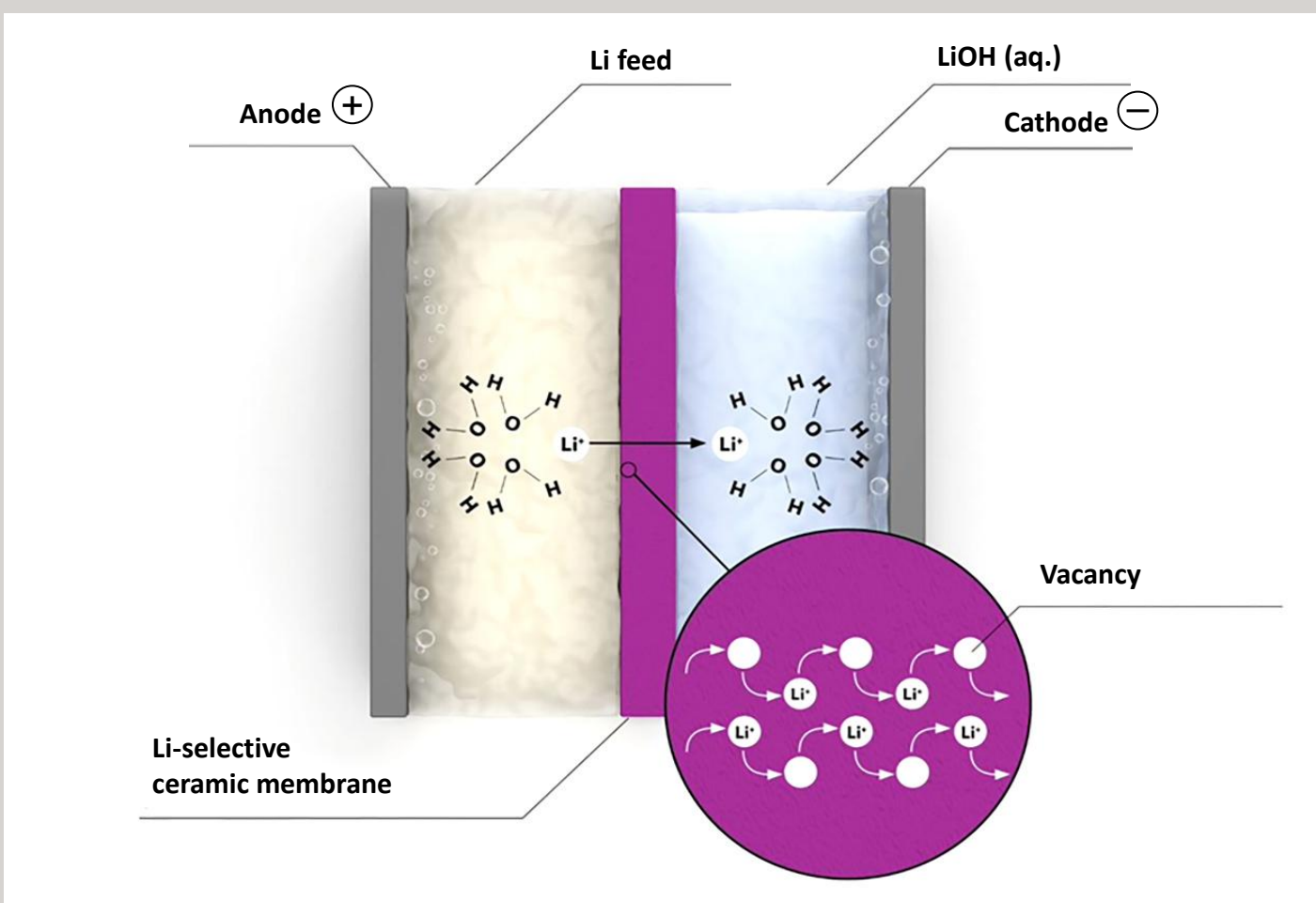


## Life cycle of Lithium-ion batteries

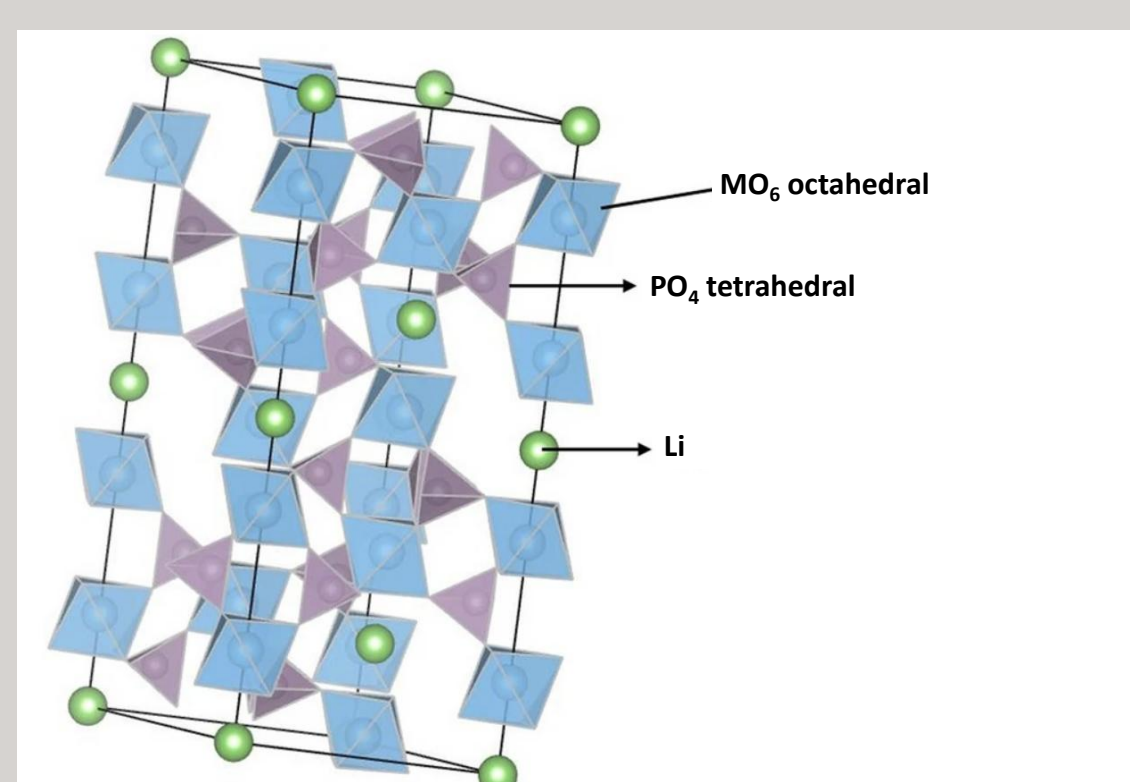


## Working principle

### Membrane selectivity for Li<sup>+</sup>: >99%

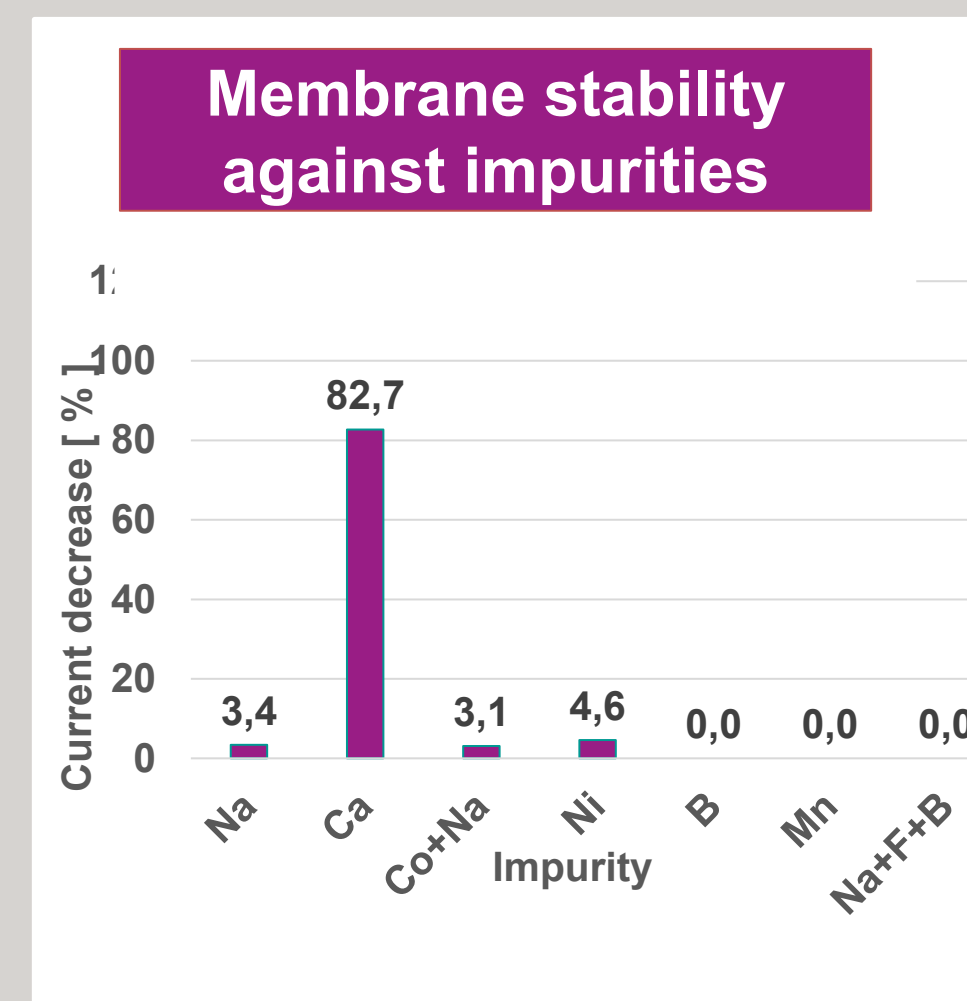
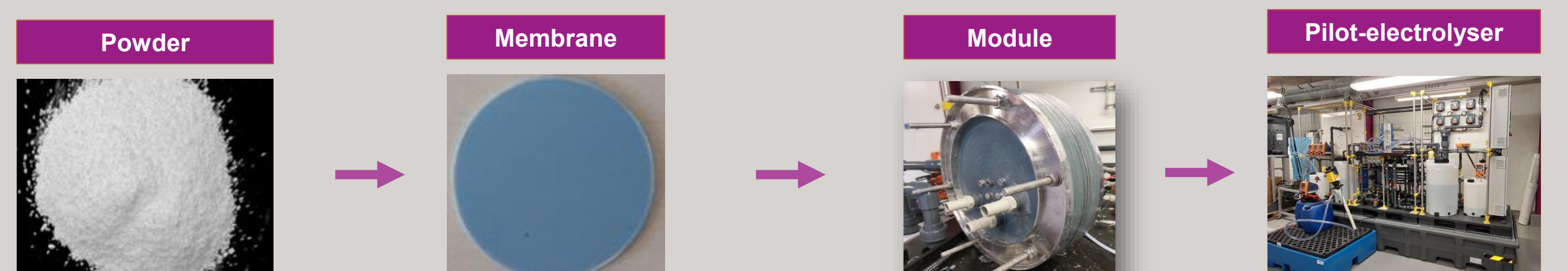


Evonik's lithium-ion conductive ceramic membrane consists of LISICON\*- type material



\*J. Electron. Mater., 51, S. 2663-2672 (2022) LISICON: Akronym für Lithium Super Ionic CONductor conductivity: 3-4 10<sup>-4</sup> S/cm

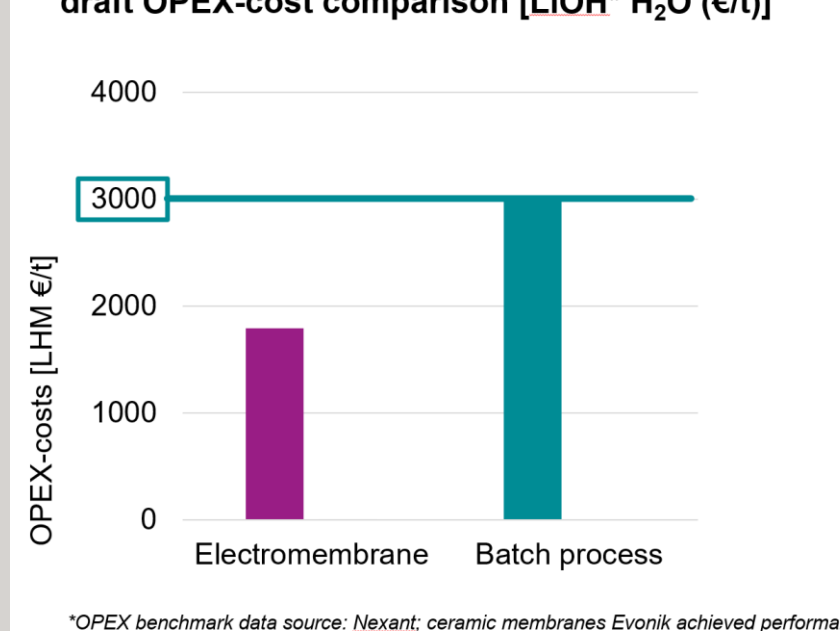
## Translating the idea into a practical process design



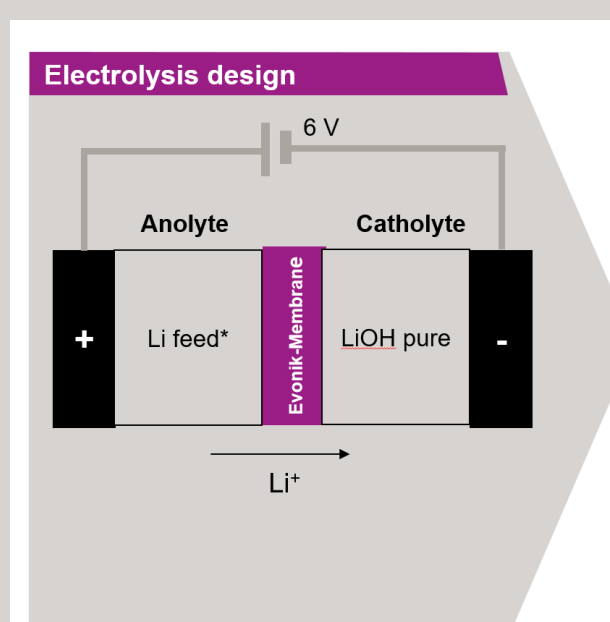
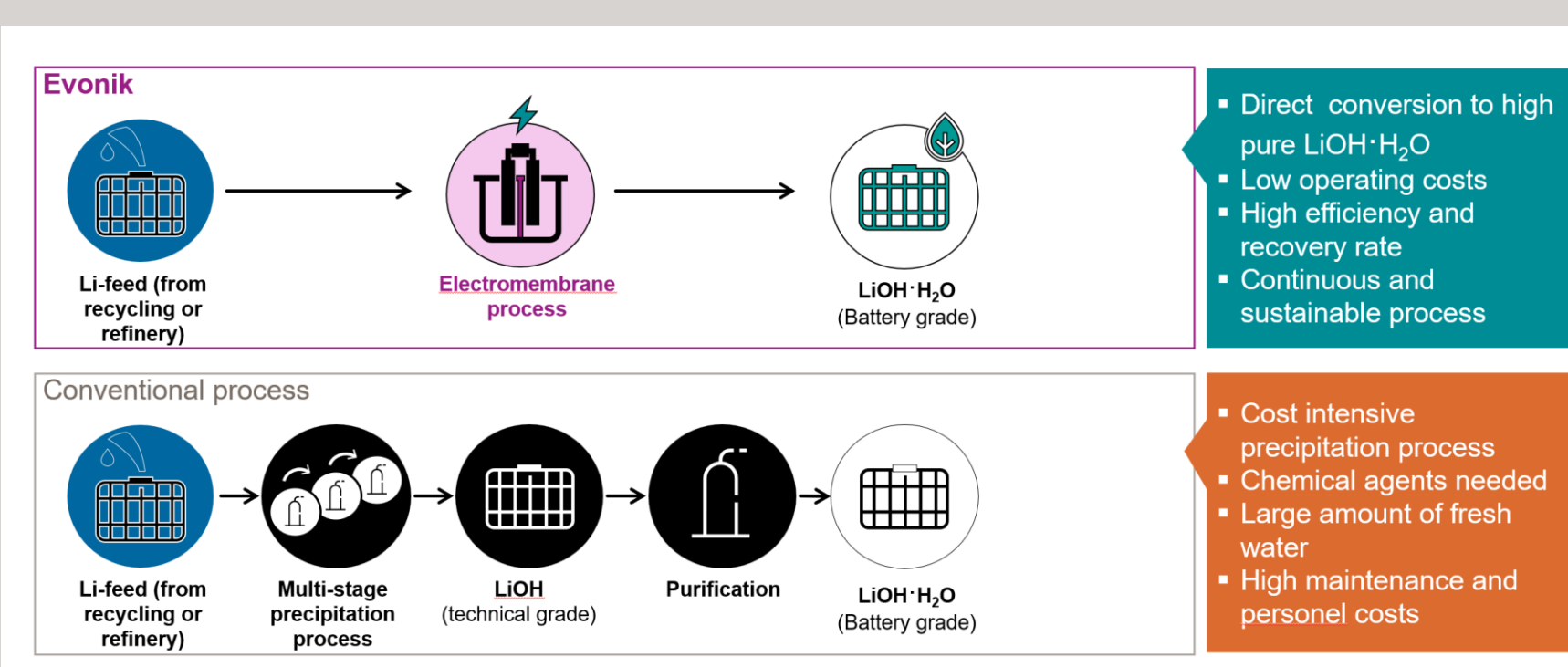
Type of ion (Impurity)	Amount [ppm]
Na	300
Ca	30
Co+Na	30+300
Ni	30
B	1000
Mn	30
Na-F	300-247
Na-F+B	300-247+1000

## Electrochemical properties

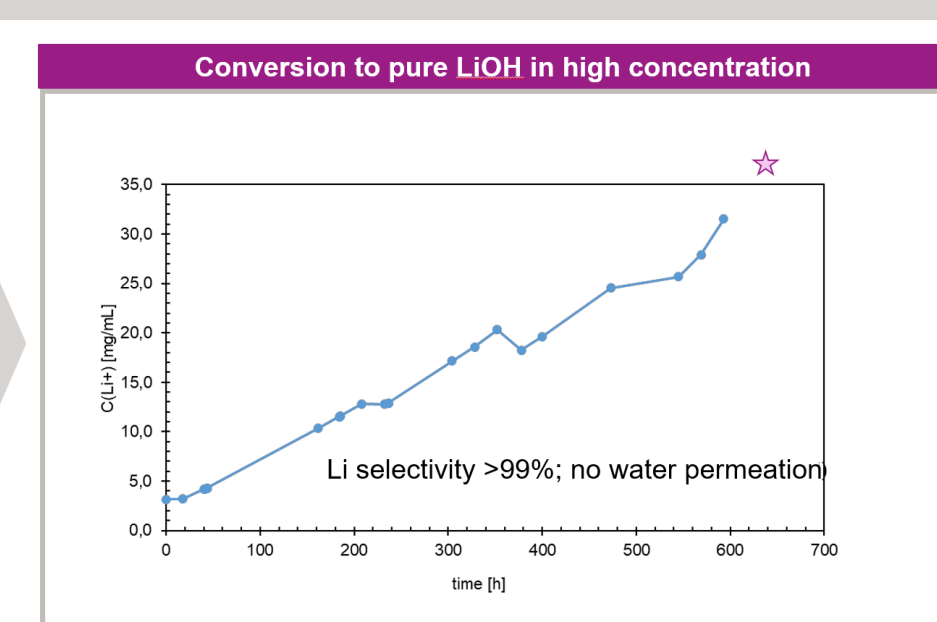
### Positive outlook of Electromembrane Process in draft OPEX-cost comparison [LiOH·H<sub>2</sub>O (€/t)]



\*OPEX benchmark data source: Ifreant, ceramic membranes Evonik achieved performance data with ion-conductive ceramic membranes in demo-tests: LiOH·H<sub>2</sub>O



\*Li feed: different feed composition possible



\*Max. solubility of LiOH in water (at 20°C): 127 mg/ mL (38 mg Li/ mL)

Draft	
Module size 20 m <sup>2</sup> *	LiOH·H <sub>2</sub> O/ year: 95-110 t (8000 hrs/a)
Typical production rate/a	LiOH·H <sub>2</sub> O/ year: 4.8-5 t/m <sup>2</sup> a
Target current density	200-300 A/m <sup>2</sup>
Current efficiency	>95 %
Energy demand	4-5 kWh/kg LiOH·H <sub>2</sub> O
Opex energy	0.4-0.5 €/kg (price for kWh: 0.1 €/kWh)
Membrane lifetime	>2.4 years
Electrolyzer lifetime	>10 years

## Key benefits

### Best in class costs ...

- Lower OPEX – highest current efficiency compared to others
- No additional chemicals required
- Continuous process

### Easy adoptable ...

- Close pressure module design
- Flexible and scalable – Plug & Play solution
- Flexible to impurities – minimal pretreatment required

### Best in-class performance ...

- Excellent Lithium recovery >99%
- High membrane selectivity >99%
- Direct conversion into LiOH without any barrier

### ... sustainable Lithium recovery

- Resource conserving: no need for precipitating agents
- Lower water consumption
- (Green) electrolysis process