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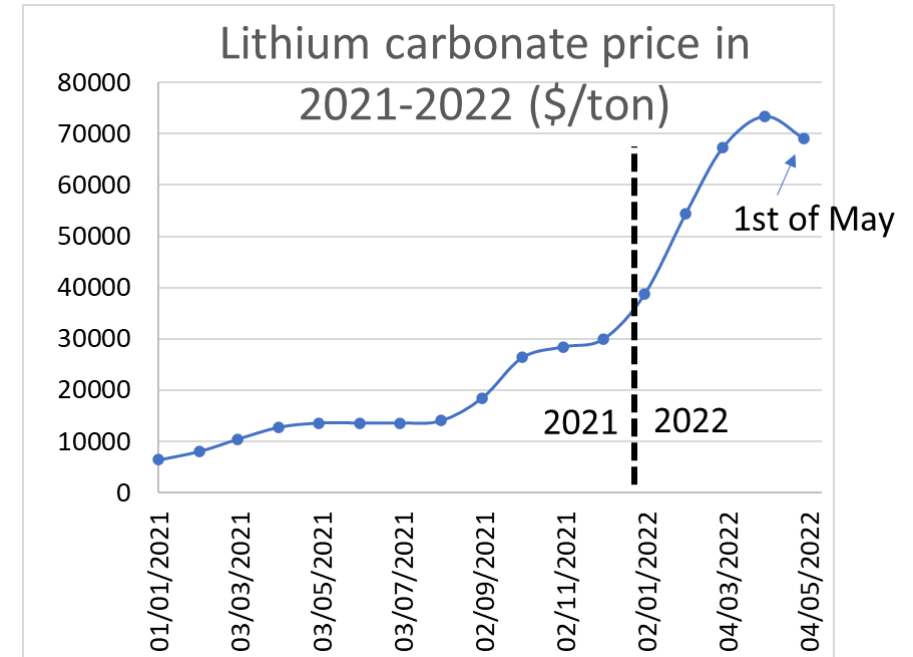
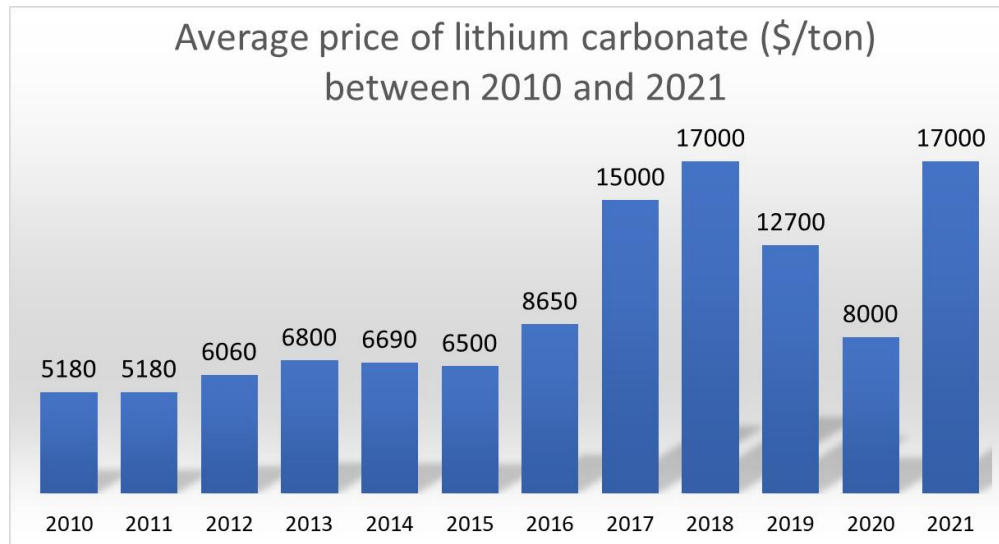
Sustainable recovery of lithium from seawater brines

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Some ~~fun~~ facts about lithium and Li-ion batteries

- Lithium is not the main element of Li-ion batteries (Li-NMC, Li-NCA, Li-FP), but it is the key and irreplaceable element.
- Price of lithium carbonate is rising:



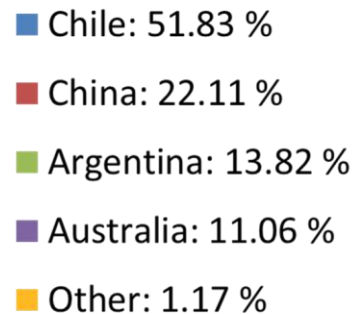
- Carbon footprint of an Electric Vehicle (XC Recharge) becomes smaller than of the corresponding XC40 fossil-fuel powered car only after 110 000 km. When it reaches 200 000 km (vehicle lifetime), it will generate just 15% less CO₂ emissions.

New sources of lithium (brines from saltworks)

Lithium in oceans:
230 billion tons



Lithium on land:
14 million tons



Lithium extraction from seawater can be an opportunity to explore almost unlimited lithium source, however its low concentration in seawater (~0.2 ppm) is a challenge.

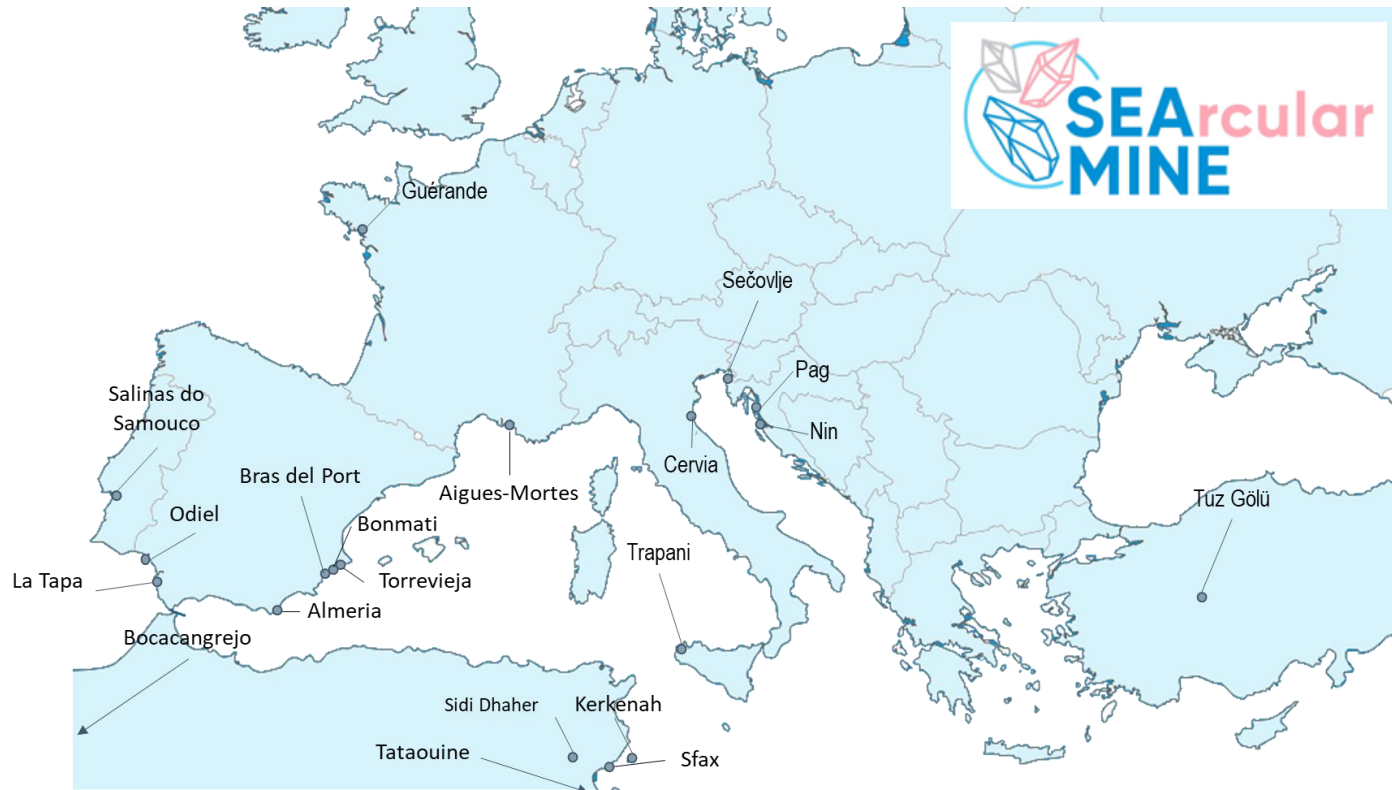
What about recovery of valuable raw materials (including lithium) from seawater brines (bitterns)?

$$\frac{\text{Bittern produced}}{\text{Salt produced}} = 2.1 \text{ (m}^3\text{/ton)}$$



Salinas do Samouco

Saltworks



Lithium in bitterns: up to 80-160 times more concentrated than in seawater.

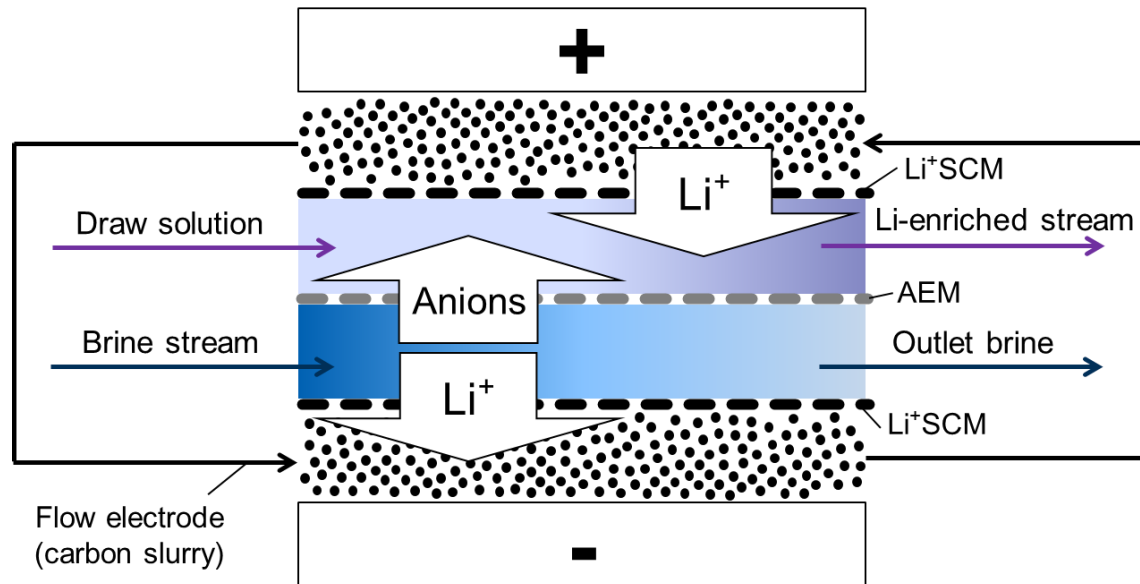
17 700 t/Y of lithium global production potential from bitterns.

Note 1: Lithium mine worldwide production in 2021 was ~ 100 000 tons.

Note 2: Lithium mine reserves in Portugal are estimated to be ~ 60 000 tons.

Special acknowledgment to André Batista (Salinas do Samouco), Fabrizio Vicari (Resourseas) and all partners from SEArcularMINE consortium.

Lithium recovery by Flow Capacitive Deionization (FCDI)

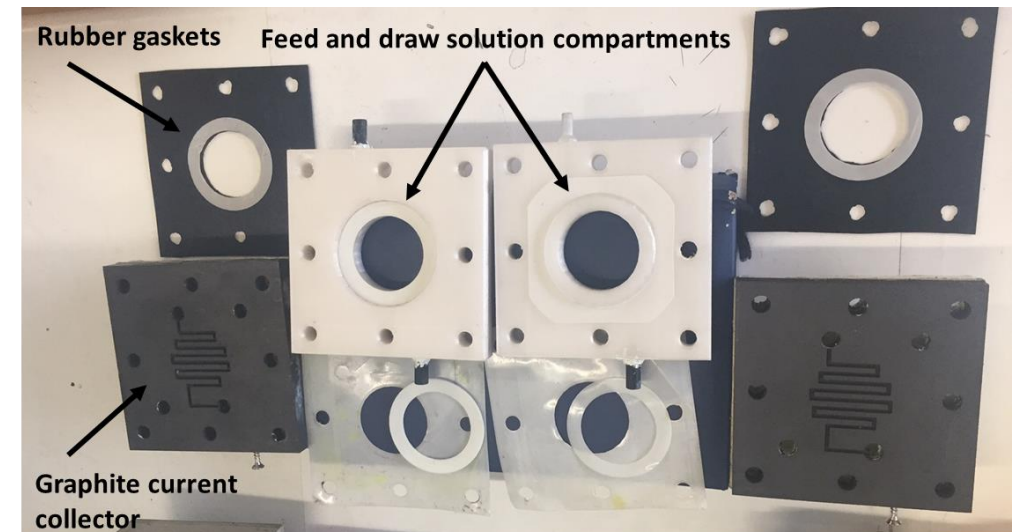


Li⁺SCM = Lithium selective cation exchange membrane

AEM = Anion exchange membrane

Draw Solution = 0.1 M HCl solution

- Electromembrane process
- Membranes are selective barriers
- Continuous operation in a single device
- Electric potential difference (electricity) is the driving force

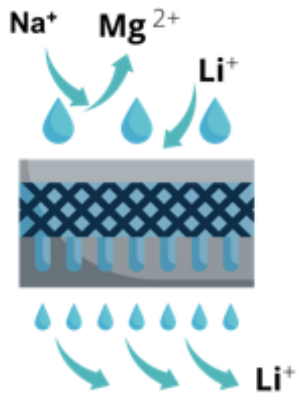


Inhouse constructed FCDI cell using 3D printer and CNC milling

Lithium selective membranes and flow-electrodes



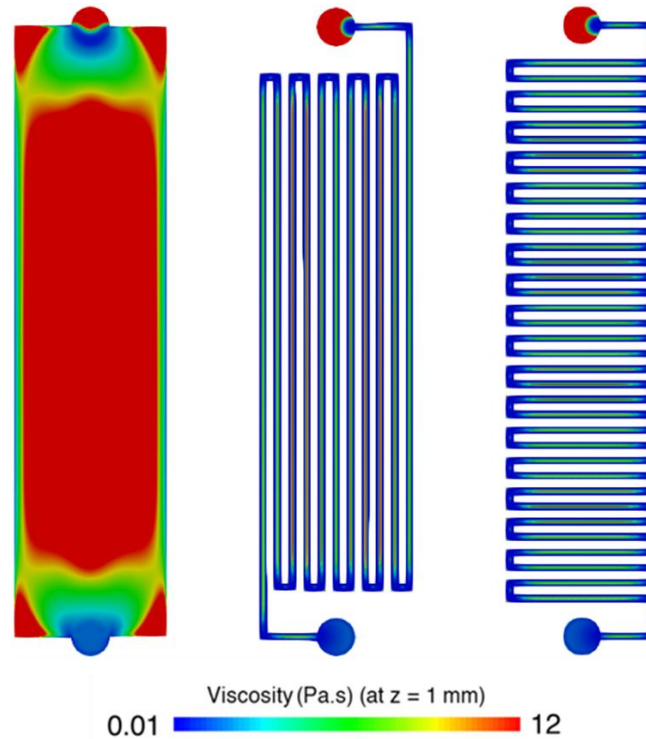
HMO + SPES + additives



Selectivity:
Li⁺/Mg²⁺ = **11.75**,
Li⁺/Na⁺ = **3.56**,
Li-flux (mol/m².h) = **0.11**

H. M. Saif *et al.*, "Development of highly selective composite polymeric membranes for Li⁺/Mg²⁺ separation", JMS 620 (2021) 118891.

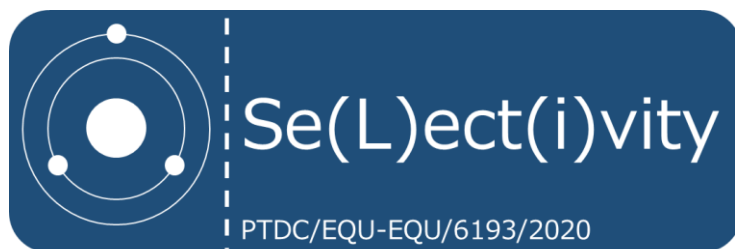
Rheological and electrochemical characterization of carbon slurries: YP50F carbon showed to have high maximum salt adsorption capacity (122 mg/g), fast adsorption rate (0.0042 mg/g/s) and low viscosity (less than 0.06 Pa.s (for shear rate of 200 s⁻¹) at very high mass loadings (20 wt. %)).



CFD-assisted design of flow electrode channels



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Thank you!

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encontro CIÊNCIA'22, Lisboa 16 a 18 Maio 2022

