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Hybrid Capacitive Deionization as an Emerging Method for Lithium Removal from Geothermal Water

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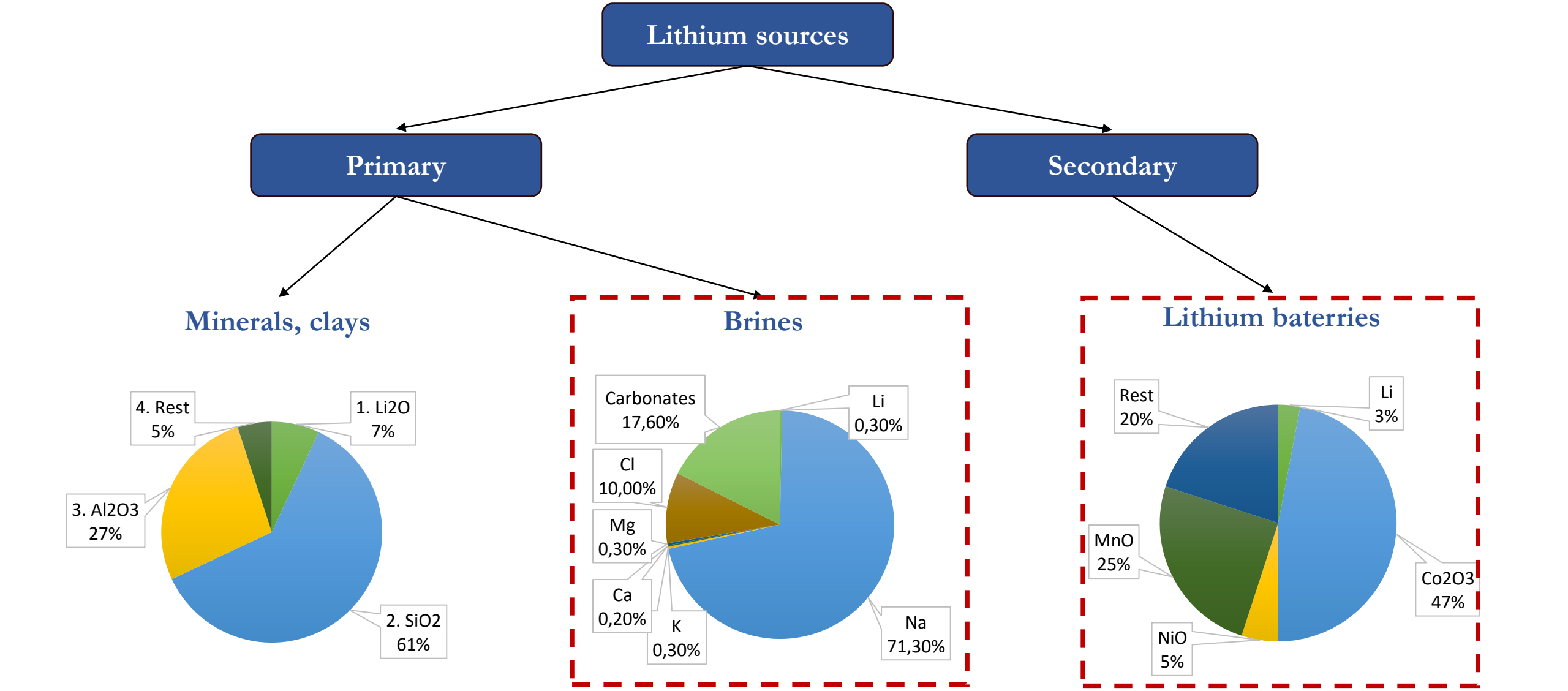
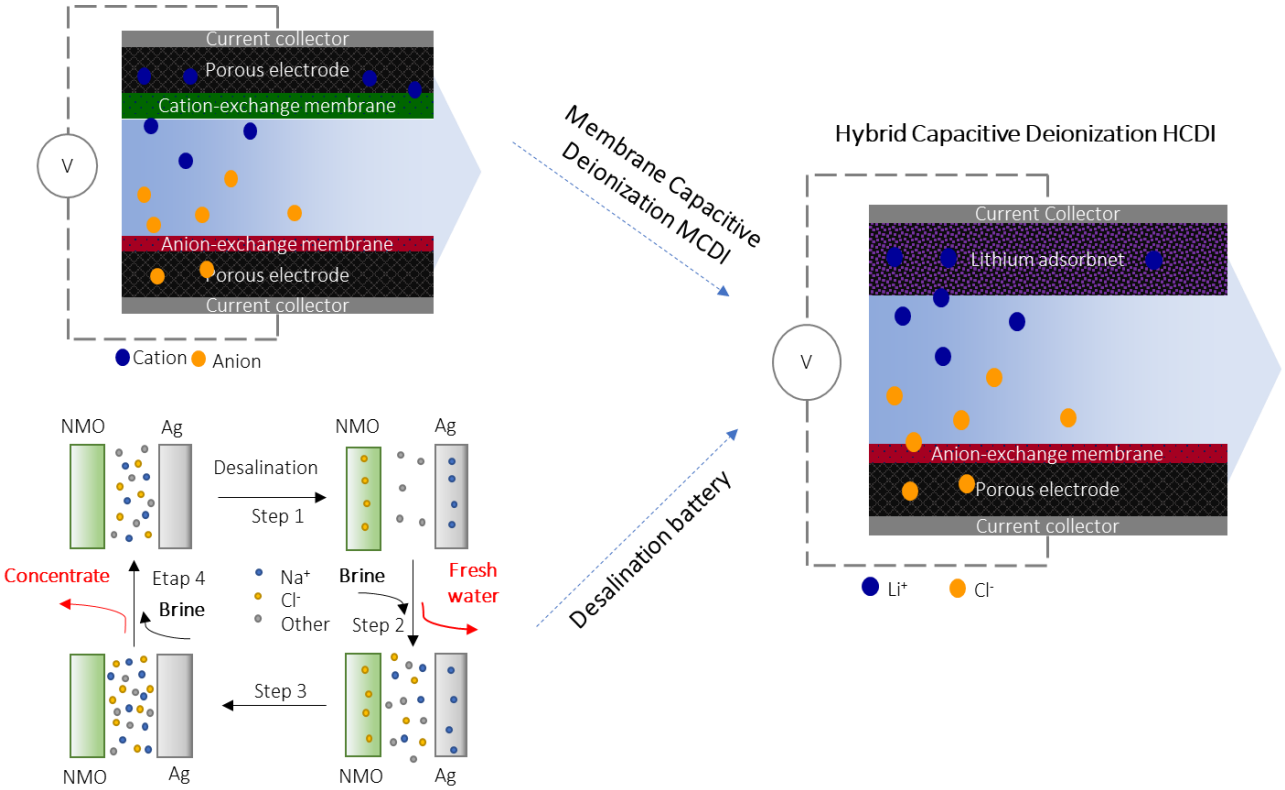
Lithium background

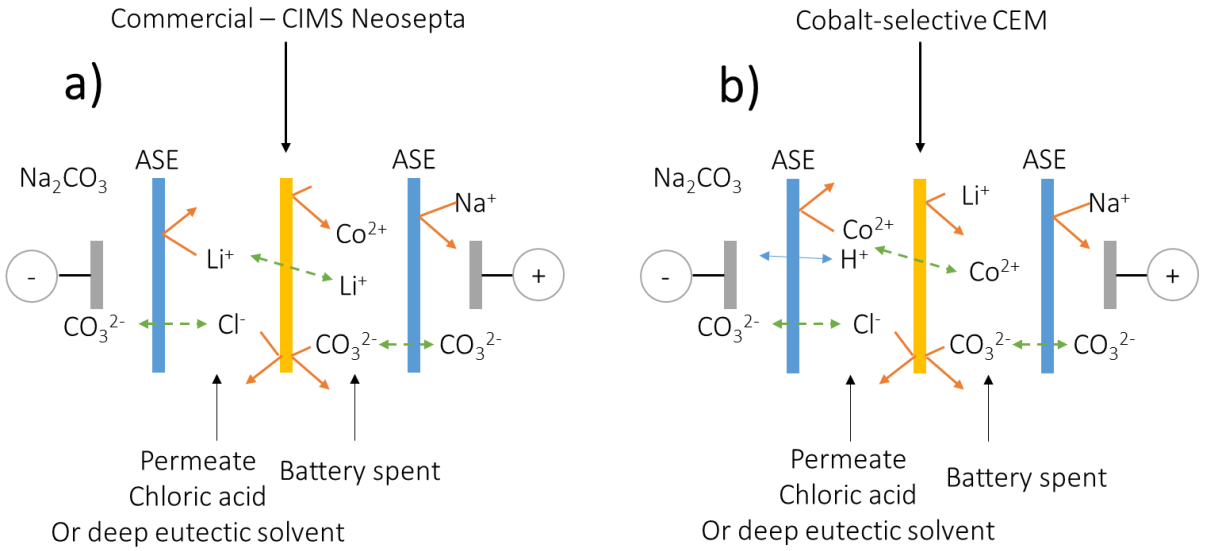


Electromembrane processes for lithium separation

Hybrid Capacitive Deionization

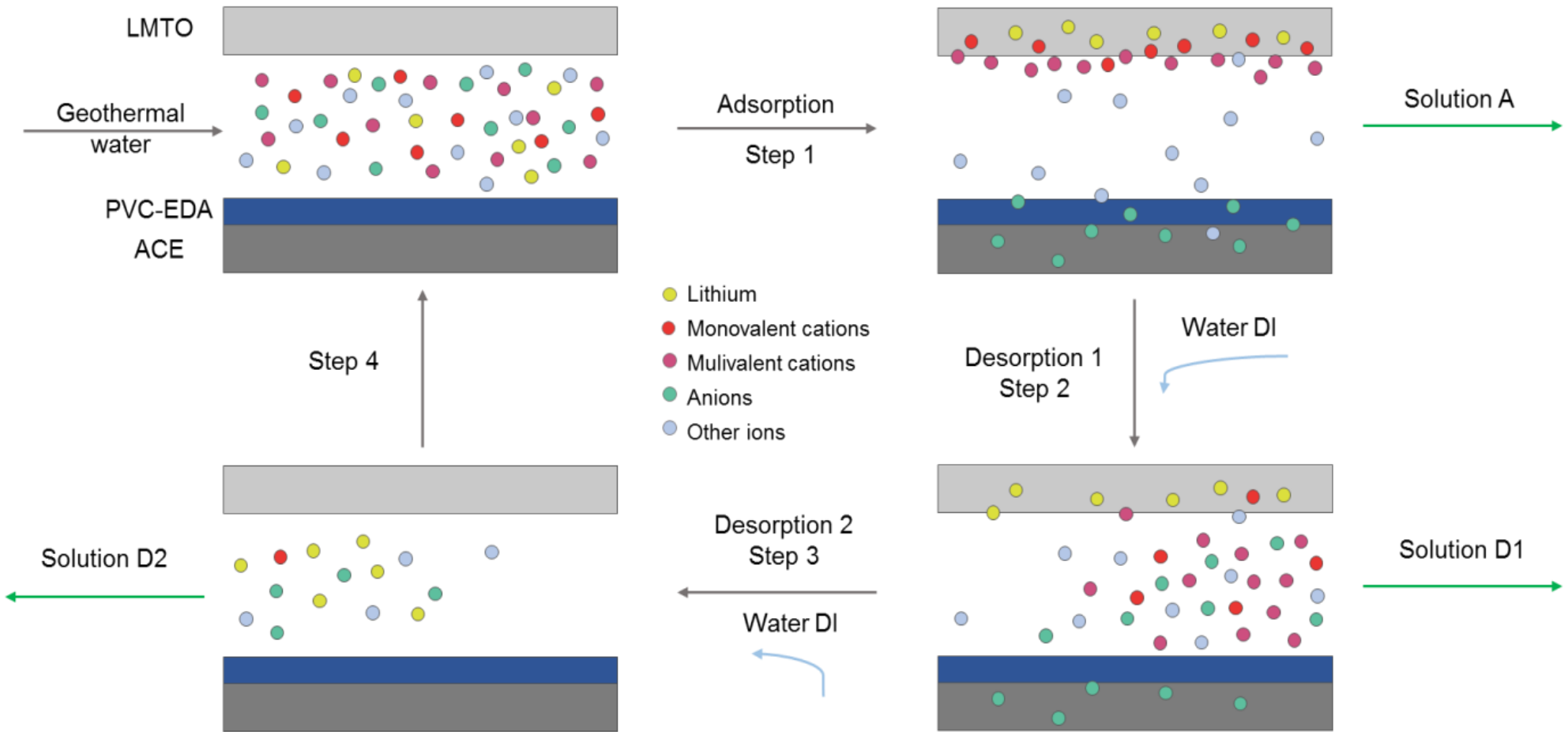


Electrodialysis

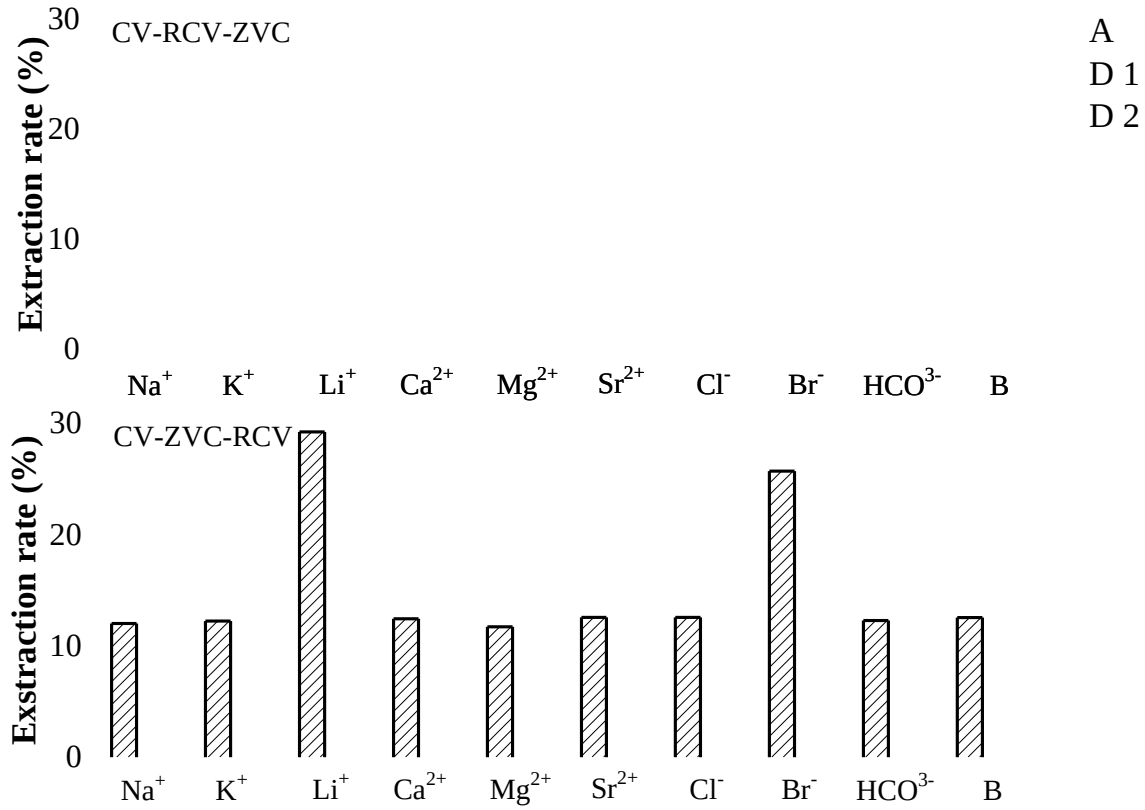


Siekierka et al. Lithium dedicated adsorbents for the preparation of electrodes useful in the ion pumping method, Separation and Purification Technology 194 (2018) 231-238

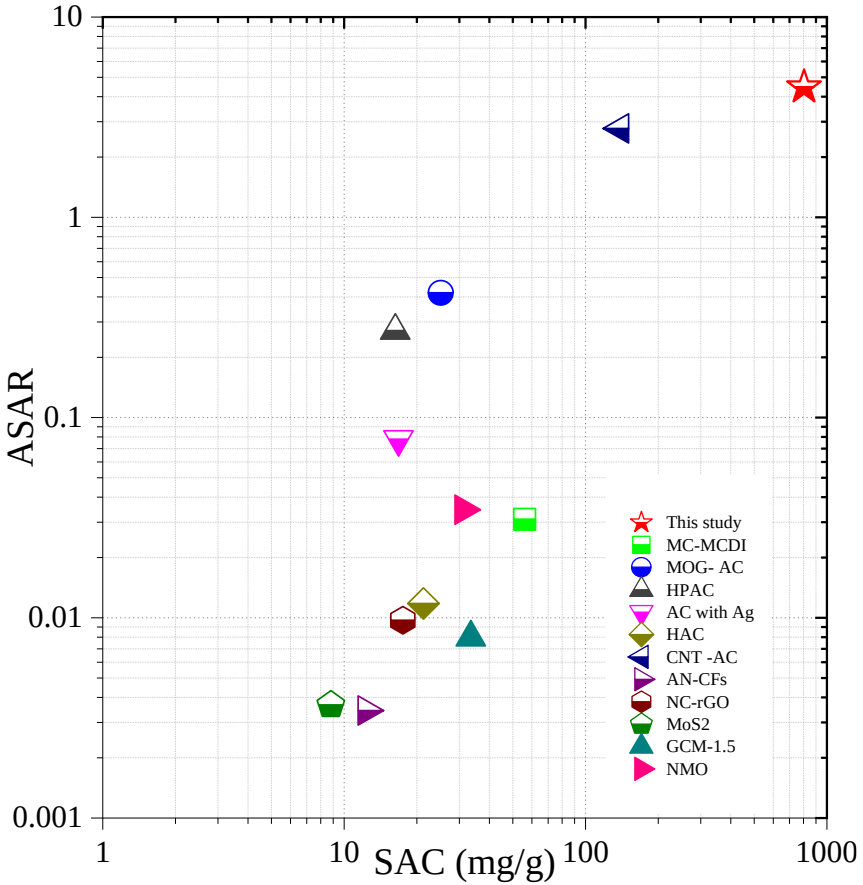
Hybrid Capacitive Deionization – proces performance



Li-Mn-Ti adsorbents

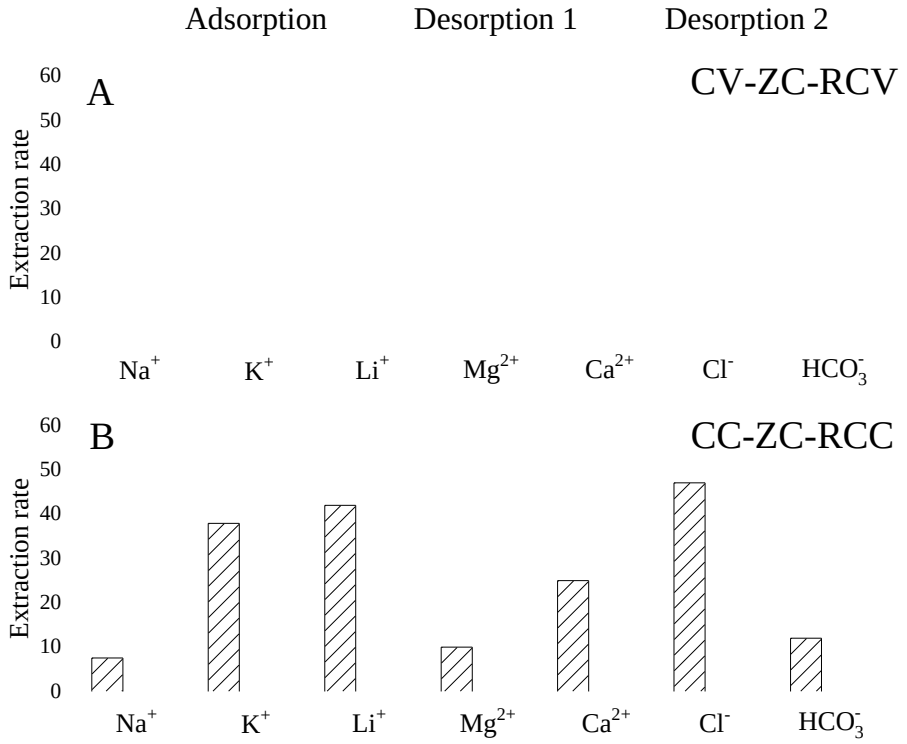


Effective rate of extraction during A, D1 and D2 for evaluated configurations.

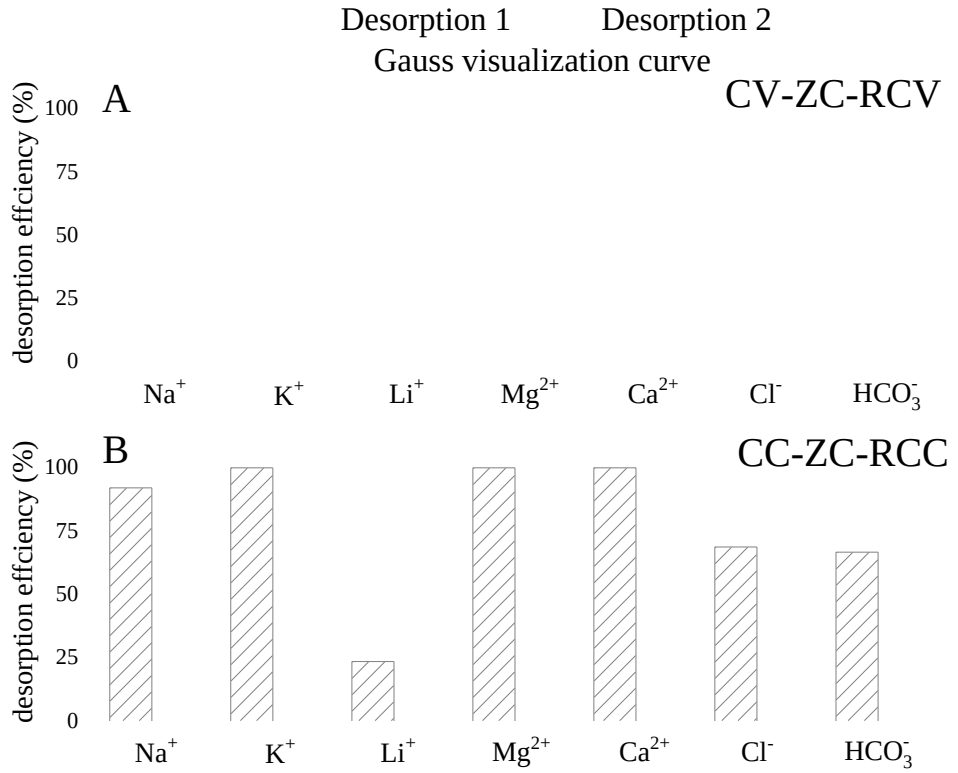


Modified Ragone plots for evaluated configurations and comparison results with literature data

Li-Mn-Fe adsorbents

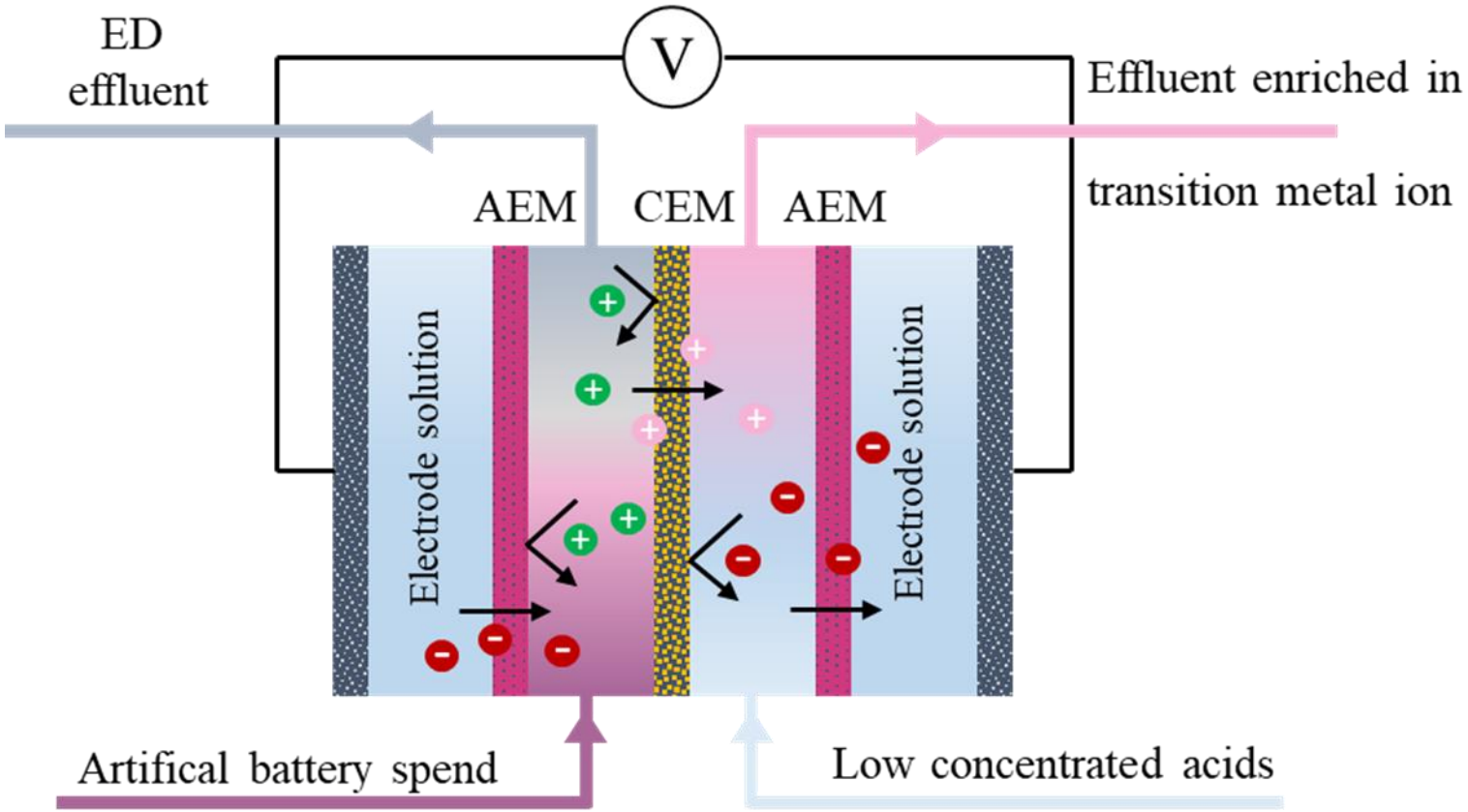


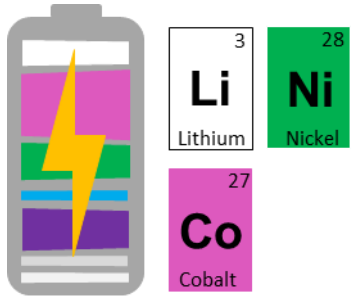
Extraction rate for particular elements for Adsorption, Desorption 1 and Desorption 2 in different electrical modes: A) constant voltage configuration and b) constant current configuration. Applied adsorbent: 1.5LFM, CV=2V, RCV=-2V, t_{ads}=3min, $t_{des,1}$=1min, $t_{des,2}$=5min. CC_{ads}=0.05mA/cm^2, $CC_{des,2}$=-0.05mA/cm^2.



Efficiency of ions elution ratio in both configurations. Applied adsorbent: 1.5LFM, CV=2V, RCV=-2V, t_{ads}=3min, $t_{des,1}$=1min, $t_{des,2}$=5min. CC_{ads}=0.05mA/cm^2, $CC_{des,2}$=-0.05mA/cm^2.

Electrodialysis - strategy

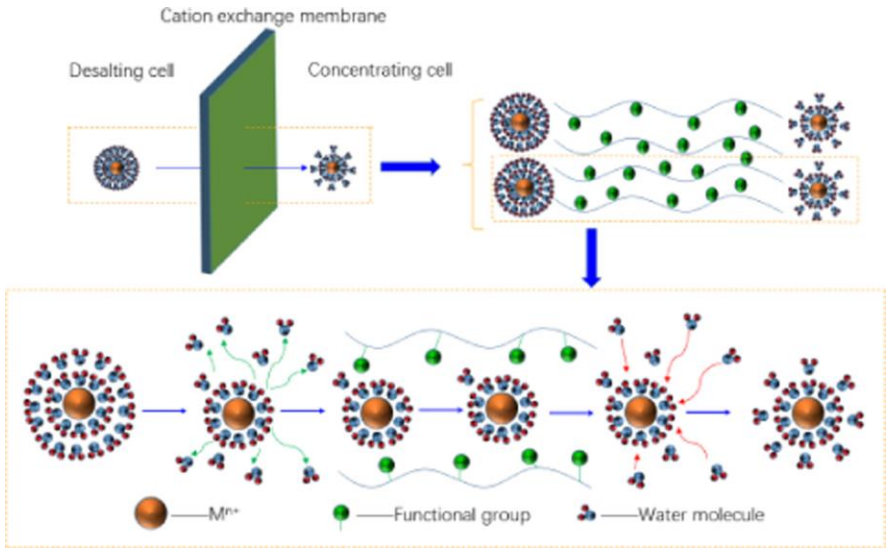




Cation-exchange membranes

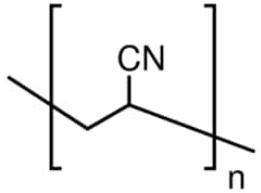
Two strategies for selective ED process design

Application of monovalent selective CEM



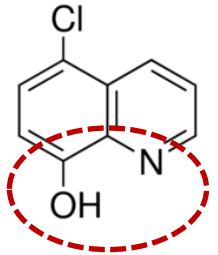
Partial dehydration conceptual model of ion migration in the cation exchange membrane. Ref.2.

Develop cobalt selective CEM



PAN
Well known membrane creative material

+



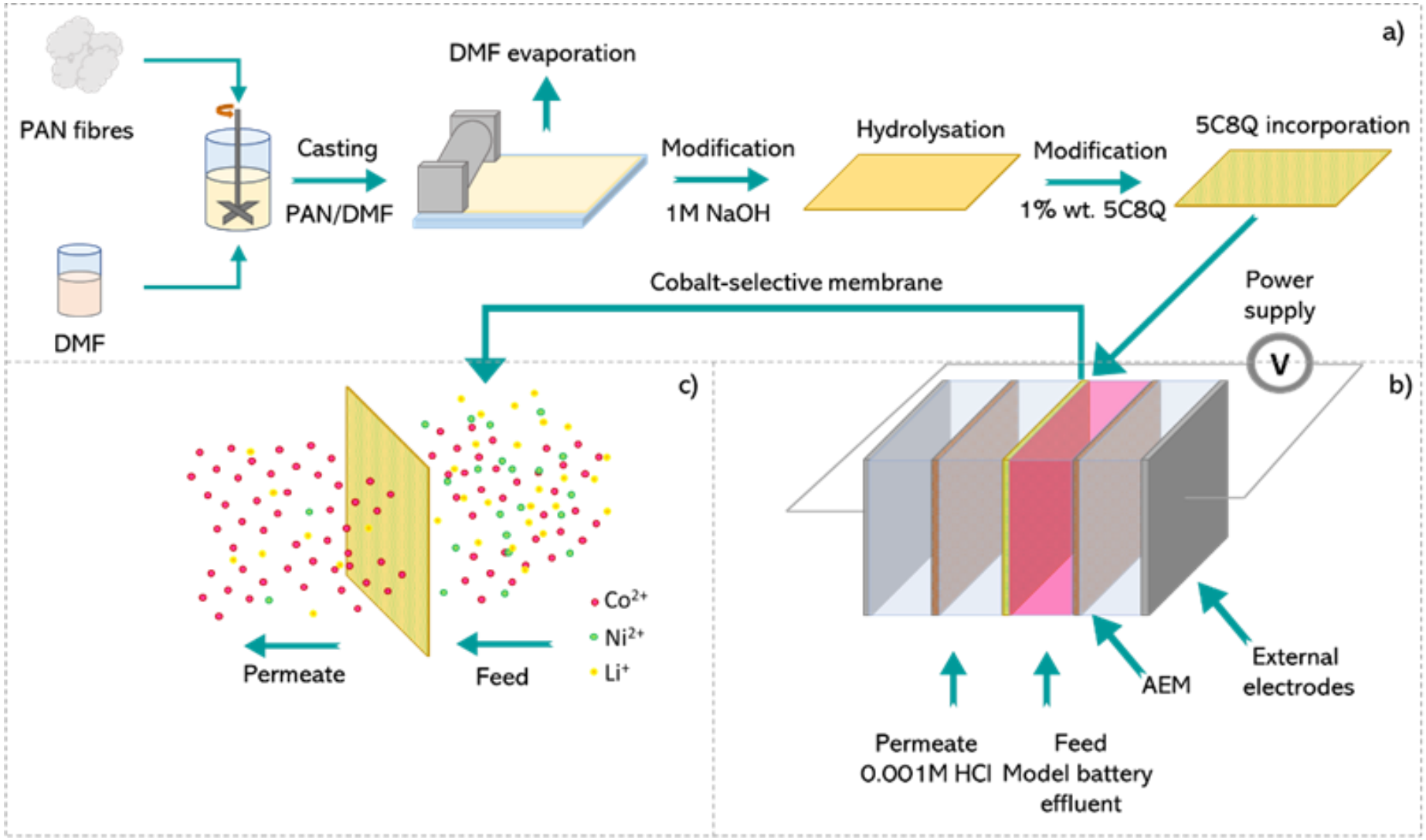
5-Chloro-8-hydroxyquinoline
Cobalt removal by dedicated chelating agent

Ionic radius for Co and Li

Ionic radius [pm]	+1	+2	+3
Li	90		
Co		79	68.5

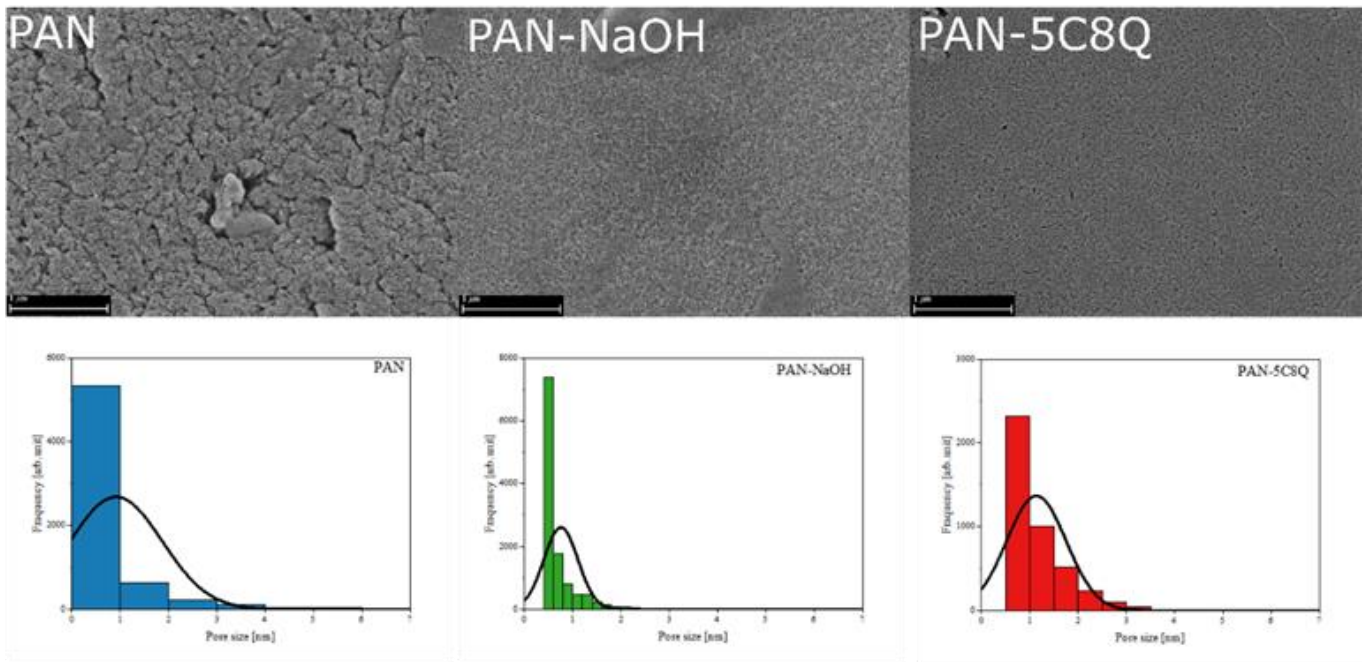
J Membr Sci, 325,2,2008, 712-718
J. Membr. Sci, 548, 2018, 408-420

Electrodialysis - strategy

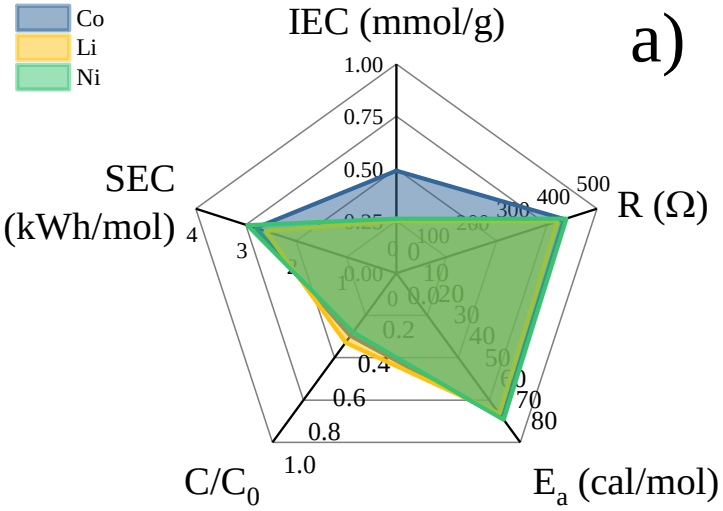


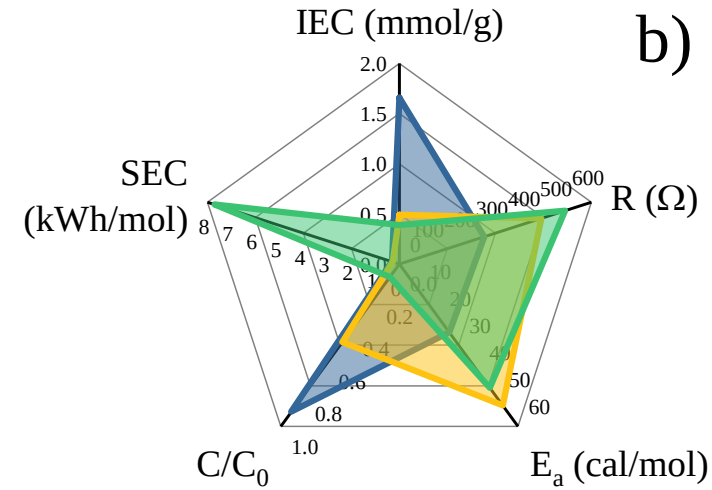
A.Siekierka, F.Yalcinkaya, Selective cobalt-exchange membranes for electrodialysis dedicated for cobalt recovery from lithium, cobalt and nickel solutions, Separation and Purification Technology 299 (2022) 121695

Novel chemistry of cation exchange membranes



Modification paths





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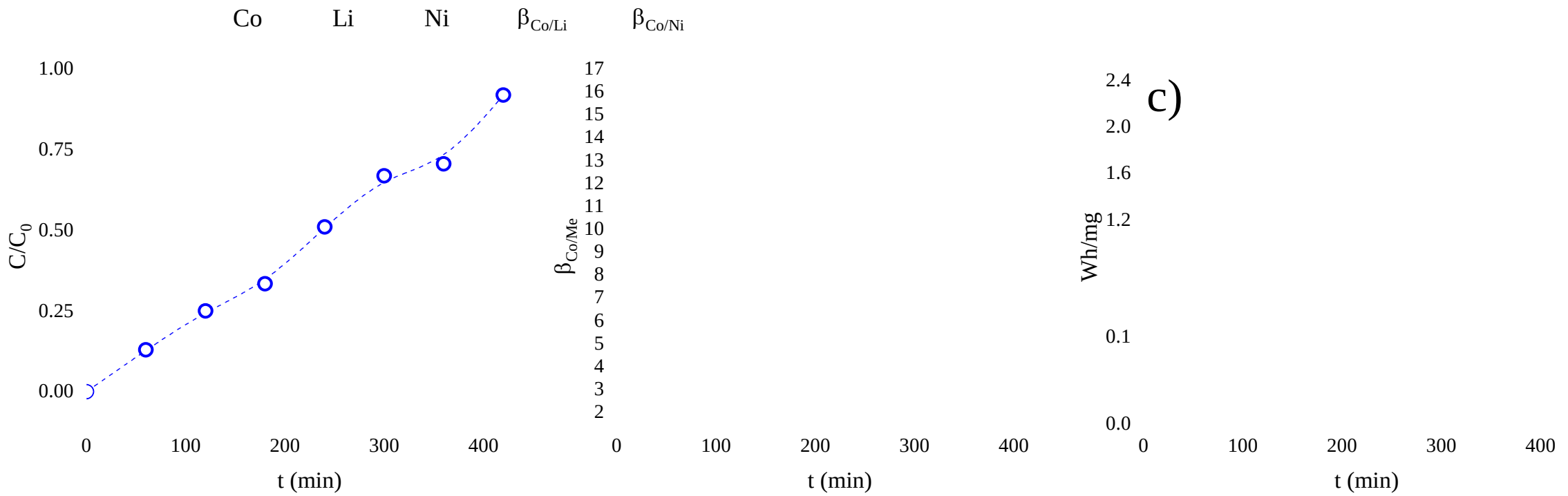
Electrodialysis performace – multicomponent solution

Constant voltage, U=5V

CHANGING TIME OF OPERATION

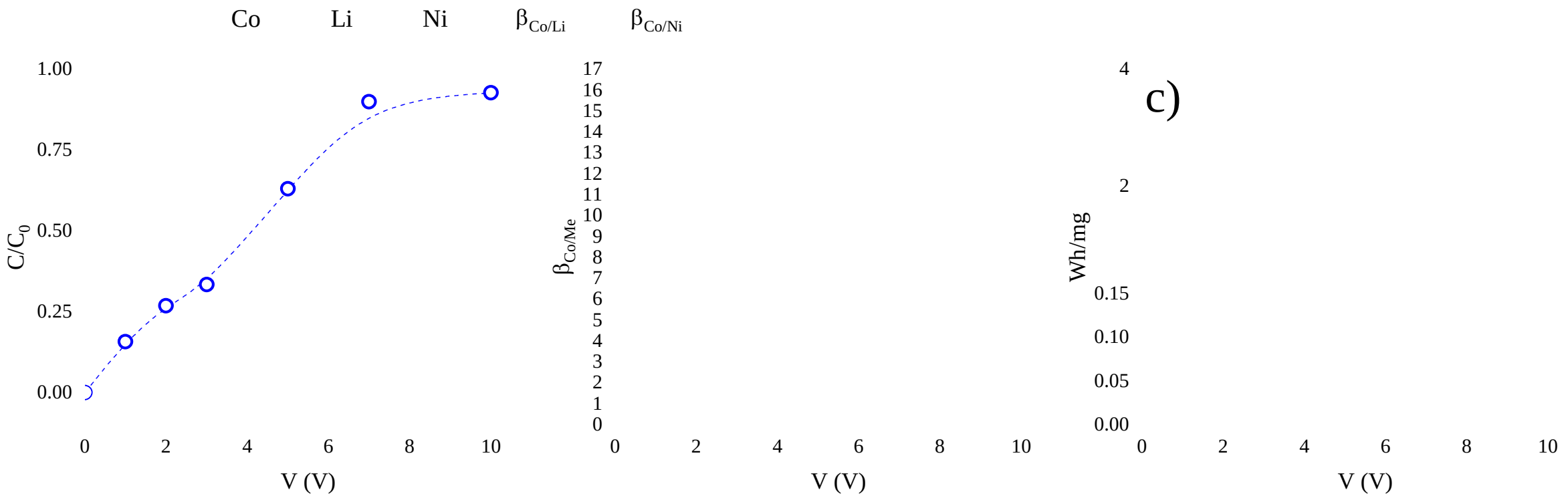


Fractionation of cobalt from Co, Li and Ni mixture during ED process with application of PAN-5C8Q. Relative concentrations (a), permselectivity of Co/Me (b), energy consumption in Wh/mg (c). Operation conditions: CV=5V, volume of each circulating solution = 0.2L, CCo,0 =107.7mg/L, CLi,0 = 27mg/L, CNi,0 = 49mg/L, TDC (mg/L) = 183.7 mg/L.

Electrodialysis performace – multicomponent solution

Constant voltage, U=5V

CHANGING EXTERNAL VOLTAGE

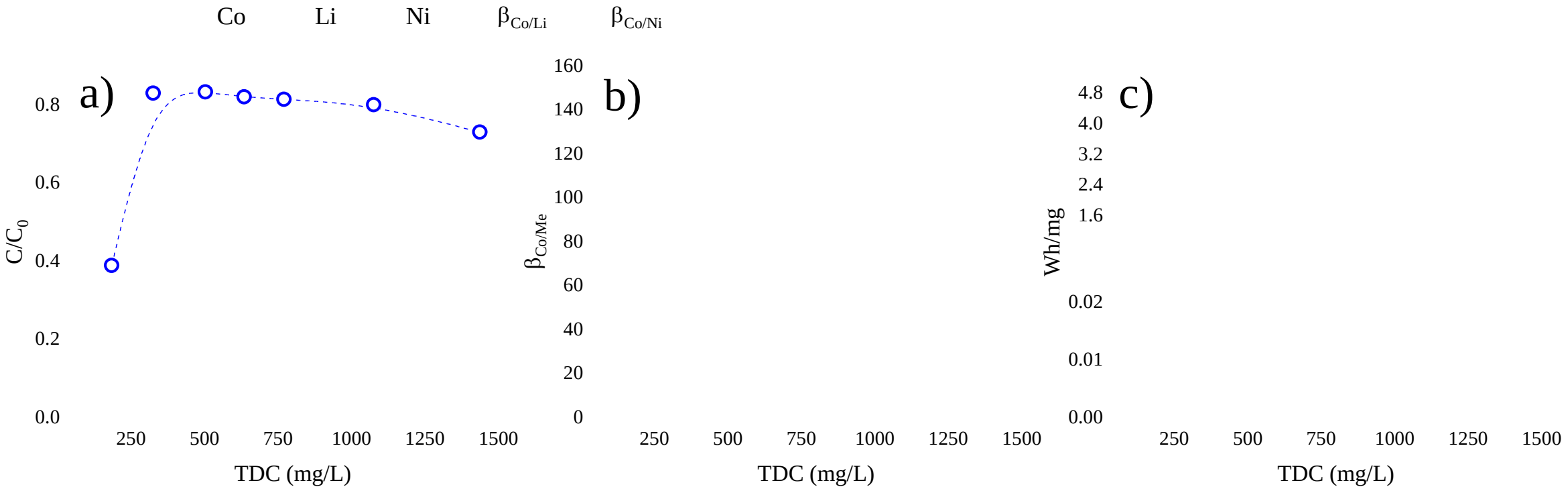


Fractionation of cobalt from Co, Li and Ni mixture during ED process with application of PAN-5C8Q. Relative concentrations (a), permselectivity of Co/Me (b), energy consumption in Wh/mg (c), flux (d) energy consumption in kWh/mol (e) over the external voltage. The permselective Co/Me over the relative concentration of Co2+ in permeate. Operation conditions: t=180 min, volume of each circulating solution = 0.2L, CCo,0 =107.7mg/L, CLi,0 = 27mg/L, CNi,0 = 49mg/L, TDC (mg/L) = 183.7 mg/L.

Electrodialysis performace – multicomponent solution

Constant voltage, U=5V

CHANGING INITIAL CONCENTRATION



Fractionation of cobalt from Co, Li and Ni mixture during ED process with the application of PAN-5C8Q. Relative concentrations (a), permselectivity of Co/Me (b), energy consumption in Wh/mg (c), flux (d) energy consumption in kWh/mol (e) over the total dissolved cations (TDC) in initial feed solution. The permselective Co/Me over the relative concentration of Co2+ in permeate. Operation conditions: t=180 min, CV=5V volume of each circulating solution = 0.2L.

Summary

The combination of the two techniques allowed to obtain a new effective technique to selectively desalination - **Hybrid Capacitive Deionization**

It is possible to selectively desalination of **lithium** ions from the multicomponent aqueous solutions

Hybrid Capacitive Deionization

By grafting procedure of modification PAN the selective, stable and effective cobalt-selective membrane was discover

Electrodialysis

Application this membrane allow to separate multicomponent mixture of Li, Co and Ni in selective way, with separation factor Co/Li over 5

Thank you for your attention

Acknowledgements

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