Group : Advanced Materials for Chemical Selectivity
Project : Electro-driven, Ion-selective Removal
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Keywords: Organic synthesis, ion-selectivity, surface modification, polymers

Electro-driven desalination processes, which currently focus on purifying water, have also the potential to obtain salts at high purity. For instance, lithium, which is increasingly used to fabricate Li-ion batteries, is largely drawn from salt-lake brines, but the presence of interfering ions like Na^+ and K^+ reduces the purity. Also, phosphate, which is a high-value, non-renewable natural resource, is currently mainly recovered from waste streams using precipitation methods that require chemicals and lack selectively. High purities could be obtained when combing electro-driven separation with ion-selective properties.

In this research program we make use of capacitive deionization (CDI), a technique that includes porous electrodes, which will be loaded with ions using an electrical field (Figure 1, left)). Currently, CDI can only discriminate between the type of charge (anion versus cation), but the addition of ion-selective membranes would enable one to recover/harvest specific ions from (waste) water.

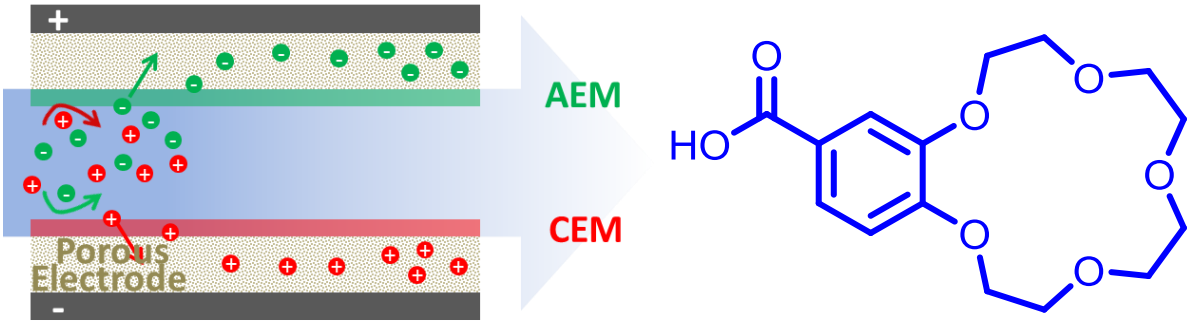

*Figure 1. **(left)** Schematic representation of capacitive deionization with anion and cation-exchange membranes (AEM and CEM, respectively) and **(right)** the structure of an Na^+-selective molecule that will be used to functionalize the porous electrodes.*

We explore the use of electro-driven separations to achieve targeted (ion-selective) removal. Our current focus is on the preparation of ultrathin coatings of alternating layers of oppositely charged polymers (polyelectrolytes). The integration of ion-selective materials, like the one shown in Figure 1, will be used to tune the selectivity.

Opportunities for BSc and MSc students

- Monovalent/Bivalent Selectivity: balancing selectivity and reversibility
- Sieving Brine to Harvest Lithium: a molecular approach
- Electrosorption of Phosphate: the effect of pH (as of fall 2018)
- Phosphate-selective Coatings: ion rejection or ion transport? (as of fall 2018)

Techniques to be used

Synthesis (+ NMR, UV-Vis, IR), surface modification (XPS, AFM), electrochemical techniques and analytical techniques to study the salt composition of aqueous solutions (*e.g.*, ion chromatography and ion-coupled plasma, in collaboration with the Chair of Environmental Technology). Modelling of electrical double layers can also be performed in strong collaboration with Wetsus (Dr. Biesheuvel).

Additional information

1. Youtube movie showing the CDI principle [link]
2. Richardson, Björnmalm and Caruso, *Science*, **2015**, *348*, 411 [link]
3. Cao, Gordiichuk, Loos, Sudhölter and De Smet, *Soft Matter* **2016**, *12*, 1496 [link]

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