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Capacitive Deionization with Membranes for Selective Ion Removal

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Motivation

Existing technologies that allow the removal of ionic compounds are facing a major challenge regarding to the separation of ionic species with the same charge and valence without using chemicals. The nitrate removal from groundwater, the reduction of sodium concentration in irrigation water, and the preferential separation of lithium ion from seawater are some examples of processes which would strongly benefit from the selective removal of ions.

Membrane capacitive deionization (MCDI) technology is able to remove a wide range of ionic species from water. In MCDI, the ion exchange membranes (IEMs) are important components which enhance the salt adsorption capacity of the electrodes [1]. IEMs can be either placed as a separate layer or coated in front of the electrodes, see **Fig.1**. Replacing IEMs for ion selective membranes can be seen as a strategy to selectively extract one type of ion from multi-ion aqueous solutions, see **Fig. 2**.

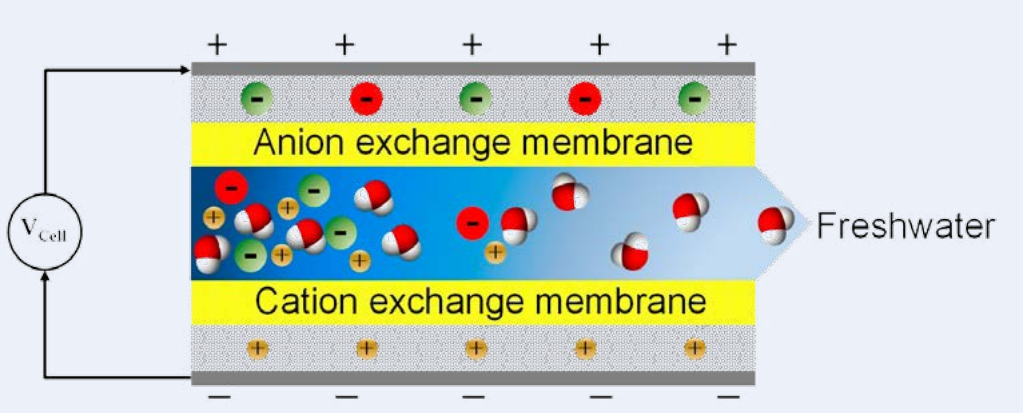

Fig.1 Schematic diagram of membrane capacitive deionization showing the removal of charged ions by two charged electrodes

Scientific challenge

IEMs enable the transport of only one type of ions: cations or anions [2]. However, state-of-the-art IEMs exhibit poor performance when the selective uptake of ions is the aim, e.g., the removal of ions with the same charge and valence.
Endowing IEMs with selective properties most often results in modification of other electrochemical properties of IEMs, such as electrical resistance.
In addition, MCDI systems with ion selective membranes requires a deep understanding of ion transport processes and the interaction of ions with the membranes and the porous carbon electrodes.

Research goals

To develop IEMs with good electrochemical properties, that allow the selective uptake of ions from aqueous solutions containing multicomponent mixture of salts.
To study the ion-removal process based on MCDI with carbon electrodes covered by ion-selective membranes.

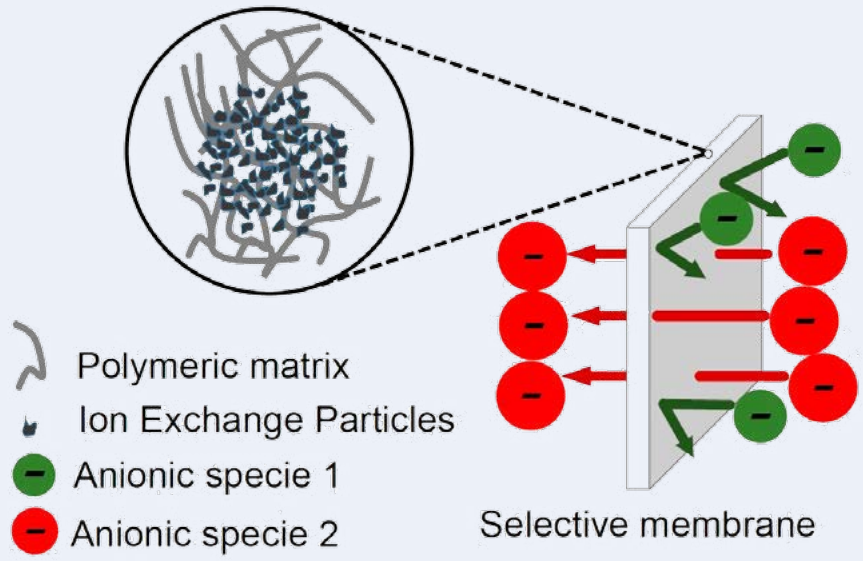

Fig.2 Schematic view of a heterogeneous ion selective membrane retaining one type of ion from a mixture of ions having the same charge and valence

Approach

To separate ionic species of the same charge and possibly the same valence, we propose to combine the use of electrosorption of ions via the formation of an electrical double layer (EDL) inside porous carbon electrodes and ion-selective membranes. Initially, we will focus on studying free-standing membranes which will be synthesized by three fabrication routes, see Fig. 3.

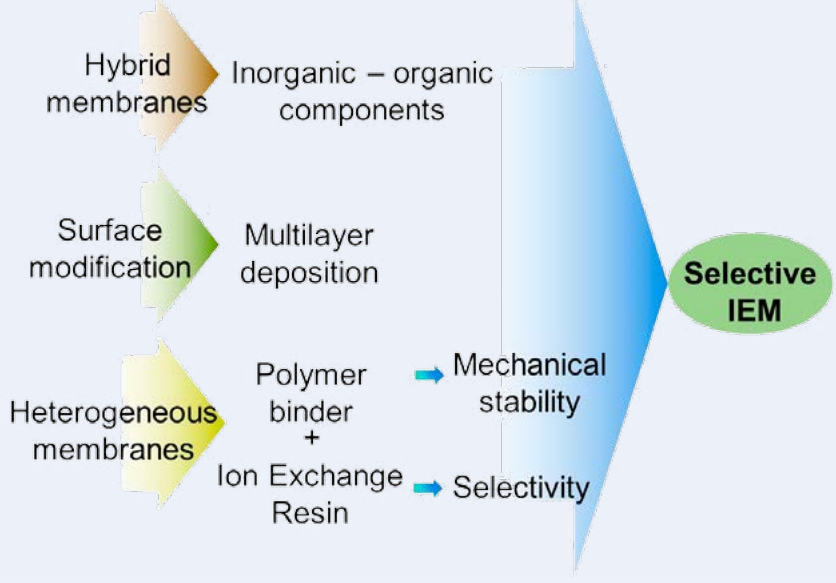

Fig.3 Overview of fabrication routes proposed for preparation of ion selective membranes

[1] Suss, M. et al. 2015. *Energy Environ. Sci.*, **8**, 2296-2319.
[2] Ran, J. et al. 2017. *J. Mem. Sci.*, **522**, 267–291.

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