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Evaluation of Co-Ion Desorption and Faradaic Losses in Capacitive Deionization

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The efficiency of Capacitive Deionization (CDI) is largely determined by the charge loss associated with two distinct parasitic processes, namely, co-ion expulsion and faradaic reactions. There is wide agreement that the first factor dominates the inefficiency of CDI; however, the evaluation of the relative incidence of co-ion repulsion on CDI inefficiency remains somewhat elusive. In this work, in the assumption of relatively small ohmic losses, we propose a simple model to quantify charge losses due to either of these processes in CDI cells, disregarding ohmic losses.

A single-pass flow-by CDI system was used for the experiments. Activated carbon (AC, YEC-8A) paste electrodes (80 wt% AC, 10 wt% carbon black and 10 wt% PTFE; 100 ± 10 µm, mass loading of 4.5 ± 0.6 mg cm^{-2} stuck onto 130 µm thick graphite current collectors) were used in CDI and membrane-CDI (MCDI) cells. Anion- and cation-exchange membranes (AEM and CEM, 30 µm) were purchased from Fumatech. Electrical conductivity and pH probes were inserted in the effluent line. For deionization experiments, a N_2 purged 10 mM NaCl solution was flowed through the cell at the rate of 10 ml min^{-1}, applying a constant potential of 1.0 V and 0.0 V for 600 s, during desalination and regeneration cycles, respectively. The effluent electrical conductivity was used to calculate the salt concentration by the Nernst-Einstein equation. CDI and membrane-CDI (MCDI) cells were run for a variable number of cycles, up to 60.

Fig.1. a-c and Fig.1 d-f show a comparative synopsis of the results and of the elaboration of the raw data, namely specific current, I_{cell}, and concentration change of the stream, $\Delta[NaCl]$ (both normalized to overall mass of electrodes), for CDI (Fig. 1a) and MCDI (Fig. 1d), respectively. In Fig.1b,e, we plot the charge supplied to the cell and the desalination charge. By subtraction of the desalination charge from the cell charge we get the magnitude of the charge loss as a function of time, as shown in Fig.1 c,f, which is fitted to the following expression:

$$\Delta Q(t) = \Delta E \cdot C_{des} \cdot \left[1 - \exp\left(-\frac{t}{\tau}\right)\right] + i_F t$$

where ΔE / V is the cell potential, C_{des} / F and τ / s *are* capacitance and time constant attributed to co-ion expulsion, i_F / A is a faradaic current. Accordingly, the model allows for the discrimination of efficiency losses associated to co-io desorption and faradaic reactions, as shown in Fig.1 c,f, by the blue and red dashed lines for the charge spent on co-ion expulsion and the faradaic charge, respectively. The main outcome of the above analysis are evident: a significant decrease of the charge loss for co-ion desorption in MCDI; a relatively small difference of faradaic loss between CDI and MCDI. In conclusion, we propose a simple model to evaluate inefficiencies in CDI, accounting for both desorption and faradaic losses.

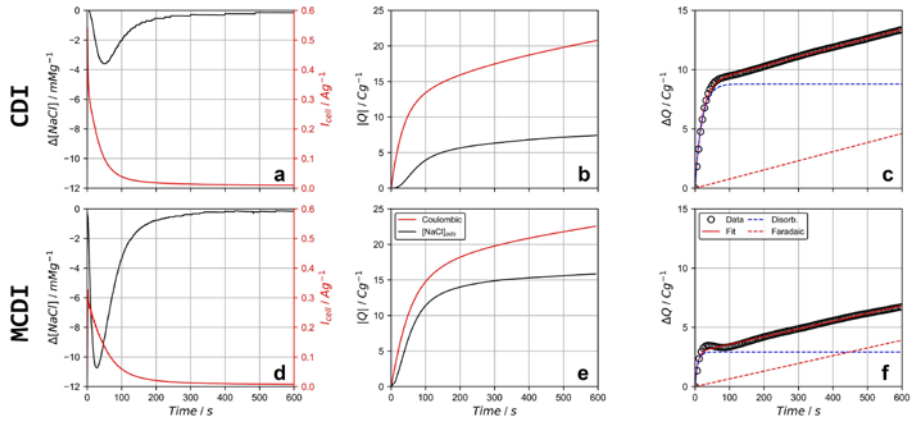

Fig. 1 – (a,d) Cell current (red line) and concentration change of the stream for CDI and MCDI cell, respectively; (b,e) charge supplied to the cells (red lines) and used for salt adsorption (black lines); (c,f) magnitude of charge loss (open circle) and model evaluation of desorbed charge and faradaic charge in CDI and MCDI.

S10-P-006

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Electrodeposited Na-Birnessite on Carbon Cloth as Positive Electrode for Capacitive Deionization

S10-P-007

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Evaluation of Co-Ion Desorption and Faradaic Losses in Capacitive Deionization

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Hamideh Darjazi *(Applied Science and Technology, Politecnico di Torino, Torino, Italy)*, Alessandro Piovano, Matteo Bonomo, Michele Chierotti, Claudia Barolo, Giuseppina Meligrana, Alberto Fina, Giuseppe Antonio Elia, Claudio Gerbaldi

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