

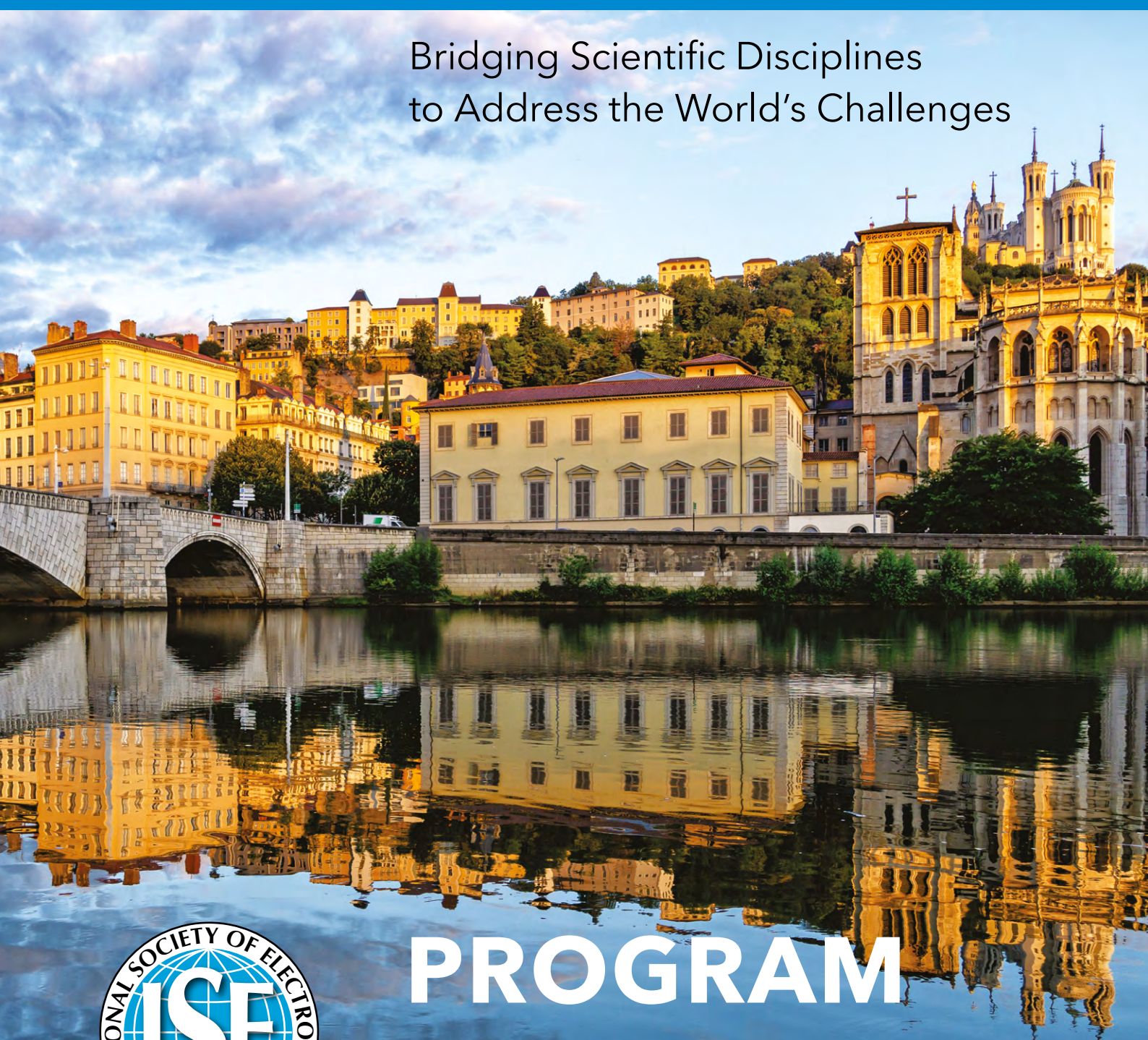
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Electrodeposited Na-Birnessite on Carbon Cloth as Positive Electrode for Capacitive Deionization

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Capacitive Deionization (CDI) based on traditional activated carbon (AC) electrodes faces some important intrinsic hurdles, such as the co-ion expulsion phenomenon and unwanted faradaic reactions, harming efficiency, operational stability, and electrode lifetime. The incorporation of ion-exchange membranes (IEM) in CDI, as free-standing films applied onto the electrodes, was shown to be an effective solution to improve charge efficiency and has led in fact to the commercialization of MCDI (membrane-CDI). An alternative way to improve CDI performance is the use of ion insertion materials, such as metal oxides and layered double hydroxides. In this work, we examine the performance of sodium-birnessite electrodeposited on commercial carbon cloth (CC) as the positive electrode of a flow-by CDI cell, coupled to an ordinary AC / AEM stack as the negative electrode.

Electrochemical characterization, namely Cyclic Voltammetry (CV) and Electrochemical Impedance Spectroscopy (EIS) of sodium-birnessite was performed in a neutral, 1 M Na₂SO₄ solution. A single-pass flow-by CDI system was used for the desalination experiments. Activated carbon (AC, YEC-8A) paste electrodes (80 wt% AC, 10 wt% carbon black and 10 wt% PTFE), of 100 ± 10 μm, and the mass loading of 4.5 ± 0.6 mgcm⁻² areal mass loading, stuck to a 130 μm thick graphite current collector, were used as the negative electrode of the CDI cell. An anion-exchange membrane (Fumatech) was applied to the AC electrode. Sodium birnessite was anodically deposited on CC from 4.6 mM MnSO₄ and 57.5 mM Na₂SO₄ solution at a constant potential of 1.2 V_{Ag/AgCl} with a conditional limitation of 3 Ccm⁻² normalized by CC geometrical area. Mass loading of the birnessite electrode was in the order of 2.0 mgcm⁻². The desalination test was performed in 10 mM NaCl under inverted constant potential mode (inverted CDI, iCDI) to avoid manganese oxide dissolution. Desalination and regeneration cycles were performed by applying 0.0 V and 1.0 V for 600 s, respectively. The effluent electrical conductivity, corrected for the contribution of protons and hydroxyl ions, was used to calculate the salt concentration according to the Nernst-Einstein equation.

The voltammetric response of electrodeposited sodium-birnessite, plotted in Fig. 1a together with the CV of pristine CC, reveals a regular pseudo-capacitive rectangular shape originating from sodium-ion storage in the layered structure of the oxide, with the typical hump at around 0.5 V_{Ag/AgCl}. The specific capacitance evaluated over the 0.6 V potential window is 150 Fg⁻¹, in accord with the limiting capacitance derived from EIS, as shown in Fig. 1b. Results of the desalination test performed at 10 mlmin⁻¹ (Fig. 1c) reveal a moderate salt adsorption capacity in the range of 6 mgg⁻¹, efficiency of 70 %, and a steady desalination performance during 50 cycles of operation.

In conclusion, both electrochemical and desalination tests show that electrodeposited birnessite on CC is an attractive candidate for desalination application by iCDI. In our purpose, this is a preliminary study devising a general strategy for the fabrication of oxide/CC electrodes for membraneless CDI in flow-through configuration.

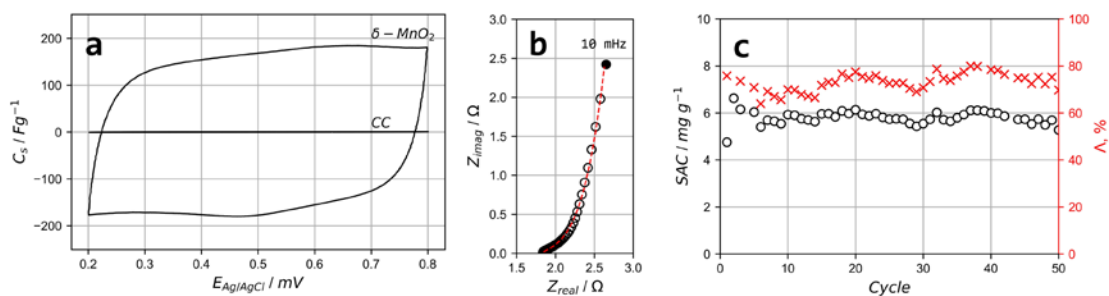


Fig. 1 – (a) CV at 1 mVs⁻¹ and (b) EIS complex plot of Na-birnessite ($\delta\text{-MnO}_2$)/CC electrodes 1 M Na₂SO₄; and (c) iCDI desalination performance in 10 mM NaCl.

S10-P-006

Maksim Bahdanchyk (*Dipartimento di Chimica, Materiali e Ingegneria Chimica, Politecnico di Milano, Milano, Italy*), Xinyue Ren, Jacopo Manidi, Antonello Vicenzo

[Electrodeposited Na-Birnessite on Carbon Cloth as Positive Electrode for Capacitive Deionization](#)

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