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

Maksim Bahdanchyk[1], Xinyue Ren[1], Jacopo Manidi[1] and Antonello Vicenzo[1]

[1] *Politecnico di Milano, Dipartimento di Chimica, Materiali e Ingegneria Chimica "Giulio Natta" , via Luigi Mancinelli 7, 20131 Milan, Italy*
maksim.bahdanchyk@polimi.it

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 Na_2SO_4 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 $MnSO_4$ and 57.5 mM Na_2SO_4 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.1 c) 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.

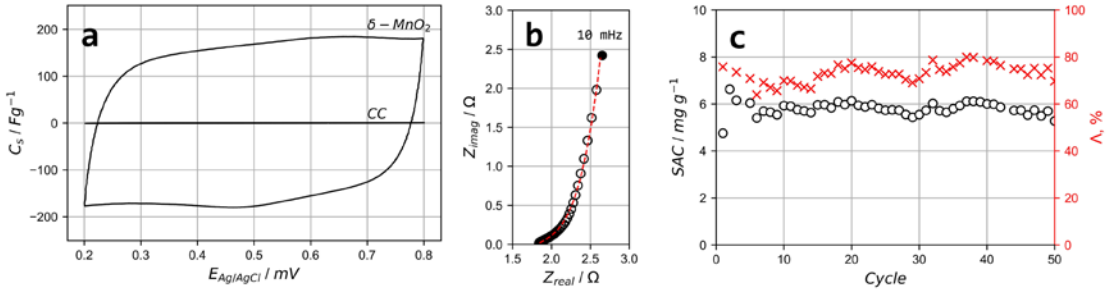

Fig. 1 – (a) CV at 1 mVs^{-1} and (b) EIS complex plot of Na-birnessite (δ-MnO_2)/CC electrodes 1 M Na_2SO_4; and (c) iCDI desalination performance in 10 mM NaCl.

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

S10-P-007

Maksim Bahdanchyk *(Dipartimento di Chimica, Materiali e Ingegneria Chimica, Politecnico di Milano, Milano, Italy)*, Nidhin Thekkedath Madhu, Jacopo Manidi, Antonello Vicenzo

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

S10-P-008

Olivier Befolo *(Applied Sciences, Hochschule Coburg, Coburg, Germany)*

Trace Analysis of Metal(II) Pyrithiones in Building Materials by means of Adsorptive Stripping Voltammetry.

S10-P-009

Tom Breugelmans *(Applied Electrochemisty and Catalysis (ELCAT), University of Antwerp, Antwerpen, Belgium)*, Jonathan Schalck, Jonas Hereijgers

A CO_2-free production of Ethylene Oxide through a Bromide Mediated Electrosynthesis in a Tandem Recycle Flow Reactor

S10-P-010

Mariela Brites Helu *(LCPME, Université de Lorraine, Villers les Nancy, France)*, Ranine El Hage, Mathieu Etienne

Enhancing Mass Transfer and Performance of Redox Flow Batteries through Structured Carbon Felts and 3D printed Electrodes

S10-P-011

Iris Burgers *(Process and Energy, Technical University Delft, Delft, Netherlands)*, Nandalal Girichandran, Elena Pérez-Gallent, Ruud Kortlever, Earl Goetheer

Integrating CO_2 capture and Electrochemical Conversion Using a Bicarbonate Flow Cell with a Cu/Ag Foam Electrode Configuration

S10-P-012

Christian Candia Onfray *(Edificio de Ciencia y Tecnología, Universidad Tecnológica Metropolitana, Santiago, Chile)*, Abdoulaye Thiam

NSAIDs Electrochemical Degradation using a Binary Electro-Fenton Catalyst obtained from Biomass Waste and CuFe Nanoparticles

S10-P-013

Sai Venkata Akhil Kumar Challuri *(Applied Electrochemistry, Fraunhofer Institute for Chemical Technology, Pfinztal, Germany)*, Jens Noack

The Impedance of an Iron/Iron Redox Flow Battery at Different State of Charge Conditions – A Distribution of Relaxation Times Analysis

S10-P-014

Yifat Cohen *(Biotechnology and Food Engineering, Technion, Haifa, Israel)*, Matan M. Meirovich, Yara Zeibaq, Omer Yehezkeli

Hemin as a Catalyst for Artificial Nitrogenase Mimicry

S10-P-015

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

Efficient recycling of polyvinyl butyral from laminated glass construction wastes in battery applications in a circular economy approach.

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