Pseudocapacitors based on Layered Double Hydroxides electrodeposited on Pt electrode

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Electrochemical capacitors also known as supercapacitors can be divided into two categories, namely, electric double layer capacitors (EDLCs), founded on non-Faradic charge storage process, and pseudocapacitors, which use metal oxides/hydroxides as the main electrodes since their capacitance arises from redox processes occurring at or near the solid electrode surface. Layered double hydroxides (LDHs) especially those containing transition metals are considered as ideal pseudocapacitive materials due to their peculiar properties such as efficient anion exchange capacity and high redox activity[1,2]. LDHs have the general formula $[M(II)_{1-x}M(III)_x(OH)_2]^{x+}[X_q^{x/q-} \cdot nH_2O]$ where M(II) and M(III) are bivalent and trivalent metal cations and X is the charge-balancing interlayer anion.

Electrosynthesis is an efficient method to prepare LDH thin films suitable for sensing applications and in the last few years our group has optimised the one-step electrodeposition, mainly on Pt electrodes, of LDHs based on redox active metals as Ni or Co and Al [3]. The applications of LDH modified electrodes requires the formation of well adherent thin films and this result can be achieved if Pt surface is electrochemically pre-treated in 0.1 M H_2SO_4 [4].

In this work four LDHs containing Co and Ni, as bivalent and Fe and Al as trivalent cations have been synthesized on Pt by electrochemical reduction, at –0.90 V *vs* SCE for 30 s, of the proper electrolytic solution [5]. All the LDHs have been characterized in basic solution (0.1 and 1 M NaOH) to investigate if they behave as pseudocapacitive materials by using cyclic voltammetry and galvanostatic charge/discharge curves. The calculation of capacitance per gram of material is very important when evaluating materials for this application, so the mass deposited during the synthesis was determined using the electrochemical quartz crystal microbalance. As an example in Fig. 1 a and b the CV and the galvanostatic charge/discharge curves recorded for the LDH containing Al and Co, are shown.

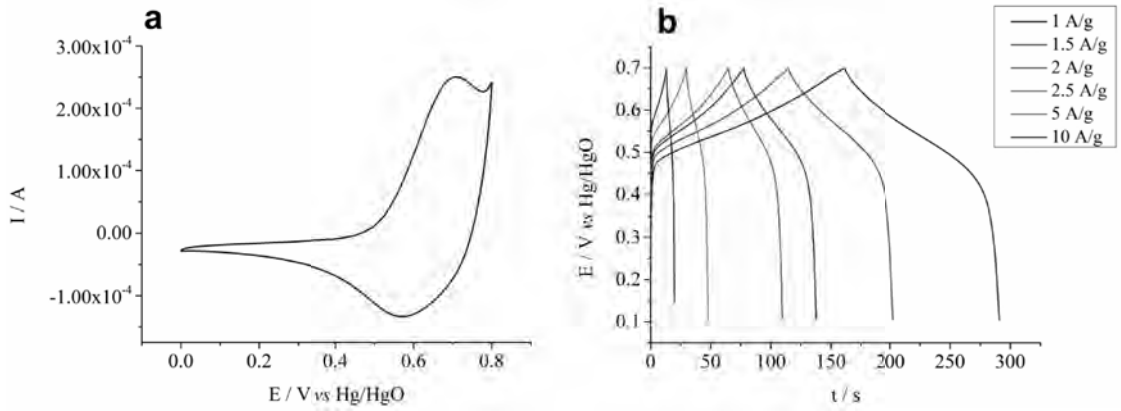

Fig. 1. Characterization CV (5th cycle) of Co/Al-LDH coated Pt recorded in NaOH 0.1 M at the scan rate of 0.05 Vs^{-1} (a) and galvanostatic charge/discharge curves recorded in NaOH 0.1 M (b)

All the LDHs displayed good performances both in terms of specific capacitance and life cycles, as estimated by galvanostatic charge/discharge curves. As conductive support also glassy carbon was investigated in order to fabricate cheaper devices.

References

[1] M.F. Shao, F.Y. Ning, Y.F. Zhao, J.W. Zhao, M. Wei, D.G. Evans, X. Duan, Chem. Mater. 24 (2012) 1192.
[2] B. Wang, Q. Liu, Z. Qian, X. Zhang, J. Wang, Z. Li, H. Yan, Z. Gao, F. Zhao, L. Liu, J. Power Sources 246 (2014) 747.
[3] E. Scavetta, B. Ballarin, M. Gazzano, D. Tonelli, Electrochim. Acta 54 (2009) 1027.
[4] E. Scavetta, A. Casagrande, I. Gualandi, D. Tonelli, J. Electroanal. Chem. 722-723 (2014) 15.
[5] I. Gualandi, A.G. Solito, E. Scavetta, D. Tonelli, Electroanalysis 24 (2012) 857.