Synthesis, characterization and improvement of $\alpha$–Co(OH)$_2$ for Supercapacitor applications

A. Aydin$^1$, Ş. Patat, A. Ülgen, H. Şahan, F. Kiılıç Dokan, S. Veziroğlu

$^1$University of Erciyes, Kayseri, Turkey

Abstract

With the depletion of fossil fuels and the great challenges of the increasing environmental pollution, it is urgent to develop new materials that provide a high-performance energy storage system combined with low-cost and environmentally friendly characters. Electrochemical capacitors (ECs), also called supercapacitors or ultracapacitor have attracted growing attention as important energy storage devices for potential applications in hybrid electric vehicles and mobile electronic devices [1-3]. ECs store energy using either ion adsorption (electrochemical double-layer capacitors, EDLCs) or fast surface redox reactions (pseudocapacitors) and they have higher energy density than conventional capacitors and higher power density than batteries. Pseudocapacitive active materials, such as RuO$_2.x$H$_2$O, have high specific capacitance than those of carbon-based active materials used in EDLC. However, high-cost and low cell voltage (1 V in aqueous electrolytes) has led to the research interest to inexpensive electrode materials with good capacitance character without sacrificing the cycle life and power delivery [4-6].

In the present study, $\alpha$-Co(OH)$_2$ was prepared by a potentiostatic deposition process at $-1.0$V (vs. Ag/AgCl) onto a nickel electrode by using a aqueous solution of 0.1 M Co(NO$_3$)$_2$. The structure and surface morphology of the obtained the $\alpha$-Co(OH)$_2$ were studied by using X-ray diffraction analysis and scanning electron microscopy. The capacitive characteristics of the $\alpha$-Co(OH)$_2$ electrodes were investigated by means of cyclic voltammetry and constant current charge–discharge cycling in 1 M KOH electrolyte with and without addition of 0.05% Triton X-100. Galvanostatic charge–discharge curves showed that the capacitance was increased from 720 F g$^{-1}$ to 804 F g$^{-1}$ and the capacitance retention from 63% to 76% after 500 charge/discharge cycles by addition of 0.05% Triton X-100 surface active materials to 1M KOH electrolyte solution.

Fig. 1 shows the SEM images of the as prepared $\alpha$-Co(OH)$_2$ electrode, $\alpha$-Co(OH)$_2$ electrode after first CV and $\alpha$-Co(OH)$_2$ electrode after 500 charge/discharge cycles. The variation of the specific capacitance and the coulombic efficiency with the specific current is shown in Fig. 2. Even at the high specific current of 40Ag$^{-1}$, the specific capacitance value was 520 F g$^{-1}$ for 1.0M KOH aqueous solution and 560 F g$^{-1}$ for 1.0M KOH aqueous solution with 0.05% Triton X-100. The coulombic efficiency ($\eta$) was calculated from the charge/discharge tests as follow [7]:

$$\eta = \frac{Q_d}{Q_c} \times 100 = \frac{\Delta t_d}{\Delta t_c} \times 100 \quad (7)$$

where $\Delta t_d$ and $\Delta t_c$ are the times of charging and discharging, respectively. According to the Eq. (7), the average coulombic efficiency was calculated to be about 91.0% for 1.0M KOH aqueous solution and 92.5% for for 1.0M KOH aqueous solution with 0.05% Triton X-100 at the high specific current of 40Ag$^{-1}$. high specific capacitance and coulombic efficiency at the high specific current of 40Ag$^{-1}$ demonstrate the stable reversible characteristics of the deposited $\alpha$-Co(OH)$_2$.

References