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Activated Carbon Electrode From Desiccated Coconut Residue for High Performance of Supercapacitors

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Abstract

Supercapacitors with nanostructured activated carbon electrodes from natural precursors have sparked huge attention due to its great stability of cycle as well as low cost and excellent performance. In this study, activated carbon was produced from desiccated coconut residue by chemical activation with KOH. The supercapacitor was characterized in a supercapacitor configuration by cyclic voltammetry and charge-discharge with potential window of 1V and current loads of 1A/g. Supercapacitor electrodes prepared from desiccated coconut residue exhibited excellent specific capacitance of 83 F/g.

Keywords: supercapacitor, activated carbon, desiccated coconut residue, cyclic voltammetry, charge discharge

1. Introduction

Electrical double layer capacitors (EDLCs) with activated carbon electrodes from natural precursors have attracted huge attention due to their cycle stability, low cost, and imposing performance. These ACs basically represent high specific surface area, high electrical conductivity, easy and environmental friendly production in huge quantities (Liu & Pickup, 2008). In 1957, Becker had discovered a capacitor based on carbon material with high surface area as electrode and sulphuric acid as electrolyte (Kotz & Carlen, 2000). It fills in the gap between batteries and conventional capacitors in terms of power and energy densities. Both batteries and fuel cells have high specific energy but low specific power while capacitors have high specific power and low specific energy (Kotz & Carlen, 2000). Low specific energy can be improved by increasing the electrode capacitance or electrolyte voltage window. The electrode capacitance can be overcome by using high capacitance electrode materials whereas the electrolyte voltage can be improved by using non-aqueous electrolyte with larger window of electrochemical stability (Jampani et al., 2010). Hence, electrochemical capacitors may improve both devices by providing both high specific and energy density (Kotz & Carlen, 2000 & Jagadale et al., 2013). This study was aimed at introducing a supercapacitor derived from desiccated coconut residue (DCR) based activated carbon (AC) treated with potassium hydroxide (KOH).

2. Experimental

The preparation of DCR-AC was based on our recent study (Yahya et al., 2015). A known amount of raw DCR was first carbonized into char under N_2 flow and then treated with KOH for 1h and dried at 105°C for overnight followed by heating it for 1h under N_2 flow. Out of nine samples, we selected the best DCR-AC in terms of specific surface area and porosity after examined by N_2 adsorption at 77 K (Quantachrome, Autosorb 2). Scanning Electron Microscope/Energy Dispersive X-Ray (EDX) was performed on Hitachi SU 1510/Horiba Emax 450. X-Ray Diffraction (XRD) was performed with Bruker AXS Germany (D8 Advance).

DCR-AC with specific surface area of 823.81 m^2/g, pore volume of 0.50 cm^3/g and porosity of 76 % (Yahya et al., 2015) was used to cell fabrication. Electrode was prepared by mixing 85 wt% of DCR-AC, 10 wt% of carbon black (TIMCAL), and 5% of polyvinylidene-flouride (Sigma-Aldrich) in 1-methyl-2-pyrrolidone (Merck, Germany) to form slurry. The mixtures were then poured into an aluminium foil with thickness of 2.5 µm using Elcometer Film Applicator. It was then dried in an oven for overnight at 120°C. A sandwich type cell was fabricated from two electrodes with similar weights with electrode area of 1 cm^2 and separated by filter paper as a separator and an electrolyte (1M Na_2SO_4). Capacitive performances were evaluated by cyclicvoltammetry (CV) and galvanostatic charge-discharge cycles (CD). CV was measured at scan rates of 5, 20, 50 and 100 mV/s. CD was measured with current load 1 A/g.

3. Results and Discussion

3.1 Physical Properties of DCR-AC

Figure 1 shows the results of EDX analysis of the DCR-AC studies. It was observed that weight percentage (wt %) of carbon was 85.24%, followed by oxygen (12.93%), Chlorine (0.82%), Potassium (0.56%) and Silica (0.15%). Figure 2 shows the XRD spectra of DCR-AC. Result showed a turbostratic disordered carbon with low crystallinity between graphite and amorphous carbon. The peak at 26.3^0 was related to gaphitic plane (Bhattacharjya & Yu, 2014).

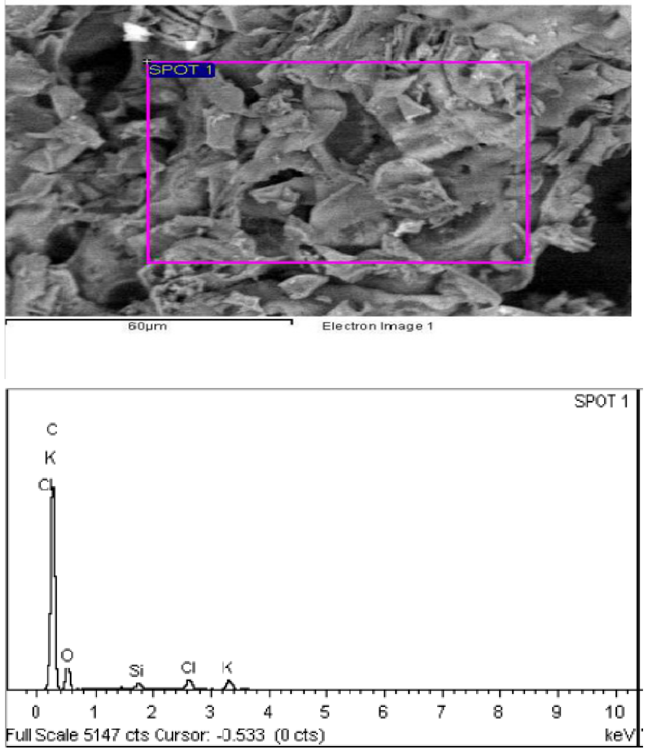

Figure 1. EDX analysis of DCR-AC

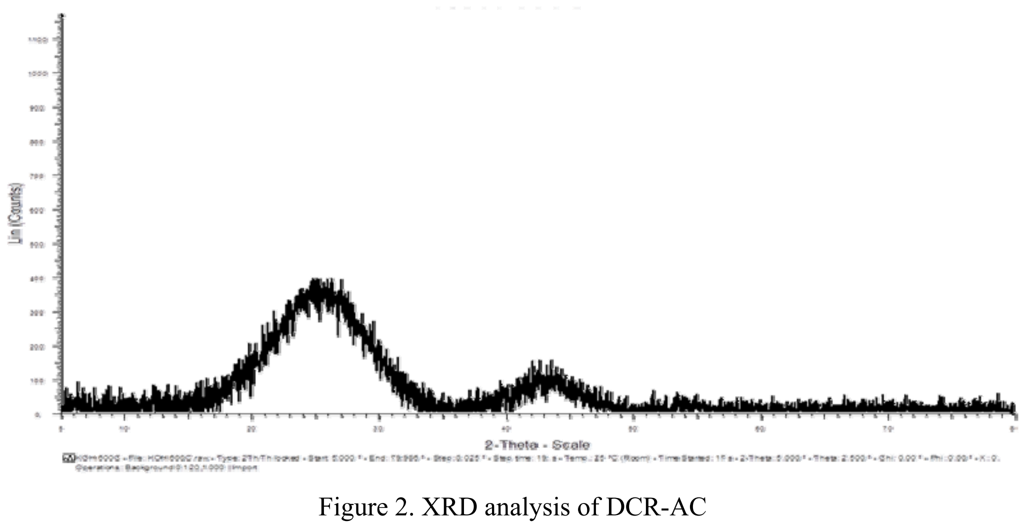

Figure 2. XRD analysis of DCR-AC

3.2 Electrochemical Behavior

Figure 3 shows a cyclic voltammogram of the DCR-AC of the fabricated supercapacitor for all scan rates studied. It exhibits typical double-layer capacitive behaviour. It was also found that the cathodic and anodic charging currents increased with scan rates indicating that dependence of the capacitance on the scan rates and a pure capacitive behaviour (Cho et al., 2011). A high rate scan could stimulate large ohmic resistance distorting the CV loop hence resulted in a narrower loop with an oblique angle (Cheng et al., 2014). It was found that the specific capacitance at 100 mVs^{-1} was found to be 41.04 F/g. Figure 4 shows the charge-discharge cycles of the DCR-AC supercapacitor at 1A/g. Generally, a symmetrical triangle curve indicates a good reversibility, high electrochemical stability, and no redox phenomena during the charge-discharge process. The IR drops of DCR-AC shows a good linear relationship with current densities which indicated low equivalent resistant and ideal capacitive characteristics behaviour (Cheng et al., 2014). The specific capacitance was found to be 83 F/g.

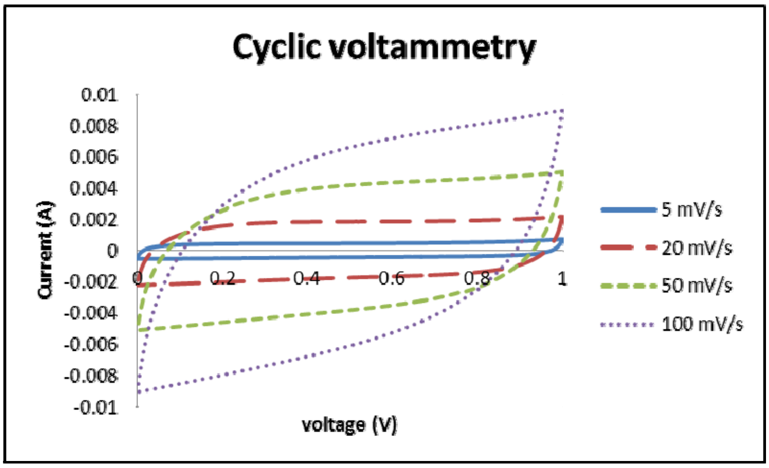

Figure 3. Cyclic voltammetry of desiccated coconut residue derived supercapacitor

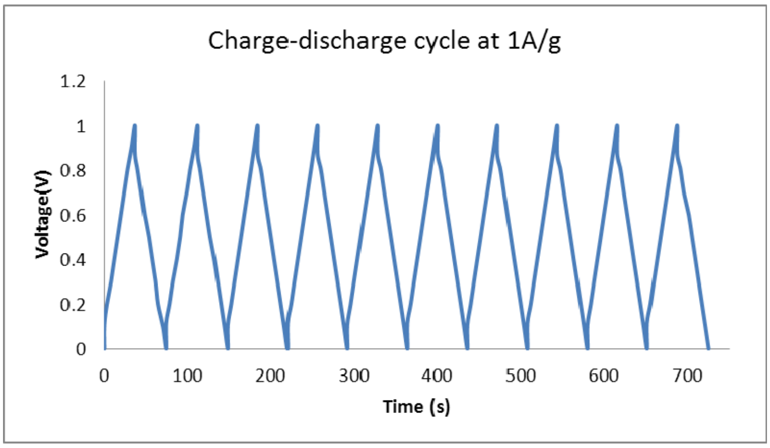

Figure 4. Charge discharge plot of supercapacitor with current load of 1A/g

4. Conclusion

In this work, we have explored the capacitive performance of a newly precursor of desiccated coconut residue supercapacitor. The cell was fabricated by combination of 85:10:5 ratios of DCR-AC, carbon black, and pvdf. Results showed that the supercapacitor exhibited good performance with high specific capacitance.

Acknowledgements

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