Recycled waste paper—A new source of raw material for electric double-layer capacitors

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Introduction

According to a recent report, approximately one-fifth of the contents of household dustbins consist of paper, of which half is newspaper and magazines. This is equivalent to over 4 kg of wastepaper per household each week. Present approximations suggest that 80% of the waste stream is disposed as landfill, 10% is incinerated, and the other 10% is recycled. Recycling or reuse is the best current solution for reducing the disposal problem. The magnitude of energy production from solid waste provides a small percentage of today's soaring power demands. There is therefore an urgent need to supply alternate energy from other resources as some forms of fuels are approaching depletion.

At present, activated carbon has been used as an electrode material in electrochemical double-layer capacitors (EDLCs) due to its high surface area and high capacitance. Activated carbon can be produced either by physical or chemical activation. In physical activation, the raw material is carbonized under an inert atmosphere and then activated at high temperature using either steam or carbon dioxide as the activating reagent. In chemical activation is the preferred route as it achieves higher yields, larger surface areas, low operating temperatures, and is cost-effective.[1-3]

In the present work, waste newspapers have been selected as the raw material for producing activated carbon. Waste newspaper is a cheap raw material that can be used for supercapacitors with special focus on upgrading waste to valuable energy. The authors are interested in adding value to these waste newspapers by preparing activated carbons, as they are great in quantity and low-cost. Shimada et al.[4] have prepared activated carbon from waste newsprint paper by activation using 8% phenol resin and have studied its absorption capacities. Though activated carbon has been prepared from waste newsprint paper, for the first time, we have used this activated carbon as electrode material for supercapacitors and studied its physicochemical properties by means of various techniques. Hence, the purpose of this study is to examine the feasibility of obtaining activated carbon from waste newspapers and evaluate the applicability of the obtained carbon as an electrode material for EDLCs. For comparison, a carbon gel has been prepared from phenol and its electrochemical properties investigated.

Experimental

For the preparation of activated carbon, the waste newspaper was cut into small pieces and soaked in hot water to make a pulp. Pulp was added to KOH and stirred well until forming a thick paste. The colour of the solution changed from clear yellow to deep red after addition of the KOH. The precursor was dried in a vacuum oven at 90 °C for 12 h and pyrolyzed at 500 °C under flowing Ar and a heating ramp of 10 °C/min with a hold period of 1 h. After reaching room temperature, the resulting sample was washed with de-ionized water and HCl until the pH of the solution was approximately 7. The sample was then dried at 150 °C for 24 h and the final activated carbon synthesized from the waste newspaper, hereafter denoted as WP carbon. The powder X-ray diffraction (XRD) using Cu Kα radiation was used to identify the crystalline phase of the synthesized material. The morphology of the waste paper carbon was examined by field emission scanning electron microscopy (S-4700, Hitachi, Japan). The electrochemical measurements (cyclic voltammetry and electrochemical impedance analysis) were carried out in a three-electrode cell using carbon coated on stainless steel as the working electrode with a platinum wire and a saturated calomel electrode (SCE) as the counter and the reference electrode, respectively. A two-electrode cell was assembled for galvanostatic charge/discharge tests in the KOH electrolyte at 1 mA/cm^2 current density.

Results and Discussion

Carbon from waste newspapers has been successfully prepared by a simple pyrolysis technique treatment with KOH. The long cycle stability of WP carbon is due to its structure, good surface morphology, high pore diameter and high surface area. From the charge–discharge profiles in Fig.1, a maximum specific capacitance of 160 F g^{-1} is obtained for WP carbon with 99% columbic efficiency at a current density of 1 mA cm^{-2}. It is noteworthy to mention that the source of the raw material is cost effective for making green technology.

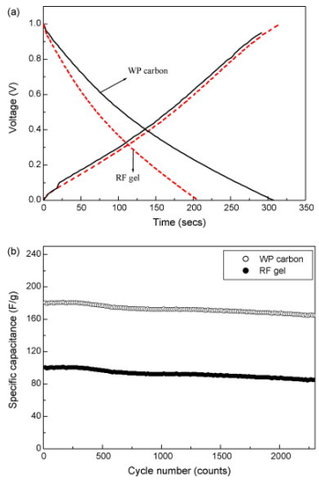

Fig. 1. (a) Typical charge–discharge profiles of RF gel and WP carbon; (b) discharge profiles of RF gel and WP carbon.

References

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