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Specific capacitance of electrochemical capacitor using RuO_2 loading arc-soot/activated carbon composite electrode

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ABSTRACT

An AS-containing CNH and graphite ball was synthesized using a twin-torch-arc apparatus to make an electrode for an electrochemical capacitor with RuO_2 of metallic catalyst. The electrode was composed of activated material, graphite, and binder. RuO_2-AS was prepared by oxidization of Ru-AS. The capacitance current of RuO_2-AS electrode increases with an increase in the catalyst loading amount. RuO_2-AS electrode in case of 4 wt.% RuO_2 has a capacitance current comparable to an AC electrode. The increase of specific capacitance for a composite electrode loading of 2 wt.% RuO_2 was 360% (16.6–60 F/g), while that for a loading of 4 wt.% was 640% (16.6–106 F/g). RuO_2-AS electrodes have a smaller internal resistance than not only AC but also AS. Capacitance current of RuO_2-AS/AC electrode is about twice that of AC electrode and RuO_2-AS electrode. The RuO_2-AS/AC electrode has a high specific capacitance and smaller internal resistance than AC electrode and RuO_2-AS electrode.

1. Introduction

Electrochemical capacitors attract great interest as electricity storage devices due to their high power capability and long cycle life. These electrochemical capacitors may be classified into two groups, namely electric double-layer capacitors (EDLCs) and pseudo-capacitors (PCs) [1,2]. EDLCs are mainly for carbon materials [3,4], which utilize the capacitance arising from charge separation at an electrode/electrolyte interface. PCs are mainly for catalytic metal [5–7], which utilize the charge-transfer pseudo-capacitance arising from reversible Faradaic reactions [8].

In terms of long cycle-life and high specific capacitance, carbon and catalytic metal have been recognized as promising electrode materials for supercapacitors. Activated carbons (AC) [9–14], carbon nano-tubes (CNTs) [15], carbon fibers [16–18] and carbon aerogels [19,20] are some of the materials that have been investigated for their charge-storage behavior. Among them, activated carbon is the cheapest material and hence much research has been devoted to its development as a supercapacitor electrode. Despite the high specific capacitance (up to 250 F/g) of carbonaceous materials, they suffer from poor specific energy density. Metal oxides such as RuO_2 [21–29], MnO_2 [30,31], NiO_x [32,33], IrO_2 [34], etc. are also under evaluation for their charge-storage behavior. Among all of these metal oxides, RuO_2 in its amorphous hydrous form ($RuO_2 \cdot xH_2O$) has been found to be the best material for supercapacitor applications due to its high specific capacitance, high specific energy density, high electrochemical reversibility, and long cycle-life [35].

Carbon nano-horn (CNH), which is a kind of nano-carbon, has attracted attention as an electrode material of DMFC [36]. It was found able to be synthesized as an arc-soot nano-carbon (AS) by the arc discharge method under specific conditions [37,38]. In addition, it was indicated that AS contained the non-dahlia-like CNH loaded the finer Pt/Ru particles with high dispersion [39]. AS contained the dahlia-like CNH, however, has low electrical conductivity and this adversely affects cell performance.

In the present paper, some electrodes which contained AS, AC, RuO_2 loading AS, and there mixture were prepared, and specific capacitance of electrochemical capacitor using these electrodes was evaluated.

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