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Electrochemical properties of arc-black and carbon nano-balloon as electrochemical capacitor electrodes

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Abstract. In this study, we used two types of carbon nanomaterials, arc-black (AcB) which has an amorphous structure and carbon nano-balloon (CNB) which has a graphitic structure as electrochemical capacitor electrodes. We made a coin electrode from these carbon materials and fabricated an electric double-layer capacitor (EDLC) that sandwiches a separator between the coin electrodes. On the other hand, RuO_2 was loaded on these carbon materials, and we fabricated a pseudo-capacitor that has an ion insertion mechanism into RuO_2. For comparison with these carbon materials, activated carbon (AC) was also used for a capacitor electrode. The electrochemical properties of all the capacitors were evaluated in 1M H_2SO_4 aqueous solution. As a result of EDLC performance, AcB electrode had a higher specific capacitance than AC electrode at a high scan rate (≥ 100 mV/s). In the evaluation of pseudo-capacitor performance, RuO_2-loaded CNB electrode showed a high specific capacitance of 734 F/g per RuO_2 weight.

1. Introduction

Electrochemical capacitor (EC) has a high power density and a long lifetime. Then, EC is expected to be applicable to an electric vehicle. [1] ECs are distinguished by the difference of charging mechanism. There are two types of ECs: electric double-layer capacitors (EDLCs) and pseudo-capacitors (PCs). EDLC does not use a chemical reaction for charge/discharge and enables us to operate for a long cycle life. Commercial EDLCs employ inexpensive activated carbon (AC). On the other hand, PC, as represented by RuO_2 [2-6], has a different charge/discharge mechanism from EDLC, which is accompanied with a redox reaction and has a higher energy density than EDLC. However, Ru is expensive and Ru resources are limited.

Recently, novel carbon nanomaterials which have a high electric conductivity including carbon nanotube (CNT) [7-12], carbon nanofiber (CNF) [13-15], and graphene [16,17] are studied for EC. Fabrication of carbon nano-sheet is also studied for effective use of a high surface area of carbon materials. [12,16,17] Novel carbon nanomaterials have a lot of potential for EC application.

In this study, we used two types of carbon nanomaterials, arc-black (AcB) and carbon nano-balloon (CNB) which were developed in our laboratory, as EC electrodes and compared their electrochemical properties with activated carbon (AC). The applicability of AcB and CNB for EC