Influences of internal resistance and specific surface area of electrode materials on characteristics of electric double layer capacitors

Yoshiyuki Suda[1, a)], Akitaka Mizutani[1], Toru Harigai[1], Hirofumi Takikawa[1], Hitoshi Ue[2], and Yoshito Umeda[3]

[1]*Department of Electrical and Electronic Information Engineering, Toyohashi University of Technology, Toyohashi, Aichi 441-8580, Japan*
[2]*Fuji Research Laboratory, Tokai Carbon Co., Ltd., Oyama, Shizuoka 410-1431, Japan*
[3]*Toho Gas Co., Ltd., Nagoya, Aichi 456-8511, Japan*

[a)]Corresponding author: suda@ee.tut.ac.jp

Abstract. We fabricated electric double layer capacitors (EDLCs) using particulate and fibrous types of carbon nanomaterials with a wide range of specific surface areas and resistivity as an active material. The carbon nanomaterials used in this study are carbon nanoballoons (CNBs), onion-like carbon (OLC), and carbon nanocoils (CNCs). A commercially used activated carbon (AC) combined with a conductive agent was used as a comparison. We compared the EDLC performance using cyclic voltammetry (CV), galvanostatic charge/discharge testing, and electrochemical impedance spectroscopy (EIS). OLC showed a poor EDLC performance, although it has the lowest resistivity among the carbon nanomaterials. CNB, which has a 1/16 lower specific surface area than AC but higher specific surface area than CNC and OLC, had a higher specific capacitance than CNC and OLC. Moreover, at current densities of 1.5 Ag^{-1} and larger, the specific capacitance of the EDLC using CNB was almost the same as that using AC. Electrochemical impedance spectroscopy of the EDLCs revealed that the CNB and CNC electrodes had a much lower internal resistance than the AC electrode, which correlated with a low capacitance maintenance factor as the current density increased.

INTRODUCTION

Electric double layer capacitors (EDLCs), also called ultracapacitors or supercapacitors, store charge and discharge by utilizing the electric double layer that arises at the interface between an electrode and electrolyte. EDLCs have advantages that provide higher specific power and longer cycle life compared with secondary batteries,[1–3] which provides a number of industrial applications, including back-up power supplies in electronic circuits, uninterruptible power sources, power supplies for rapid heating of the welding drum in laser printers, and copy instruments. Commercially available cars employ a system in which the energy stored in EDLC by regeneration is directly provided to the electric components, including the air conditioner and car audio system.[4,5]

The EDLC performance depends on the characteristics of the electrode material and electrolyte. The maximum voltage between the EDLC electrodes in an organic electrolyte (~2.5 V) is higher than that in an aqueous electrolyte (1 V), which is limited because of the redox reactions that arise at 1.23 V. This results in a higher energy density when an organic electrolyte is used.[1,6] The amount of electric charge stored in EDLC is proportional to the number of adsorbed ions. Simply, the specific surface area of electrode materials is large, so the specific capacitance of the

The Irago Conference 2016
AIP Conf. Proc. 1807, 020022-1–020022-12; doi: 10.1063/1.4974804
Published by AIP Publishing. 978-0-7354-1475-4/$30.00