Electric Double-Layer Capacitor with Binary Salt Electrolyte


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INTRODUCTION

Electric double layer capacitors (EDLCs) as energy storage devices have deserved our attention; they can store substantial large energy in an electric double layer at an interface between an electrode and electrolyte. Since there is intrinsically no chemical reaction involved, EDLCs can discharge stored energy much faster and have much longer cycle life than conventional rechargeable batteries. To realize wide use of EDLCs in energy storage application, safety enhancement of EDLC systems is requisite especially to mobile energy systems such as an electric and fuel-cell vehicle.

In this context, room-temperature molten salts or ionic liquids have attracted a growing interest for application to electrochemical devices due to their nonflammability and negligible vapor pressure. Ue et al. reported EDLC performances under several ionic liquids [1]. EDLC performances using a binary salt electrolyte with an ionic liquid, however, have not been well understood while the binary salt electrolytes for rechargeable lithium battery systems have been reported [2]. This paper reports the effect of a binary salt electrolyte with an ionic liquid on the performance of EDLCs.

EXPERIMENTAL

We examined the performance of EDLC using three sorts of electrolytes: a conventional organic electrolyte (TEMABF₄/PC 3 mol dm⁻³ (M)), ionic liquid (EMIBF₄) and binary salt electrolyte (EMIBF₄+LiBF₄) (TEMA=Triethylmethylammonium, EMIE=1-ethyl-3-methylimidazolium). The composite salt electrolyte (EMIBF₄+LiBF₄) was prepared by dissolving weighed LiBF₄ in liquid EMIBF₄ and then stirring at a room temperature for 6h. The concentration of the dissolved LiBF₄ was 0.5M in EMIBF₄. Electrochemical stability of these electrolytes was measured by running a linear sweep voltammetry in a three-electrode cell.

To examine the performance of the EDLCs, a typical model capacitor was used. It was composed of the pair of activated carbon cloth electrodes, an electrolyte and separator as main components. The charge-discharge characteristics of the model capacitors were measured under a constant current cycling condition.

RESULTS AND DISCUSSION

Figure 1 shows the linear sweep voltammograms for the electrolytes. The observed potential window of EMIBF₄ was narrower when compared to that of TEMA BF₄/PC. Cathodic decomposition voltage of EMIBF₄+LiBF₄ was observed at about -4V vs. Ag/Ag⁺, which was lower than that of EMIBF₄; Matsumoto et al. also reported the same results previously [2]. Since the overall potential window of EMIBF₄+LiBF₄ was wider than the others, we examined withstand voltages for the model capacitors with the respective electrolyte. Charge-discharge curves for the model capacitor with EMIBF₄+LiBF₄ were excellent even at a high-voltage operation. The approximate decomposition voltages were estimated to be 3.4, 3.2 and 3.6V for TEMA BF₄/PC, EMIBF₄ and EMIBF₄+LiBF₄, respectively. These results could be consistent with the potential windows for these electrolytes.

Figure 2 shows cycling performance with various rates for the model capacitors. The TEMA BF₄/PC system provided the best high-rate performance among the three electrolytes. EMIBF₄ is a high viscosity liquid and the interface resistance between the electrode and electrolyte is high. This should inevitably lead to the lower discharge capacitance under the high current density conditions. On the other hand, the addition of LiBF₄ to EMIBF₄ resulted in an increase of the discharge capacitance. This may imply that the addition of a suitable Li salt to an ionic liquid can enhance the EDLC capacitance.

REFERENCES


Fig. 1 Linear sweep voltammograms for the electrolytes.

Fig. 2 Rate performance for the model capacitors. Operating voltage: 0-1V