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Hybrid Capacitors using Organic Electrolytes

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Introduction

Electric double-layer capacitors based on charge storage at the interface between a high surface area activated carbon electrode and an electrolyte solution are characterized by their long cycle-life and high power density in comparison with batteries. However, energy density of electric double-layer capacitors obtained at present is smaller as compared with that of batteries and limits the wide spread use of the capacitors.

To obtain the new device that shows large energy density, high power density and stable performance, a new hybrid capacitor is developed [1],[2],[3]. This new capacitor comprises of an organic electrolyte containing Li salt, an activated carbon cathode and a carbonaceous anode that can intercalate and de-intercalate Li ion.

The activated carbon cathode in the hybrid capacitor adsorbs anions at the electric double-layer in the same way as the activated carbon cathode in the electric double-layer capacitor during charging and linearly polarizes to positive side. On the other hand, carbonaceous anode in the hybrid capacitor intercalates Li ions into its graphene layer during charging and de-intercalates Li ions during discharging. When the anode is charged, potential of the anode becomes very low and approaches to the potential of Li-metal anode. As a result, voltage applicable to the cell is over 4.2 V and larger than that of the electric double-layer capacitor. Moreover, capacity of the graphitic carbon is about 370 mAh/g and far larger than the electric double-layer capacitance of the activated carbon.

Experimental

The hybrid capacitor consists of a stack of a pair of the activated carbon cathode layer coated on Al-foil and the carbonaceous anode layer

coated on Cu-foil and a porous separator. These Al- and Cu-foils act as current collectors.

The anode, the porous separator and the cathode are stacked and housed in prismatic Al-laminated film cell. After the organic electrolyte solution is poured, the cell is sealed taking out the leads. The size and the capacity of the cell are 53h×31w×2t mm and 1.8 mAh, respectively.

To compare the performance of the hybrid capacitor with others, Li ion battery and electric double layer capacitor of the same construction and dimension as the hybrid capacitor are also prepared and tested.

Results and discussion

The energy density and power density of the hybrid capacitor, the Li-ion battery and the electric double-layer capacitor on the basis of the stacked volume of electrodes, current collectors and separator of each cell are compared. Energy density of the hybrid capacitor discharged from the cell voltage of 4.0 V to 1.5 V is 18 Wh/l at a power density of 500 W/l and becomes small as the power density increases. Although, the energy density of the hybrid capacitor is smaller than that of Li-ion battery discharged from the cell voltage of 4.0 V to 1.5 V at the power density less than 1500 W/l, it becomes higher than that of Li-ion battery at the power density more than 1500 W/l. This is probably because the rate of de-intercalation of Li ions out of carbonaceous anode is fast. The energy density of the hybrid capacitor is larger than that of electric double layer capacitor discharged from the cell voltage of 2.7 V to 1.35 V at the power density up to 2000 W/l.

References

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