

## Charge-Discharge and Capacity Retention Characteristics of Nickel/Metal Hydride Battery with Polymer Hydrogel Electrolyte

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Nickel/metal hydride (Ni/MH) battery with a solid or gel electrolyte would be very attractive especially in terms of its reliability, safety and designing. In our previous work,<sup>1,2</sup> negative electrode capacity-controlled Ni/MH cells were assembled using the polymer hydrogel electrolyte prepared from potassium salt of crosslinked poly(acrylic acid) and KOH aqueous solution, and their charge-discharge characteristics were investigated. In this study, positive electrode capacity-controlled cells were assembled using the polymer hydrogel electrolyte from a practical point of view, and their charge-discharge and capacity retention characteristics were examined.

The experimental Ni/MH cells were assembled using a commercial nickel positive electrode, two paste-type negative electrodes of  $MmNi_{3.6}Mn_{0.4}Al_{0.3}Co_{0.7}$  alloy and a sulfonated polypropylene unwoven cloth separator (120  $\mu\text{m}$  nominal thick) impregnated with the polymer hydrogel electrolyte.<sup>3</sup> The cell was charged at  $145 \text{ mA g}[\text{Ni}(\text{OH})_2]^{-1}$  for 2.4 h, rested for 10 min and discharged at  $145 \text{ mA g}[\text{Ni}(\text{OH})_2]^{-1}$  to the cell voltage of 0.9 V. Capacity retention was examined at various temperatures by storing the cell at an open circuit after charging. The ratio of discharge capacity after the storage to that before the storage was evaluated as capacity retention.

Figure 1 shows typical charge and discharge curves (10th cycle) for the experimental Ni/MH cells with the polymer hydrogel electrolyte and a 7.3 M KOH aqueous solution. Well-defined charge and discharge curves were obtained in each case. Discharge capacity of each cell was very similar to theoretical one of the positive electrode,  $289 \text{ mAh g}[\text{Ni}(\text{OH})_2]^{-1}$ . Moreover, the cell with the polymer hydrogel electrolyte exhibited almost the same charge-discharge cycle performance and high-rate capability, compared with that with a KOH aqueous solution. These results can be ascribed to the high ionic conductivity of the polymer hydrogel electrolyte and the formation of good electrolyte/electrode interface. Capacity retention at various temperatures are shown in Fig. 2. Capacity retention were clearly improved by using the polymer hydrogel electrolyte in the wide temperature range. The improvement was more remarkable at relatively high temperature such as  $55^\circ\text{C}$ . From discharge curves (Fig. 3) after the storage test and then charging again at  $55^\circ\text{C}$ , it was found that the polymer hydrogel electrolyte fairly suppressed both reversible and irreversible capacity losses. This can be a significant advantage for use in practical Ni/MH batteries.

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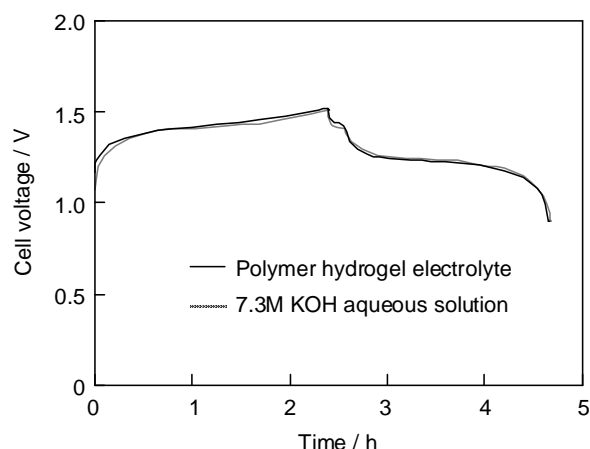


Fig. 1 Typical charge-discharge curves (10th cycle) of the Ni/MH cells at  $25^\circ\text{C}$ .

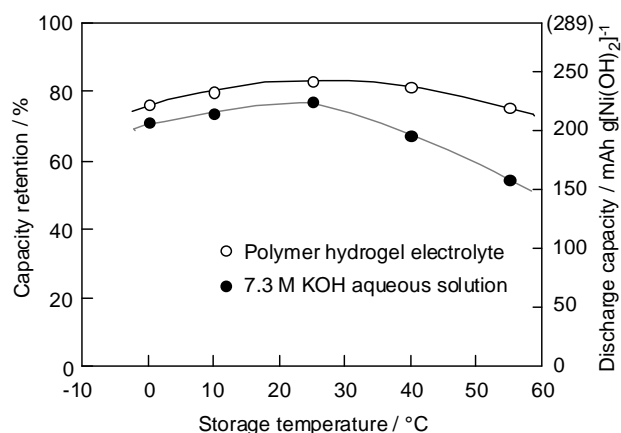


Fig. 2 Capacity retention as a function of storage temperature for the Ni/MH cells after storage for 10 days.

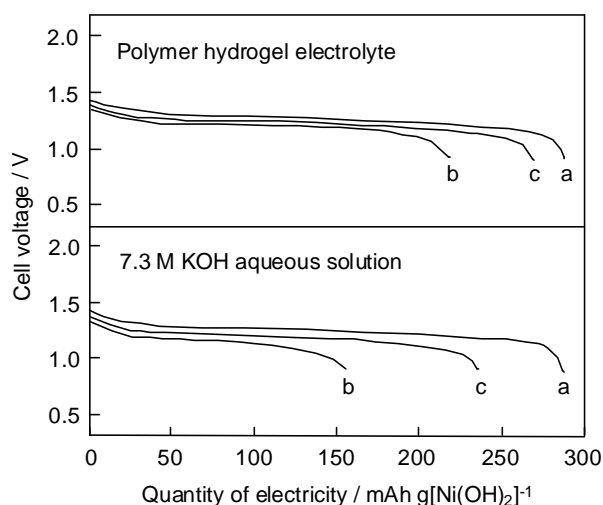


Fig. 3 Discharge curves of the Ni/MH cells (a) before storage and (b) after storage for 10 days and (c) after the storage test and then charging at  $55^\circ\text{C}$ .