Characterization of Isothermal Charge/Discharge behavior of commercial Ni-MH cells: Comparison of experimental data to a first-principles mathematical model

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The demand for nickel metal hydride batteries has recently grown for applications ranging from portable electrics to electric and hybrid-electric vehicles. Especially for clean transportation, Ni-MH battery is presently the most promising battery for hybrid-electric vehicles based on the compromise between performance and cost.

Traditionally, experimental testing is a main tool to test and design batteries. However, experiments are time-consuming and costly, and furthermore it is difficult to determine the internal process during charge and discharge. Modeling and simulation of batteries is a useful method for researchers because a good cell model can be used to identify battery mechanisms, predict the cell performance for design and optimization and also reduce the cost and time spent on the experiments.

Paxton and Newman [1] developed a mathematical model for discharge of nickel-metal hydride cells. In this model the open-circuit potential for both electrodes was an experimentally measured function of the state of charge. They argued that the proton diffusion could be neglected in their parametric range. They showed that during discharge the potential drop at the nickel electrode is the largest limiting factor of the nickel-metal hydride cell. Some experimental discharge curves from three different cells running all at the 0.5C discharge rate were compared to their model, but inadequate agreement resulted. Also, this model only modeled the discharge performance and thus the oxygen evolution reaction wasn't included.

A three-phase electrochemical model based on the micro-macroscopic coupling framework was developed by Gu *et al* [2] for nickel-metal hydride cells. By including oxygen reaction in the cell, the effect of oxygen evolution on the cell is analyzed, particularly the effects on the charge acceptance and the cell pressure build-up according to the charge rate. In addition they validated the model against literature experimental data for both charge and discharge processes; however, the agreement was poor due to the lack of a number of input parameters that were not available from experimental investigations published in the literature.

The objective of this research is to perform a tightly coupled experimental and modeling study so that the capabilities of mathematical modeling can be truly assessed. The present work is a first step in the undertaking where the applicability of the previously developed models in describing the discharge and charge behavior of Ni-MH cells is gauged. With proper modifications made in the various thermodynamic, kinetic and transport properties excellent agreement between model and experiments is seen to be achieved for both discharge and charge processes spanning rates over an order of magnitude, as shown in Figures 1 and 2.

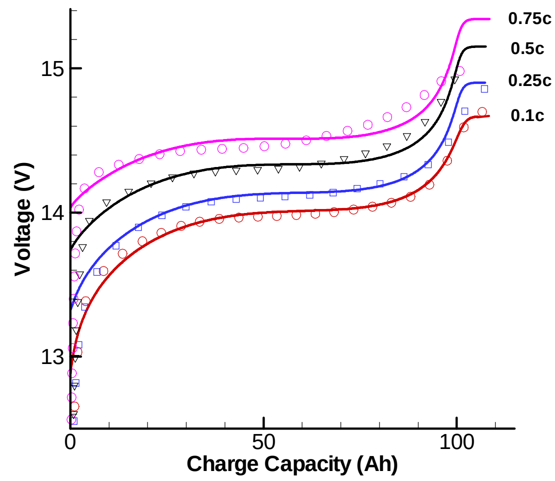

Figure 1 Comparison of simulation charge curves with experimental curves

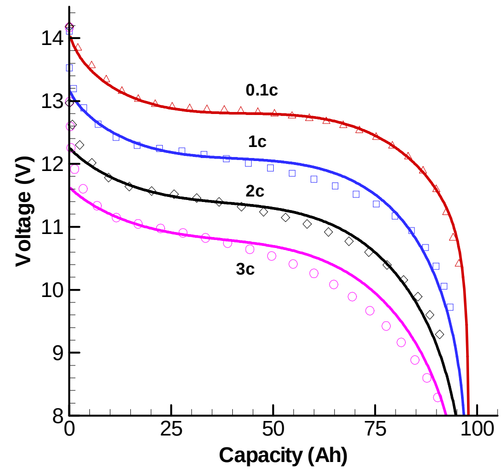

Figure 2 Comparison of simulation discharge curve with experimental curve

Reference

1. B. Paxton and J. Newman, *J. Electrochem. Soc*, **144, 3818** (1997)
2. W. B. Gu, C.Y. Wang, S. M. Li, M. M. Geng, and B. Y. Liaw, *Electrochim. Acta*, **44, 4525** (1998)