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Low Cost Na-ion Batteries with Long Cycle Life for Electrical Grid-scale Applications

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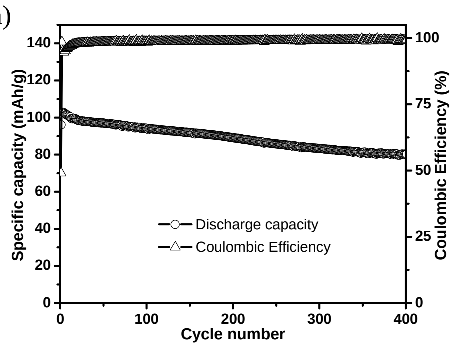
Introduction

Because of the high abundance, low cost, and less safety and environmental concerns, Na-ion batteries have been regarded as one of the emerging battery technologies beyond lithium chemistry.[1] However, the large radius (~70% larger than Li ions) of Na ions makes it difficult to find suitable host materials to accommodate the Na ions and allow reversible and rapid ion insertion and extraction. Recently, hard carbon and layer structured metal oxides and NASICON structured $Na_3V_2(PO_4)_3$ have been demonstrated to be good anode and cathode candidates.[2-6] Considering the overall performance and the cost, $Na_{0.44}MnO_2$ and hard carbon are one of the best cathode-anode pairs for Na-ion batteries. In this work, we synthesized $Na_{0.44}MnO_2$ nanowires using a scalable ball milling method and demonstrated long cycle stability in the half-cell design. A capacity of ~102 mAh/g was obtained at 0.5C current density and the capacity retention was ~80% (80 mAh/g) after 400 cycles. We also studied the electrolyte effect and demonstrated 1M $NaClO_4$ in EC/DMC (1:1) to be one of the best electrolytes for full-cell applications. The full battery using $Na_{0.44}MnO_2$ cathode and hard carbon anode exhibited a stable capacity of ~80 mAh/g over 30 cycles.

Results and Discussion

Sodium carbonate was mixed with the manganese source using a scalable ball milling method. The $Na_{0.44}MnO_2$ nanowires were obtained after annealing in air at the elevated temperature. Then, they were mixed with conductive carbon and binder and casted on an aluminum substrate and tested in coin cells. Long cycle stability was demonstrated in the half-cell design. A capacity of ~102 mAh/g was obtained at 0.5C and the capacity retention was ~80% (80 mAh/g) after 400 cycles. We also studied the electrolyte effect and demonstrated 1M $NaClO_4$ in EC/DMC (1:1) to be one of the best electrolytes for full cell applications. The full battery using $Na_{0.44}MnO_2$ cathode and hard carbon anode exhibited a stable capacity of ~80 mAh/g over 30 cycles.

(a)



(b)

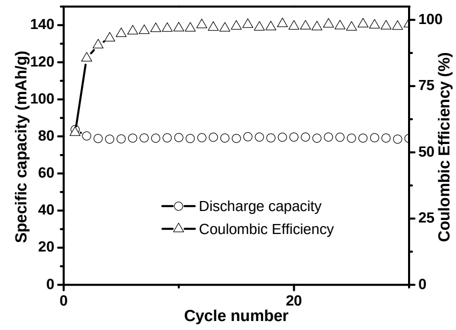


Fig. 1. (a) Long cycling stability of the $Na_{0.44}MnO_2$ half-cell. (b) Full-cell cycling stability with hard carbon as the anode.

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