A novel sulfur/polypyrrole/multi-walled carbon nanotubes nanocomposite cathode with core-shell tubular structure for lithium rechargeable batteries

Yongguang Zhang, Yan Zhao and P. Chen*
Department of Chemical Engineering, University of Waterloo,
200 University Avenue West, Waterloo, Ontario, Canada, N2L 3G1

Introduction

Lithium batteries have the highest energy density among the commercialized secondary batteries and they are leading the path for energy storage and sources for portable applications, including electric vehicle transportation. Commercial lithium batteries are based on oxide cathodes such as $LiCoO_2$, $LiFePO_4$ and $LiMn_2O_4$, which can deliver only up to 200 mAh g^{-1} of capacity, limiting their use for energy demanding applications. The elemental sulfur could be a best choice for the cathode due its theoretical capacity of 1672 mAh g^{-1}, which is one of the the highest among all known cathode materials. Combined with its abundant availability, this makes sulfur a most promising cathode for lithium batteries. However, this cathode material suffers from its low conductivity and capacity fading due to the dissolution of electrochemical reaction products [1, 2].

In this work, we report on the preparation of a novel sulfur/polypyrrole/MWNT (S/PPy/MWNT) composite with a core-shell nano-tubular structure, and on its physical and electrochemical properties as a cathode for lithium secondary batteries.

Experimental

Polypyrrole-coated MWNT (PPy/MWNT composite) was obtained by *in situ* polymerization of pyrrole on MWNT. As Fig. 1 shown, to make the S/PPy/MWNT composite, the as-prepared PPy/MWNT composite was added into aqueous suspension of nano-sulfur. After sonicated homogenously and dried in a vacuum oven, the mixture was heated at 150°C in Ar gas atmosphere to obtain the S/PPy/MWNT composite.

The S/PPy/MWNT composite was characterized using chemical analysis, XRD, BET, SEM and HRTEM. The composite cathode electrode was prepared by mixing S/PPy/MWNT composite with conductive carbon and PVdF binder and coating this mixture on nickel foam. The electrochemical properties of the composite cathode were investigated in a lithium half cell (coin-type CR2025) by cyclic voltammetry (CV) and galvanostatic cycling.

Results and Discussion

Figure 2 presents that TEM-EDS mapping results, which reveal that sulfur homogeneously coats the PPy/MWNT nanotubes and PPy is sandwiched between MWNT and sulfur. In this core-shell structure, PPy acts as an effective binder connecting sulfur and MWNT. PPy also serves as a sponge to absorb polysulfides into its porous structure, improving the cyclability of the cells. Furthermore, as a core in this composite, the MWNT can provide a high electronic conductivity and mechanically flexible framework, enhancing the rate capability of the cathode material.

Further development of this research will be presented at the Meeting.

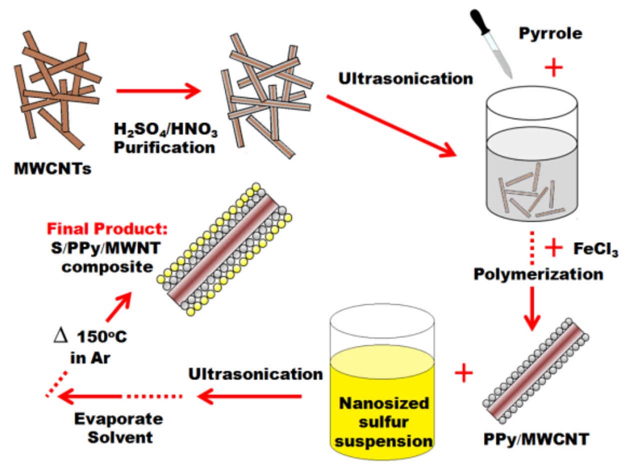

Fig. 1 Schematic of the S/PPy/MWNT composite preparation.

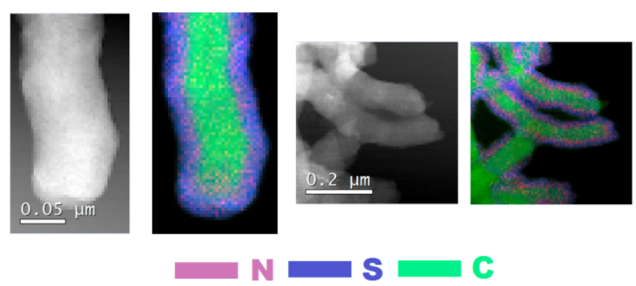

Fig. 2 HRTEM images of the S/PPy/MWNT composite sample with carbon, sulfur and nitrogen elemental mapping.

References

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