Preparation and evaluation of Copper particles on reduced graphene oxide as an efficient electrocatalyst for enhancing electrochemical performance of the Lithium-Thionyl Chloride Batteries

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Abstract

Lithium-thionyl chloride cell (Li-$SOCl_2$) has a metallic lithium anode and a liquid cathode comprising a porous carbon current collector filled with thionyl chloride. It delivers a voltage of 3.6V and is cylindrical in shape, in 1/2AA to D size, with spiral electrodes for power applications and bobbin construction for prolonged discharge. Among of all primary batteries, lithium thionyl chloride batteries have the highest voltage and energy, longest storage period, and the least self-discharge rate.

The chief objective of this work is to evaluate the effect of Cu/rGO composites as an electrocatalyst for enhancing the thionyl chloride cathodic reduction on the cathode side of Li/$SOCl_2$ battery when a load is connected.

Graphene oxide (GO) was prepared through Marcano-Tour's method. After ultrasonication, washing, pH neutralization and centrifuging, GO solution was sonicated for 30 min, and then Cu $(NO_3)_2.3H_2O$ aqueous solution was added followed by stirring overnight. Then $NaBH_4$ aqueous solution was added drop wise under N_2 atmosphere. To be sure the full reduction of copper on GO, excess amount of $NaBH_4$ was used. After the reaction completion, the mixture was allowed to stir for 24 h. Then the black suspension was filtered and washed for several times with DI water and absolute ethanol to remove residual reactant ions. Then, the prepared sample dried in the oven at 45 $^{\circ}$C. To improve the crystallinity of Cu, the product was annealed in the tube furnace at 650 $^{\circ}$C under N_2/H_2 (95/5) atmosphere for 90 min (heating rate= 3 $^{\circ}$C/min) [1].

The crystalline structure of the sample was determined by X-ray diffraction (XRD) using a Bruker advanced diffractometer with CuKα ($\lambda_{CuK\alpha}$ = 0.154 nm) radiation. Fourier transform infrared spectroscopy (FT-IR) was used to investigate the reduction of GO via mentioned preparation method by a Jasco-680 (Japan) spectrometer with scanning at wavenumber range of 400–4000 cm^{-1}.

All electrochemical characteristics were measured by SCRIBNER 850E test station. The electrochemical measurements were carried out in a designed test cell which made by PTFE and 316 stainless steel. Obtained results indicate that, adding Cu/rGO to the cathode of batteries, influence the charge transfer process during the reduction of thionyl chloride. Moreover, a higher discharge voltage was obtained in whole range of loaded currents based on polarization curves data. The results also demonstrated that cathode modification by Cu/rGO nanocatalysts in Li-$SOCl_2$ batteries enhances the battery capacity significantly.

References

[1] D. C. Marcano, D. V Kosynkin, J. M. Berlin, A. Sinitskii, Z. Sun, A. Slesarev, L. B. Alemany, W. Lu, and J. M. Tour, "Improved Synthesis of Graphene Oxide," ACS Nano, **vol. 4, no. 8,** (Aug. 2010) pp. 4806–4814.

Figures