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Electrodeposited p-type copper oxide for lithium-ion battery applications

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Lithium-ion batteries (LIBs) are considered a promising energy storage device due to their energy density, capacity, and longevity. In recent years, transition metal oxides have gained greater attraction due to their high theoretical capacity for rechargeable battery applications. The development of the anode and cathode in rechargeable batteries is crucial for enhancing overall battery performance. Among the different types of alternative anode materials for LIBs, Cu_2O is crucial due to its high specific capacity, low cost, environmental benefits, and ease of production. In this investigation, growth and characterization of p-Copper Oxide were carried out for possible anode material for rechargeable battery applications. Electrodeposition of p-Copper Oxide was carried out potentiostatically in a three-electrode electrochemical cell containing 3M lactic acid 0.04M cupric sulfate ($CuSO_4$) and 3M sodium hydroxide (NaOH) at - 450 *m*V vs Ag/AgCl for 30 min. The pH of the bath was adjusted to 12.5 using sodium hydroxide and bath temperature and stirring speed were maintained at 60°C and 200 rev./min respectively during the deposition. Titanium plate, Ag/AgCl, and platinum plate were used as working electrode, reference electrode, and counter electrode respectively. Grown materials were characterized using High Energy X-ray Diffraction (HEXRD), FTIR, Scanning Electron Microscopy (SEMs), Mott-Schottky measurements, and charge-discharge measurements. The HEXRD spectrum exhibited all the peaks corresponding to the reflection from Cu_2O and CuO. Thus, HEXRD results revealed that the grown thin films (≈1 μm) consist of polycrystalline Cu_2O with a cubic crystal structure and CuO with a monoclinic crystal structure indicating the formation of copper oxide. The FTIR spectra exhibited peaks related to Cu-O stretching vibrations and -OH groups, confirming the growth of Cu_2O having proper composition. The SEM analysis confirmed the formation of uniform polycrystalline cubic grain morphology Cu_2O having grain size in the order of 100-300 nm. Mott-Schottky analysis confirmed the p-type conductivity of Cu_2O having a doping density around 3.30×10^{16} *c*m^{-3} which is crucial for efficient conversion reactions during battery operation. The fabricated device using p-Copper Oxide as anode material exhibited a specific capacity of 205.4 *m*Ah g^{-1}. Overall results of this study reveal that electrodeposited p-Copper Oxide improves the interfacial properties between the anode and current collector and electrolyte. In conclusion, electrodeposited p-Copper Oxide can be used as a promising anode material for high-performance LIBs.

Keywords: Rechargeable Batteries, Electrodeposition, Anode Material, p-Type Copper Oxide.