Effect of electrodeposition parameters on the electrochemical behavior of electrolytic manganese dioxide (EMD)

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ABSTRACT

Manganese dioxide (MnO_2) material was electrochemically synthesized on the Lead electrode surface at varying synthesis conditions of current density (100 - 300 A m^{-2}), deposition duration (4 - 6 h), and in the presence of surfactant additive at different concentrations (15 - 60 mg l^{-1}). The electrolytic bath contained manganese sulfate as the manganese source in an acidic medium. A surfactant was used as an additive in the electrolytic bath to co-deposit with MnO_2 to improve the pristine electrolytic manganese dioxide (EMD) properties. Electrodeposited MnO_2 material was scraped from the anode, followed by thorough washing with de-ionized (DI) water to remove entrained electrolyte, and the sulfate-free product was ground to obtain the final material for characterization. The consequences of varying the synthesis parameters on improving the electrochemical properties of EMD were examined in terms of capacitance, energy density, and power density. For single electrode electrochemical studies, EMD was coated on a graphite substrate and immersed in a 2 M NaOH aqueous electrolyte. A Pt wire was used as the counter electrode, and Hg/HgO was used as the reference electrode to obtain cyclic voltammetry (CV) and galvanostatic charge-discharge (GCD) data. The field emission scanning electron microscopy (FESEM) images showed that changing current densities influenced the morphology of the material, whereas changing the deposition time duration did not show a profound effect. The surfactant-assisted EMD synthesized at 200 A m^{-2} for 5 h exhibited well-defined quasi-rectangular CV curves and longer discharge times than the pristine EMD upon various current rates. The capacitance delivered by the surfactant-assisted EMD was 602 F g^{-1} at a 1 mA current rate, which increased about 6 times compared to the pristine EMD. The role of surfactant additive in the electrolytic bath is shown to be not limited to the material stability but also paving the path for electrolytically deriving the EMD powder on a larger scale.