Journal of Industrial and Engineering Chemistry 64 (2018) 318–327

Contents lists available at ScienceDirect

Journal of Industrial and Engineering Chemistry

journal homepage: www.elsevier.com/locate/jiec

Influence of small amount of Mg incorporated into hexagonal ZnO crystal on cell performance in membrane free Zinc–Nickel redox battery

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ARTICLE INFO

Article history:
Received 4 January 2018
Received in revised form 22 March 2018
Accepted 24 March 2018
Available online 31 March 2018

Keywords:
$Mg_xZn_{1-x}O$
Mg-insertion
Zinc–Nickel redox batteries
Cycle stability
Charge-transfer resistance

ABSTRACT

This study focused on improving the cell efficiency of Zinc–Nickel redox battery. The cycle life of zinc anodic material in KOH alkaline electrolyte was enhanced by small amount of Mg insertion into ZnO framework through a typical hydrothermal method. The as-prepared ZnO and $Mg_xZn_{1-x}O$ (x = 0.001, 0.0025, and 0.005) anodic materials before and after charging/discharging test were characterized by X-ray powder diffraction (XRD), scanning electron microscopy (SEM), and energy dispersive spectrometer (EDX) to investigate the effect of inserted Mg ions on the zinc dendrite growth. Cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) were utilized to examine the electrochemical performances of Mg-inserted ZnO as anodic material. The Mg-inserted ZnO–Ni membrane free redox batteries possess higher discharge voltage, higher cycle stability, lower corrosion current, and smaller charge-transfer resistance in comparison with bare ZnO. In addition, the redox cell efficiency was 85% in the ZnO anodic material inserted Mg of 0.0025 mol even after 100 cycles.
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Introduction

According to the US market research firm, Pike Research [1], the market for rechargeable batteries in 2020 is expected to be occupied by lithium-ion batteries (33%), lead acid batteries (25%) and redox flow batteries (21%). In recent years, interest in energy storage device systems (ESS), which store the electric energy generated by the diversification of renewable energy sources, has been attracting attention [2]. In addition, the redox flow battery, which is a system that can store the energy produced in the power grid and supply it at the required time to improve the energy efficiency, has been extensively studied. The basic structure of the Redox Flow Battery (RFB) consists of a stack for power output, an anode (+) and cathode (−) electrolyte tanks for capacity, and a pump for supplying the electrolyte to the stack. The material that can store electrical energy consisting of anode and cathode electrolytes is called the redox couple. The characteristics of the battery depend on which redox couple is used [3–5]. Unlike conventional rechargeable batteries, RFB has a structure in which the electrolyte tank and the stack are separated, so that output and capacity can be freely designed. Stacking the stacks in series can produce as large a desired output as possible, and it is easy to increase the capacity by simply increasing the amount of electrolyte. In addition, redox couples in electrolytes can be semi-permanently recycled, which makes it possible to utilize resources effectively [6,7].

The RFBs according to the redox couples can be variously classified as follows: all Vanadium [8], Vanadium–Polyhalide [9], Bromine–Polyhalide [10], Iron–Chromium [11], H_2–Br_2 [12], Zinc–Bromine [13], Zinc–Cerium [14], and Zinc–Nickel [15–18]. Zinc–Nickel Redox batteries have high capacity, high energy ratio, high stability, and no memory effect, allowing rapid charging and discharging. In addition, since an aqueous electrolyte is used, it does not explode under overcharging/discharging conditions, and has a good low-temperature discharge performance. Moreover, it does not cause any pollution to the environment during production

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https://doi.org/10.1016/j.jiec.2018.03.032
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