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Electrochemical synthesis of flake-like Fe/MWCNTs nanocomposite for hydrogen evolution reaction: Effect of the CNTs on dendrite growth of iron and its electrocatalytic activity

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ABSTRACT

Fe/multi-walled carbon nanotubes (Fe/MWCNTs) nanocomposite was produced using electrochemical techniques onto platinum substrate. Linear sweep voltammetry (LSV) analysis revealed that deposition rate of the nanocomposite is higher than of the pure Fe deposition. X-ray diffraction (XRD) was used to confirm nanocomposite formation. Scanning electron microscopy (SEM) images showed dendrite growth of the pure Fe onto a flake-like (thickness of about 90 nm) structure with a filamentous carbon network. The morphology of the nanocomposite consisted of only uniform nanoflakes with thickness of about 50 nm. Adsorption of the MWCNTs on the flakes led to decrease the nucleation energy and avoided formation of the prisms that are essential for dendrite growth. The nanocomposite showed superior catalytic activities for hydrogen evolution reaction (HER), twice of the pure Fe when the overpotential of −1.3 V was applied. The overpotential–time results indicated that HER activity of thin films decreased during the long-term working. But, nanocomposite was more stable than the pure Fe.

1. Introduction

Since Iijima reported the existence of carbon nanotubes in 1991 [1], they have attracted much attention. Carbon nanotubes (CNTs), single-walled (SWCNTs) and multi-walled carbon nanotubes (MWCNTs), have continued to attract intense research interests as ideal nanomaterials for the development of nanoelectronic devices [2,3], drug delivery [4,5], and high-performance electrochemical sensors [6,7]. These interests are based on the unique properties of CNTs such as high electrical conductivity, high surface area, significant mechanical strength and good chemical stability. Recently, more attention is focused on the applications of CNTs as reinforcement in structural materials [8]. Substantial advances have been made, especially for CNTs/polymer composite, CNTs/metal oxides [9–11] and CNTs/Pt [12,13].

On the other hand, hydrogen energy becomes more attractive in that it can resolve the exhaustion of fossil fuels and their environmental problems. In addition, hydrogen plays an important role in many applications, such as fuel cell [14]. Numerous works have also been developed for hydrogen generation from water by electrolysis [15]. At present, one could say that water electrolysis has been the sole commercialized technique to produce hydrogen. Furthermore, nanocomposites were applied to increase hydrogen evolution too [16].

In this study, Fe/MWCNTs nanocomposite was electrodeposited onto platinum substrate using electrochemical methods. The morphology of the Fe/MWCNTs nanocomposite and pure Fe thin films were investigated using SEM. Furthermore, XRD analysis was used to confirm the nanocomposite deposition. Finally, electrocatalytic activities of both pure Fe and Fe/MWCNTs nanocomposite thin films were evaluated for hydrogen evolution reaction (HER).

2. Experimental

The solutions were prepared by dissolving reagent grade chemicals and double distilled water. The working solutions were prepared by addition of solutions containing iron sulfate

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