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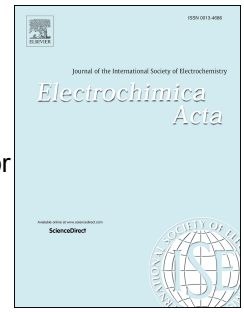

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PII: S0013-4686(18)32321-1

DOI: 10.1016/j.electacta.2018.10.082

Reference: EA 32879

To appear in: *Electrochimica Acta*

Received Date: 28 June 2018

Revised Date: 9 October 2018

Accepted Date: 13 October 2018

Please cite this article as: Z. Lin, C. Wang, Z. Wang, Q. Liu, C. Le, B. Lin, S. Chen, The role of conductivity and phase structure in enhancing catalytic activity of CoSe for hydrogen evolution reaction, *Electrochimica Acta* (2018), doi: https://doi.org/10.1016/j.electacta.2018.10.082.

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The Role of Conductivity and Phase Structure in Enhancing Catalytic Activity of CoSe for Hydrogen Evolution Reaction

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ABSTRACT

We report for the first time that CoSe with tetragonal metallic phase exhibits high electrocatalytic activity for hydrogen evolution reaction (HER) in acid solution. The prepared tetragonal CoSe exhibits an overpotential of 175 mV versus reversible hydrogen electrode at j = −10 mA cm^{-2} and a notably low Tafel slope of 36.3 mV dec^{-1}, which are considerably superior to that of CoSe with a hexagonal metallic phase (352 mV and 104.6 mV dec^{-1}). Furthermore, by comparing the catalytic activity of both tetragonal and hexagonal phases of CoSe, our study reveals that the electrical conductivity still dominates on the basis that both phases are metallic. The catalytic activity of hexagonal CoSe can be improved by compounding single walled carbon nanotubes and achieve comparable performance with tetragonal CoSe. Combined with previous works that compare a semiconducting phase and a metallic phase, this work in addition deepens our understanding of the role of conductivity and phase structure in enhancing catalytic activity for HER electrocatalysts.

KEYWORDS: Hydrogen Evolution Reaction; Electrocatalysts; Catalytic Activity; Conductivity; Phase Structure.

1. Introduction

With the growing shortage of energy resources and the intensified environmental pollution, hydrogen energy has drawn widespread attention due to the bright prospects as a green sustainable energy[1-4]. Hydrogen evolution reaction (HER), generating H_2 by electrolyzing water, is regarded as a practical means to obtain hydrogen energy. Pt, which is the most famous and active HER catalyst in acidic media[2, 5], limits its widespread applications due to its high price and relative scarcity. The desire of hydrogen energy harvesting in an economically feasible way motivates people to search for precious-metal-free and high-performance catalysts[6-8]. Over the past decades, considerable earth-abundant catalysts had been found, mainly including transition metal sulfides (CoS_2, MoS_2, WS_2, etc)[9-17], selenides ($CoSe_2$, $MoSe_2$, etc)[15, 18-27], carbides (Fe_3C, Mo_2C, etc)[12, 28, 29] and phosphides (CoP, FeP, etc)[30-39]. Despite the

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