

Utah State University

DigitalCommons@USU

Research on the Hill (Salt Lake City)

1-30-2014

Facile Preparation of 1st--Row Transition Metal Chalcogenides as Hydrogen Evolution Catalysts in Water

Lia Bogoev

Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/poth_slc



Part of the [Chemistry Commons](#)

Recommended Citation

Bogoev, Lia, "Facile Preparation of 1st--Row Transition Metal Chalcogenides as Hydrogen Evolution Catalysts in Water" (2014). Research On Capitol Hill 2014. *Research on the Hill (Salt Lake City)*. Paper 8. https://digitalcommons.usu.edu/poth_slc/8

This Poster is brought to you for free and open access by DigitalCommons@USU. It has been accepted for inclusion in Research on the Hill (Salt Lake City) by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.



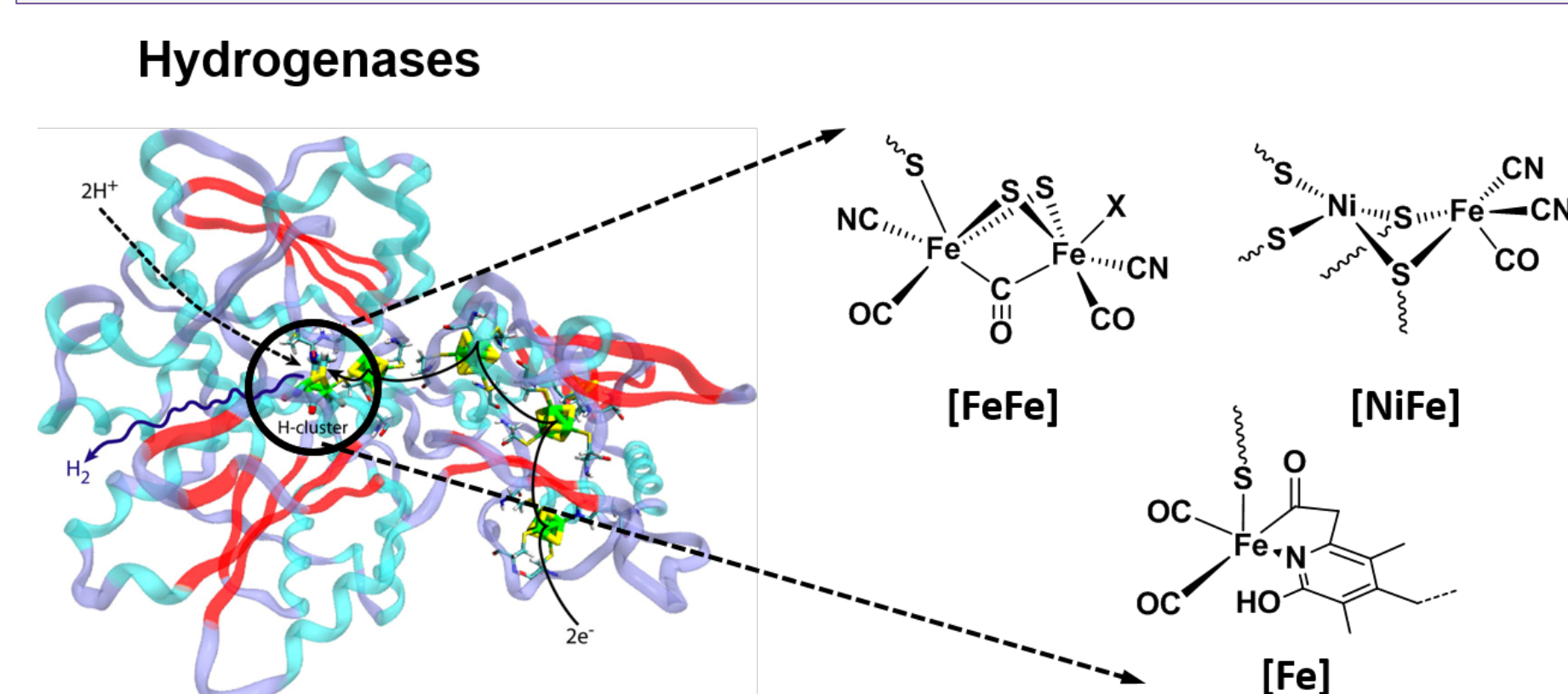
Facile Preparation of 1st-Row Transition Metal Chalcogenides as Hydrogen Evolution Catalysts in Water

Utah State
University

Lia Bogoev, *Utah State University* | Dr. Yujie Sun, *Utah State University*

I. Introduction

The combination of rising energy demands, anthropogenic climate change, and diminishing fossil fuels have dictated the search of carbon-neutral and sustainable energy sources one of the most urgent tasks in the scientific community. Among various renewable energy sources, solar energy is a promising target due to its gigantic amount. However, its nature of diurnal variation, intermittence, and unequal distribution requires efficient capture, conversion, and storage. Thus, solar-drive water splitting to produce hydrogen and oxygen has been widely regarded as an attractive approach, where hydrogen acts as the energy carrier. Nature evolves hydrogenases enzymes to catalyze the conversion between proton and hydrogen in neutral aqueous media. Three types of hydrogenase cofactors, binuclear iron/iron, iron/nickel, and mononuclear iron, have been identified. Inspired by the active sites of hydrogenases, herein we describe the facile preparation of nickel-sulfide films as competent and robust hydrogen evolution catalysts in neutral aqueous media.



Lia Bogoev
Utah State University
Dept. of Chemistry and Biochemistry
lia.bogoev@aggiemail.usu.edu

II. Methods

With the use of fluorine-doped tin oxide (FTO) as both the working and auxiliary electrodes and a Ag/AgCl reference electrode, a nickel-sulfide film can be formed on FTO from nickel nitrate and thiourea precursors via a process of potentiodynamic deposition. After rinsing thoroughly with water and acetone, the dried nickel-sulfide film was annealed under nitrogen for three hours. The morphology and valence states of the prepared nickel-sulfide film were characterized via scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). The proton reduction performance was evaluated in pH 7 phosphate buffer via various electrochemical techniques, including polarization, Tafel plot, Nyquist plot, and controlled potential electrolysis.

III. Results

Figure 1A displays the SEM images of annealed nickel-sulfide film on FTO, implying its amorphous nature. XPS data summarized in Figure 1B confirms the valence states of +2 and -2 for nickel and sulfur, respectively. It demonstrates that the major composition of the nickel-sulfide film is NiS. As depicted in Figure 1C, negligible current response was observed for blank FTO working electrode. However, once the nickel-sulfide film was deposited on FTO, a sharp rise in current was apparent when the potential was scanned more negative than -0.8 V vs Ag/AgCl. The resistance of the catalytic film was measured via electric impedance spectroscopy whose results are included in Figure 1E. The robustness of the nickel-sulfide film was confirmed by its controlled potential electrolysis (Figure 2).

Figure 1. Characterization and Electrochemistry Data

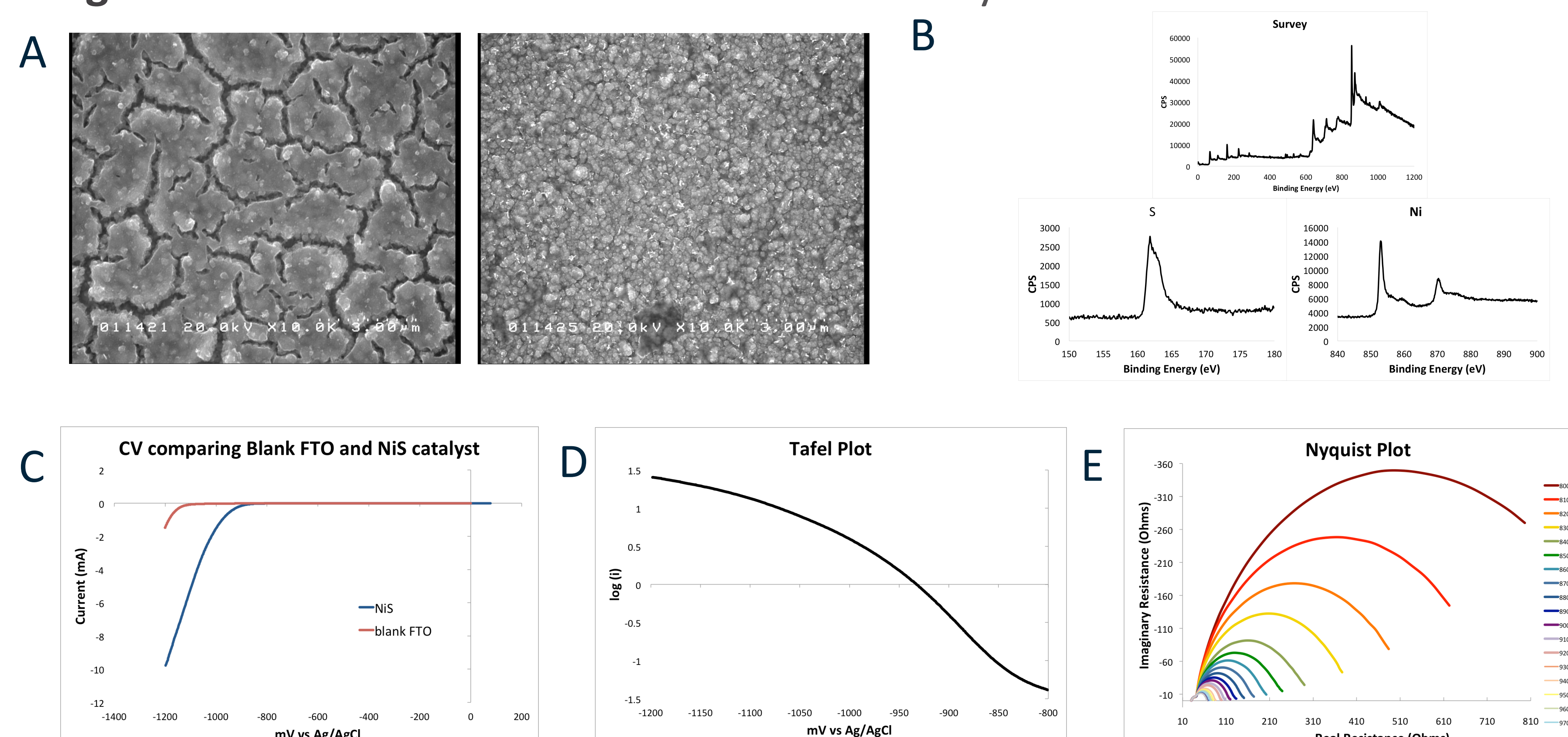
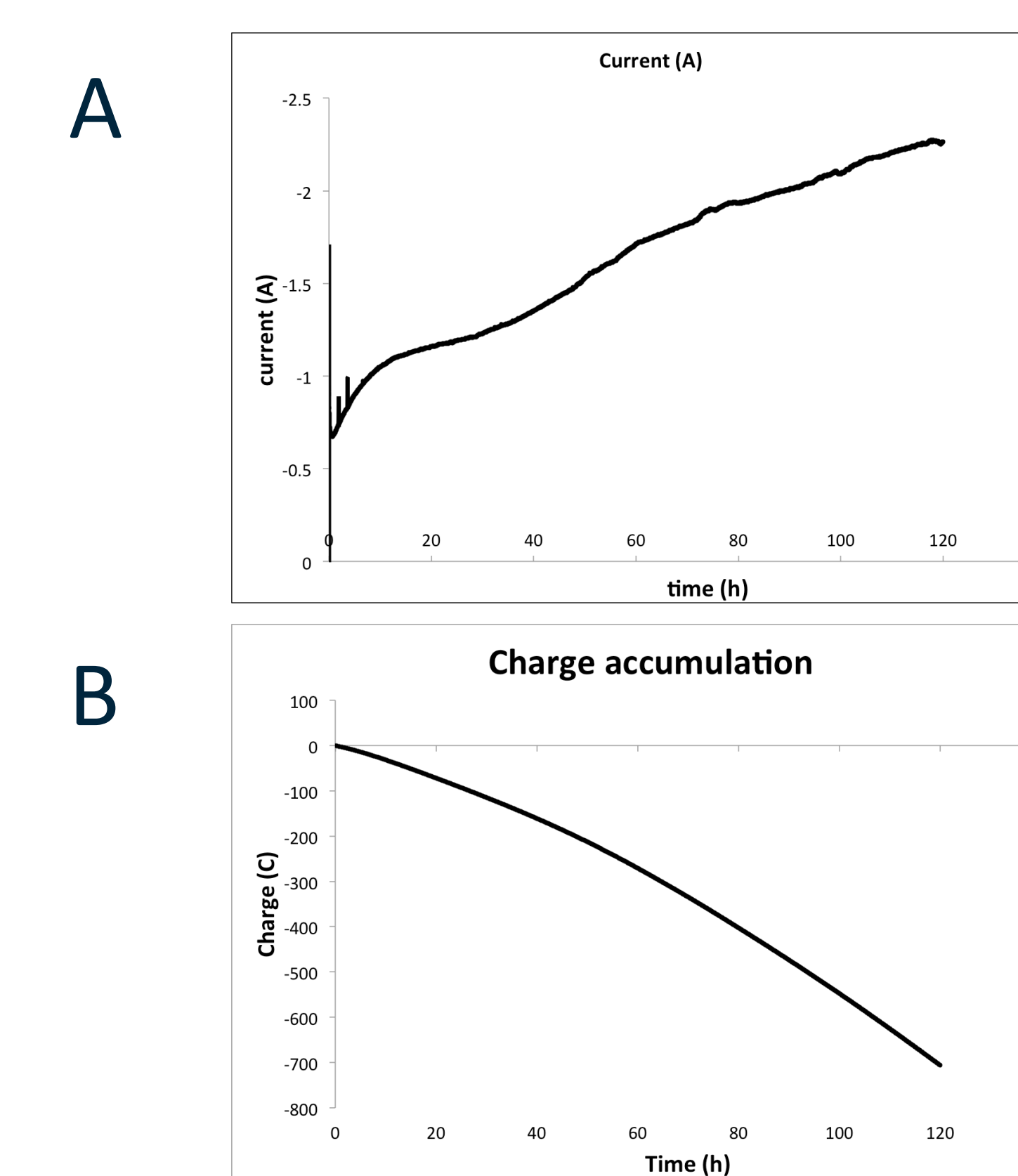


Figure 2 – Controlled Potential Electrolysis



IV. Conclusions

A facile preparation method of electrodynamic deposition allows us to generate nickel-sulfide films on FTO electrodes. Various characterization techniques were utilized to confirm its amorphous nature and major composition of NiS. This film exhibits competent and robust catalytic performance for the hydrogen evolution reaction, representing a promising catalyst candidate for electrocatalytic water splitting.

Acknowledgement

Undergraduate Research and Creative Opportunity Grant, Start-Up Funding, Research Catalyst Grant from Utah State University.