CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

S0619

Project Title

Running on Water: Electron Superhighway for Optimization of Real-Time Production of H2 and O2

Abstract

Objectives/Goals

In order to fix the problem of climate change and increasing CO2 levels, we have to find a different fuel source to power our cars and our homes. Hydrogen is a promising candidate as it burns cleanly and can be produced through electrolysis of water. However, in order to provide safe, efficient, and commercially viable access, we need to produce the hydrogen cheaply and directly where and as it is needed so complex and hazardous hydrogen storage and transportation is not required. My objective is to find the materials to efficiently make hydrogen at a high rate while using the minimal amount of material and funds.

Methods/Materials

First coat a thin & cheap material with graphene (eg. aluminum foil); this creates a superhighway for electrons to provide the needed current for high production rate reactions, using a minimal amount of materials. Then, electroplate a thin layer of an efficient and inexpensive electrocatalyst onto the reacting surface of the material, which decreases the energy required for the electrolysis reactions. For this I selected the combination of Nickel (Cathode for Hydrogen Evolution Reaction) & Nickel-Iron Oxide (Anode for Oxygen Evolution Reaction).

Results

A Nickel (Ni) and Nickel-Iron Oxide (NiFeO2) electrocatalytic coating was successfully applied through electroplating to steel, aluminum, and copper. As a base electroplating material, the steel developed the highest quality coatings in minimal time. For manufacturing graphene, a high-quality coating could not be achieved as the graphite oxide did not fuse evenly. As an alternative, Aluminum sheets with Graphene were purchased & used for the experimental data.

As an electrocatalyst, Steel performed much better than Copper, Brass & Aluminum for Hydrogen production via electrolysis of water. When a Ni cathode coating and a NiFeO2 anode coating was applied, production increased for all materials. At 12V, Ni/NiFeO2 coatings increased H2 production ~30% on Steel and ~500% on Aluminum

A Graphene backing also increased productivity (~30% on Aluminum foil at 12 V) by moving electrons throughout the material.

Conclusions/Discussion

I was able to produce an minimalist, inexpensive, efficient, and high-rate material for electrolysis by using a thin foil material coated with graphene and then electroplating Nickel/Nickel-Iron Oxide onto the reacting surfaces, and I am now one step closer to reducing the world#s use of fossil fuels.

Summary Statement

I researched aluminum foil coated with graphene and electroplated with Nickel and Nickel-Iron Oxide in order to create a commercially viable high-rate hydrogen production system.

Help Received

The Jaramillo Group (Graduate Chemical Engineering lab) at Stanford University recommended different electrocatalytic materials and gave some techniques for electroplating.