CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

S0615

Project Title

Optimization of Period IV Transition Metal-Phosphate Complex Concentration for Efficient Water Electrolysis

Abstract

Objectives/Goals

The primary objective was to analyze the efficiency of transition metal-phosphate complexes as catalysts for the electrolysis of water, specifically Iron(III) and Cobalt(II) in order to either support or provide evidence contrary to a hypothesis developed as a result of previous research. This focused on identifying whether or not transition metals with greater oxidation states would be more efficient as catalysts, as they have more electrons, and therefore have an increased capacity to conduct electricity in solution.

Methods/Materials

I tested the efficiency of the process with each transition metal by adding samples of each nitrate salt at specific concentrations from 0.02 M to 0.20 M to 25 mL samples of monobasic potassium phosphate solution. By measuring the current and voltage over a 5 minute period while connected to a DC power supply, I was able to calculate the energy input for the reaction. By collecting hydrogen gas through water displacement in a test tube, I calculated the amount of gas produced and used the Gibb's free energy of water synthesis to calculate the energy output obtainable from an ideal hydrogen fuel cell. Through comparing these two values, I was able to calculate the efficiency for each test.

Results

As a result of my research, I found that the cobalt(II) was about 26.4% more efficient than iron(III) when used to form a transition metal-phosphate complex as a catalyst. The peak efficiency of the cobalt(II) reached 28.6%, whereas the peak efficiency of the iron(III) only reached 22.5%. While the cobalt(II) only produced a peak gas output of 1.91 x 10^-4 moles compared to the iron(III)'s peak of 2.18 x 10^-4 moles, the iron was rather inefficient in producing that gas, having an efficiency of 16.7% as opposed to the cobalt(II)'s 21.1% efficiency at its peak gas production.

Conclusions/Discussion

My hypothesis was inaccurate in asserting that an increased number of oxidation states contributed to increased efficiency, as my research provided evidence to the contrary, showing that cobalt(II) was more efficient than iron(III). Moving forward, I hypothesize that because of the increased number of oxidation states, the iron(III) is conducting too much current, causing there to be more electricity in solution than can be used to effectively collide with the water molecules, and that the cobalt(II) is more efficient because of how it restricts the current in solution.

Summary Statement

I investigated the use of transition-metal phosphate complexes as catalysts for the electrolysis of water through analysis of their efficiencies.

Help Received

My chemistry teacher provided the chemicals. My Father provided the garage and the supplies within.