Name(s)

Daniel S. Fishman

Project Number

S0611

Project Title

Renewable Energy from the Oceans: Optimizing Hydrogen Electrolysis in the Solar/ Fuel Cell Energy Cycle

Abstract

Objectives/Goals

This experiment seeks to expand our knowledge of cost-effective, renewable energy for populations living near salt water. Specifically, it aims to determine how the efficiency of hydrogen electrolysis, a storable intermediate in the Solar - Fuel Cell Energy Cycle, is affected by differences in solutes, conductivity, reactivity and voltage.

Methods/Materials

144 trials involving different combinations of solute concentration (ocean, NaCl, tap & pure water), conductive elements (Al, C, Cu, Pt, Ti, Zn), and voltage (9.0v and 12.0v solar cells) to determine efficient methods to electrolyze hydrogen. Recorded measurements included: solar cell voltage, time to electrolyze a given quantity of H_2 (a measure of efficiency), and observations of electrolysis and reactivity for each sample.

Results

Greater solute concentration proved positively correlated with efficiency. Pure water generated no H_2, while water with a concentration of 12.0 g NaCl per 404.8 mL produced more H_2 across metals tested (eg, Al at 12.0v produced 2.0 mL of H_2 in 2.6 minutes with a SD of 0.1 while Ti did the same in 13.5 minutes with a SD of 0.3). Interestingly, ocean water with a higher concentration of NaCl was less efficient than pure NaCl water. The most efficient metal element was Al, and the least efficient was Ti across trials. Though Cu is highly conductive, it readily reacted and lost surface area, while Al did not noticeably react during the trials and preserved surface area. Higher voltage improved efficiency across metals.

Conclusions/Discussion

Based on the experiment results, ocean water is an efficient, naturally-occurring solution for production of H_2 via electrolysis when combined with a commonly-available, corrosion-resistant Al electrode. This combination, along with power from a low-cost, 12.0v polycrystalline solar cell, produces sufficient H_2 during daylight hours when combined in series with 16 like electrodes to power a 1.0v LED light during nighttime hours using a PEM fuel cell consuming 7.0 mL of H_2 per minute. This Solar - Fuel Cell Energy Cycle is renewable, relatively low cost and has no moving parts. It is also independent of any electrical distribution, so the technology can be used by populations in developing economies that have access to ocean water (which covers ~70% of the surface of the Earth). The technology also has the potential to produce pure drinking water as a clean by-product.

Summary Statement

The oceans hold great promise as a distributed source of electrolyzable hydrogen, a storable intermediate in the Solar - Fuel Cell Energy Cycle, considering the impact on efficiency from differences in conductivity, reactivity and voltage.

Help Received

None