HyPIR electrolysis for a 0.25 M Epsom salt solution

Abstract

Previous work has shown that HyPIR Electrolysis, or Hydrogen Production by Infrared Electrolysis, can increase the rate of hydrogen production from a solution of Epsom salt dissolved in water by irradiating the electrolyte with an optimum wavelength of light. This article presents additional data that shows that the molarity of the electrolytic system affects the rate of hydrogen production.

Key Words: Hydrogen Production, Infrared Laser, Electrolysis, HyPIR Electrolysis

Introduction

Widespread adoption of hydrogen as an energy carrier depends on our ability to supply hydrogen at a competitive price. A previous article described a process that increased hydrogen production rate by irradiating an electrolytic solution with light of an optimized wavelength[1,2] during electrolysis. The process was referred to as hydrogen production by infrared (HyPIR) electrolysis and is based on concepts reported in the literature[3,4,5].

The experiment is described by Fanchi[1] for a 0.12 M Epsom salt-water solution. Figure 1 shows the HyPIR electrolysis apparatus used in this experiment. The rate of production of hydrogen gas is measured by recording the rate at which the fluid level rises in the manometer. The experiment was conducted at room temperature.

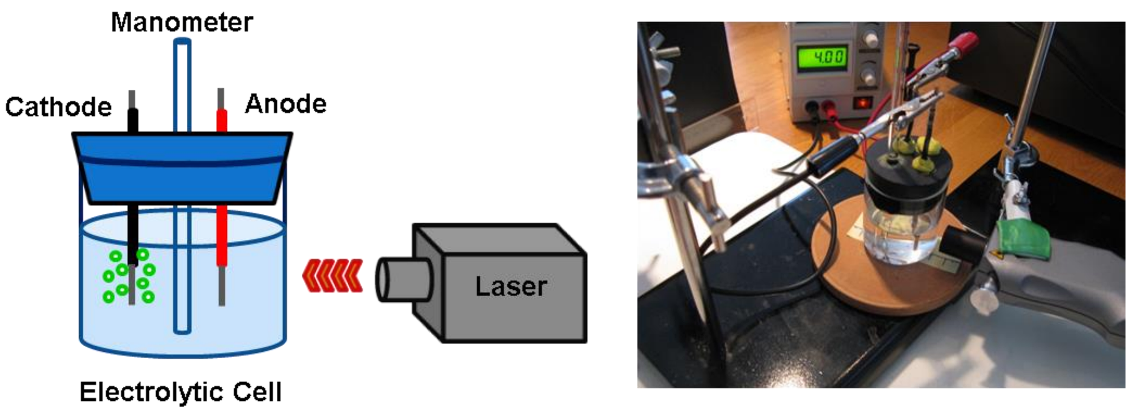

Figure 1. HyPIR Electrolysis Apparatus (courtesy Fanchi Enterprises)

The Erbium-YAG laser[6,7] selected for this experiment provides a beam of light with a wavelength of 2.94 microns. The Erbium-YAG laser was chosen because the photon energy at this wavelength is readily absorbed by the symmetric stretch vibrational mode of water at 2.734 microns wavelength and the asymmetric stretch vibrational mode of water at 2.662 microns wavelength. These vibrational modes refer to the stretching of the hydrogen-oxygen bond in water. The laser beam provided 600 mJ energy per pulse at a pulse rate of 4 Hz[7]. In this article we compare HyPIR electrolysis results for two different molarities.

Figure 2 shows the result of HyPIR electrolysis for 40 ml of a 0.25 M solution of Epsom salt in water. The experimental results show that the rate of change of fluid level (y in the regression equation) has a linear dependence on DC voltage (x in the regression equation) for the voltage range covered by the experiments. The slope of the lines represents the hydrogen production rate.

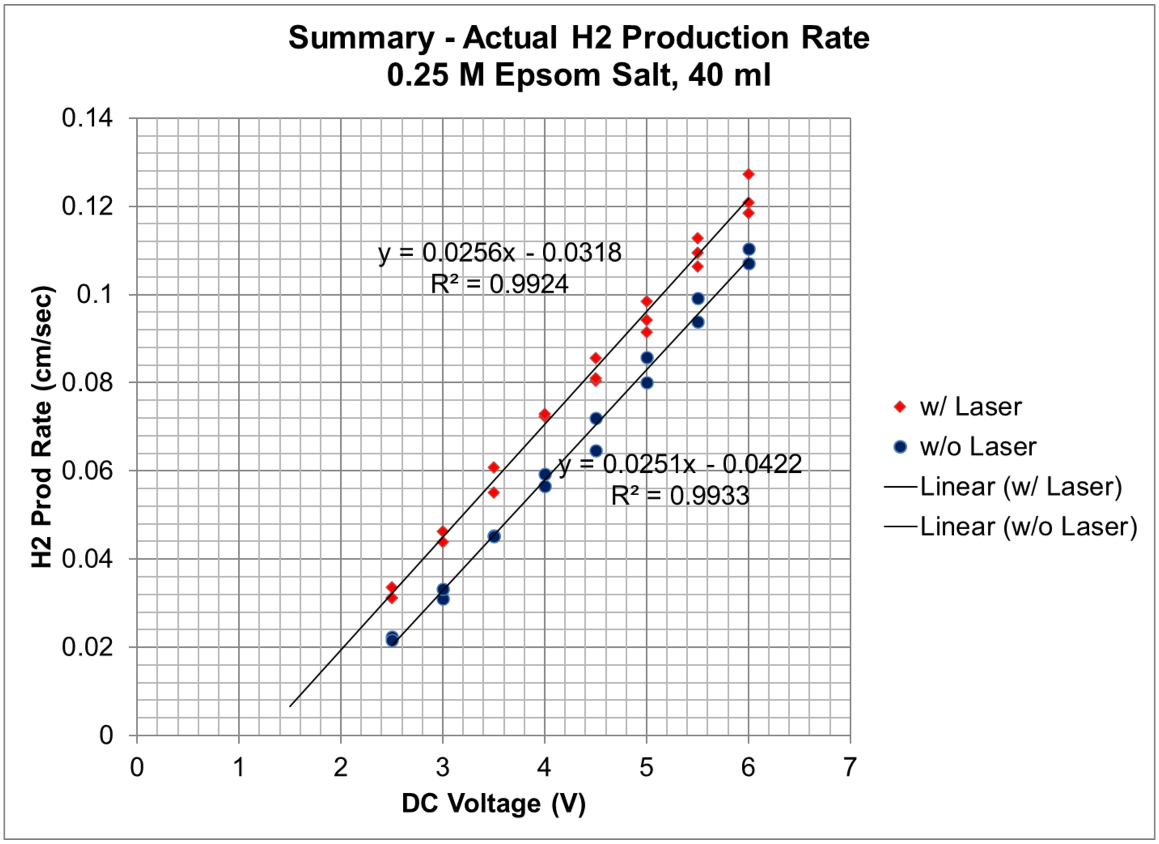

Figure 2. HyPIR Electrolysis Results for 0.25 M Epsom Salt Solution

The percent increase in hydrogen production rate is defined as 100% x (H_{IR} - H_0)/H_0 where H_{IR} is the rate of hydrogen production by electrolysis with the infrared laser beam, and H_0 is the rate of hydrogen production by electrolysis without the laser. The percent increases in hydrogen production rate for a 0.12 M solution and a 0.25 M solution are compared in Figure 3.

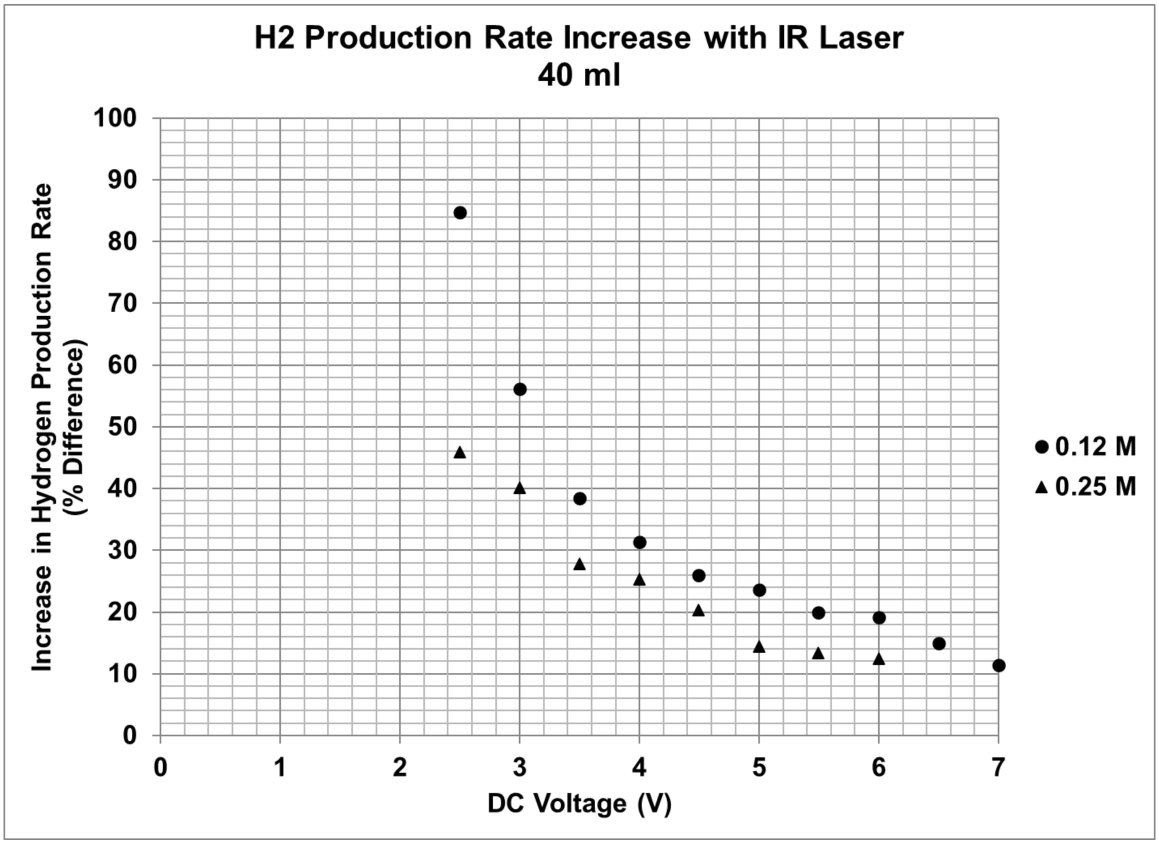

Figure 3. Comparison of Percent Increase in Hydrogen Production Rate for Two Molarities of Epsom Salt in Water

Discussion

This work used Epsom salt (magnesium sulfate) to form the electrolyte. The products of the reaction with the copper electrode were hydrogen, copper sulfate, and magnesium hydroxide. The formation of copper sulfate consumed the copper electrode and formed a precipitate. These undesirable results can be eliminated by using an alkaline water electrolysis system that does not consume the electrode and produces desirable byproducts. For example, use of potassium hydroxide (KOH) as the electrolyte creates an alkaline water system that does not interact with the copper electrode. Electrolysis with a KOH solution and a copper electrode can produce hydrogen gas and oxygen gas, two desirable products.

Conclusions

The results show that hydrogen production by infrared (HyPIR) electrolysis increases the rate of hydrogen production relative to the rate of hydrogen production without the laser. In this set of experiments, the increase in hydrogen production rate is greatest at low voltages and the increase is larger using a 0.12 M Epsom salt solution than a 0.25 M Epsom salt solution.

The choice of electrolyte can have disadvantages. For example, the use of Epsom salt produces an undesirable byproduct (a precipitate) and consumes a copper electrode during the electrolytic process. Future work should attempt to remove these difficulties by identifying an alternative electrolytic system.

References

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