

HyPIR Electrolysis for a 0.25 M Epsom Salt Solution

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Short Communication

ABSTRACT

Previous laboratory work using a 0.12 M Epsom salt solution showed 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 data for a 0.25 M Epsom salt solution. A comparison of the data for different molarities shows that an increase in molarity of the electrolytic system decreases the rate of hydrogen production.

Keywords: Hydrogen production; infrared laser; electrolysis; HyPIR electrolysis.

1. 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 a 0.12 M Epsom salt-water 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]. Other electrolysis techniques include hydrogen production by green laser irradiation [6], hydrogen production by PEM electrolysis [7], hydrogen production by electrolysis powered by renewable energy [8], low temperature water electrolysis [9], alkaline water electrolysis in the presence of a magnetic field [10], and a solar-to hydrogen device based on earth-abundant

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materials [11]. An alternative to hydrogen production by electrolysis is the production of hydrogen during sodium metal dissolution in concentrated aqueous Epsom salt solution [12]. Different technologies for the large-scale storage of hydrogen are reviewed by Andersson and Grönkvist [13]. This article presents data for a 0.25 M Epsom salt solution and compares the data for different molarities.

1.1 Experimental Procedure

The experiment described by Fanchi¹ uses a 0.12 M Epsom salt-water solution. This experiment uses a 0.25 M Epsom salt-water solution. Fig. 1 shows the HyPIR electrolysis apparatus used in this experiment. The Epsom salt (magnesium sulfate) solution in an electrolytic cell is electrolyzed with a copper anode to form copper sulfate, magnesium hydroxide, and hydrogen. The hydrogen is captured by a seal and forms a gas cap that increases the pressure in the cell. The increase in pressure is measured by a manometer. The rate of production of hydrogen gas is measured by recording the rate at which the fluid level rises in the manometer due to the pressure increase in the electrolytic cell. The experiment was conducted at room temperature.

The Erbium-YAG laser [14,15] 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 [15]. In this article we compare HyPIR electrolysis results for two different molarities.

1.2 Experimental Results

Fig. 2 shows the results 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.

The percent increase in hydrogen production rate is defined as $100\% \times (H_{IR} - H_0)/H_0$ 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 Fig. 3.

2. DISCUSSION

Fig. 3 shows that the increase in molarity results in a decrease in hydrogen production rate associated with IR laser irradiation. The purpose of IR laser irradiation was to stretch the hydrogen-oxygen bond and make it easier to dissociate the hydrogen and oxygen atoms. The increase in molarity increases the presence of ions in solution and appears to decrease the effectiveness of IR laser irradiation. It should be noted that the increase in DC voltage in the electrolytic cell also appears to decrease the effectiveness of IR laser irradiation.

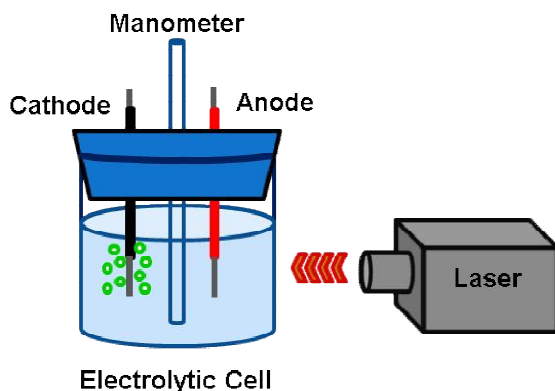


Fig. 1. HyPIR Electrolysis apparatus (courtesy Fanchi Enterprises)

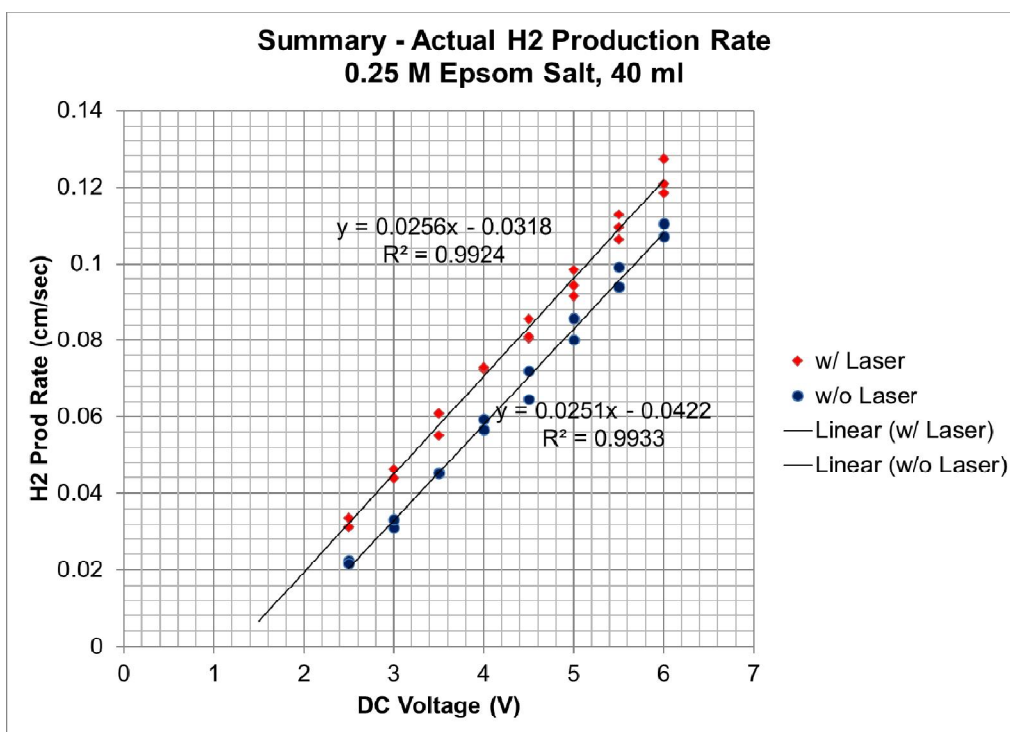


Fig. 2. HyPIR Electrolysis Results for 0.25 M Epsom Salt Solution

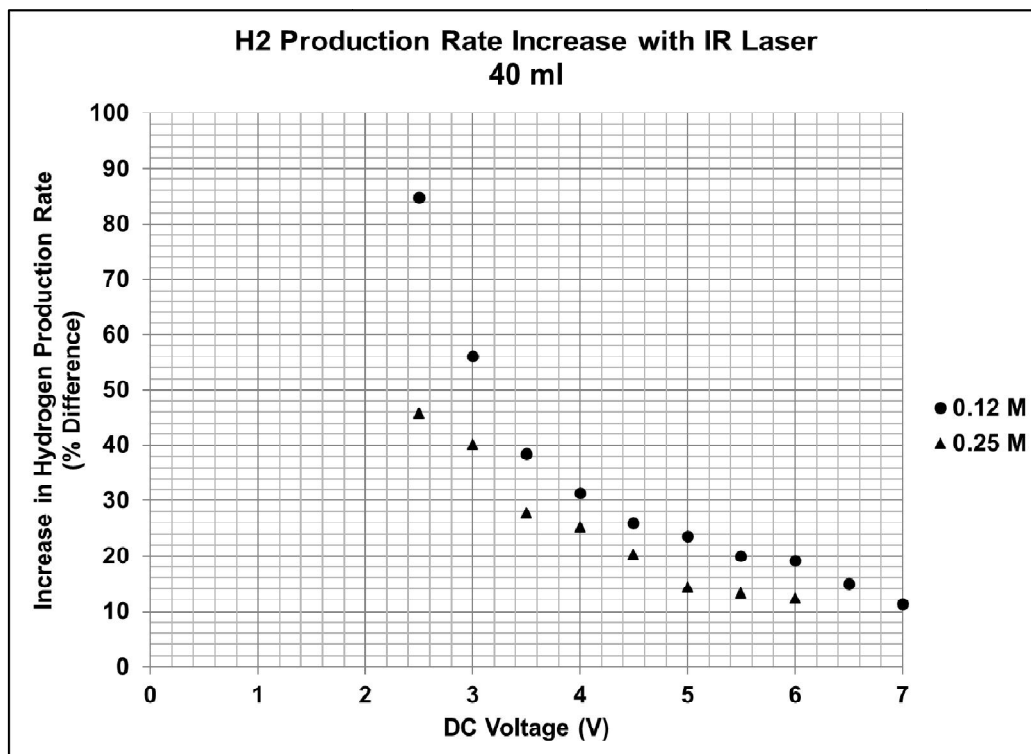


Fig. 3. Comparison of Percent Increase in Hydrogen Production Rate for Two Molarities of Epsom Salt in Water

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 [16-18] 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.

3. 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.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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