Enhancement of hydrogen using green laser from plasma electrolysis of water

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In the wake of vicious and irreversible effects of global warming, it has always been a global concern on how to develop substitute form of energy part from oil. With the increasing energy costs and shortage of oil reserves, production and supply, the need of new energy sources becoming popular. Hydrogen is considered to be the most viable energy carrier for the future In order to enhance the production of hydrogen from plasma electrolysis of water, the capability of diode pumped solid state laser with second harmonic of wavelength 532 nm has been investigated. Different acids and bases have been used as a catalyst. A comparative study of acids and bases has been ascertained as a function of laser constraints. The efficiency of bases was found to be greater than the acids. Different factors such as laser power, irradiation time and laser focusing effect have been focused during experiment.

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1. Introduction

Utilization of hydrogen energy has many striking attributes, including energy renewability, flexibility, and nil green house emissions. Direct decomposition of water is very difficult in normal condition. The pirolysis reaction occurs at high temperatures above 3700C^{o} [1]. Anomalous hydrogen generation during plasma electrolysis was already reported [2-5]. The electrical signals induced by lasers have been presented [6-8]. A lot of research has been done on photo catalytic hydrogen production. Many scientists produce hydrogen from water by using different photo catalysts in water and reported hydrogen by the interaction of lasers [9-13]. In addition to this photolysis of water has been studied using UV light [14]. But these methods are not economical and the yield of hydrogen was not to an extent. The other main problem is photo-corrosion of the materials. Hydrogen production by laser induced plasma electrolysis of water has been achieved recently [15-18].

Our work on lasers has revealed the important parameters which played a critical role in the enhancement of hydrogen from water using lasers. Most of the research work basis on photo splitting of water has carried out using flash lamps; a very little work is done by lasers [19]. The second parameter is that the most of the work has done on light water, distilled water and heavy water; we have used drinking water for production of hydrogen. In order to enhance the production of hydrogen from plasma electrolysis of water, the capability of diode pumped solid state laser with second harmonic of wavelength 532nm has been investigated. Different acids and bases have been used as a catalyst. A comparative study of acids and bases has been ascertained as a function of different laser constraints.

2. Experimental Setup

A schematic diagram of the hydrogen reactor is shown in Figure 1.The reactor contained a glass made hydrogen fuel cell having dimension 16cm × 10cm. The fuel cell contained a window for irradiation of laser, an inlet for water and electrolyte, two outlets for hydrogen and oxygen gasses, an inlet for temperature probe and a D.C. power supply (model ED-345B).Two electrodes, steel and Aluminum were adjusted in the fuel cell. In order to measure the breakdown current and gas flow, a multimeter and gas flow meter arranged with the fuel cell. The diode pumped solid state laser with second harmonics DPSS LYDPG-1 model DPG-2000 having green light of wavelength 532 nm was placed near the fuel cell for irradiation during electrolysis of water. The drinking water 40 ml mixed with 10mL acids and base afterword. In order to start the electrolysis current was applied by D.C source through electrodes. The laser beam from diode pumped laser was incident on water through the window of the fuel cell. The hydrogen and oxygen produced were measured by gas flow meter. The laser beam power was measured by a power meter model Nova Z01500.The temperature of the water was measured by a temperature probe i.e. a thermocouple thermometer and mercury thermometer. The current was registered with the help of a multimeter. The entire experimental run time was 90 minutes. The data was recorded after every minute of the run.

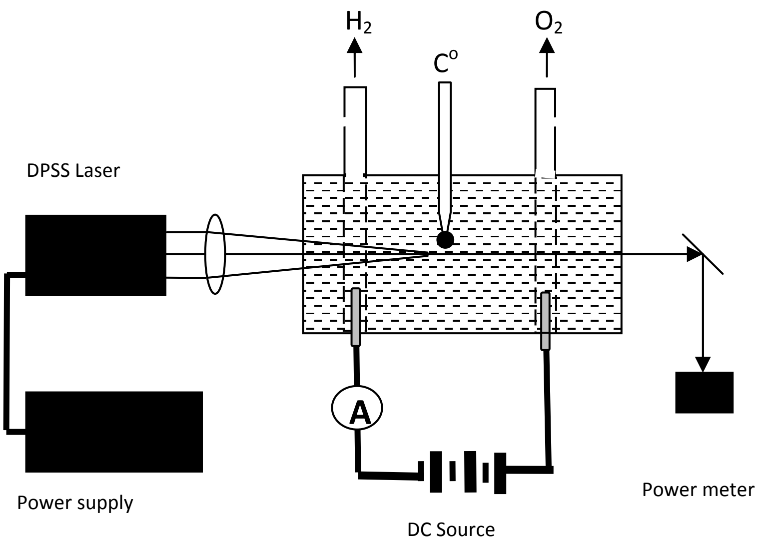

Fig. 1. Schematic diagram of hydrogen reactor

3. Result and discussions

In order to investigate the performance of electrolytes (acid and base) water splitting under the influence of laser induced plasma electrolysis, various experiments were performed. It has been observed that various important factors affected the yield of hydrogen.

(i) Effect of temperature
(ii) Laser focusing effect
(iii) Effect of laser power

3.1 Effect of temperature

The Hydrogen yield as a function of water temperature is shown in Figure 2.The result showed that the hydrogen production increased with increase in temperature of the water. It was because of the fact that when temperature of the water increased its bond dissociation energy decreased. The laser energy at this point was enough to split the water into hydrogen and oxygen. It is also evident from the results that (Figure 2(a)) in the case of bases, hydrogen yield was superior as compared to acid catalysts. In case of base catalysts; at a temperature of 310.3K the hydrogen yield was 0.38cc where as it was 0.13cc for acid catalysts. It envisaged that the molar absorptivity of green light in bases is greater than acids.Figure2 (b), (c) show the comparison of hydrogen yield with and without laser irradiations. Again it is evident from the results that base catalysts were more feasible during laser induced plasma electrolysis of water.

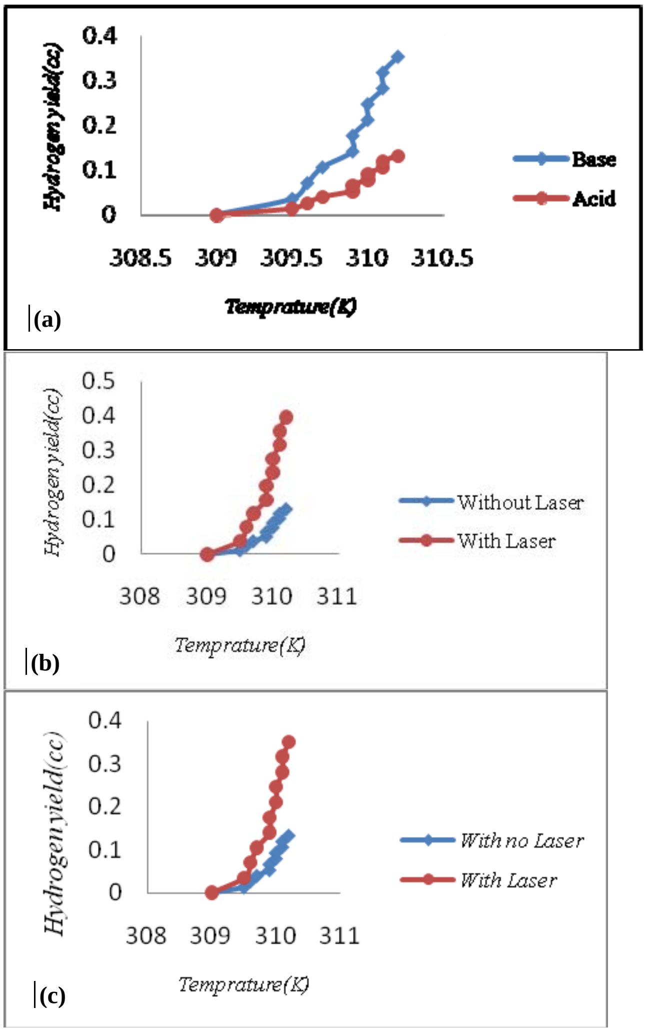

Fig. 2 A graph between temperature of the water versus hydrogen yield (a)Comparison of base and acid with laser (b)Base with and without laser irradiation(c) acid with and without laser irradiation.

3.2 Laser focusing effect

The laser focusing effect on the production of hydrogen is shown in Figure 3.The results blurt out that when the reactor was in the vicinity of the focus of the laser beam, the yield of hydrogen was large. As the distance from the focus increased the production found to be less. It was due to the fact that when reactor was near the focus the intensity of beam was large, so at that point powers per unit area became outsized, so large amount of laser energy enough to split the water. Similarly when the distance form the focus increased power per unit area also decreased, so hydrogen yield observed to be less. The non linear behavior of the curve in the figure 5 shows the moment of the focus point due to stirring of the water. Maximum hydrogen yield was at 15cm both in the case of base and acids catalysts, after that yield decreased and minimum yield was found at a distance of 60cm from the laser focus.

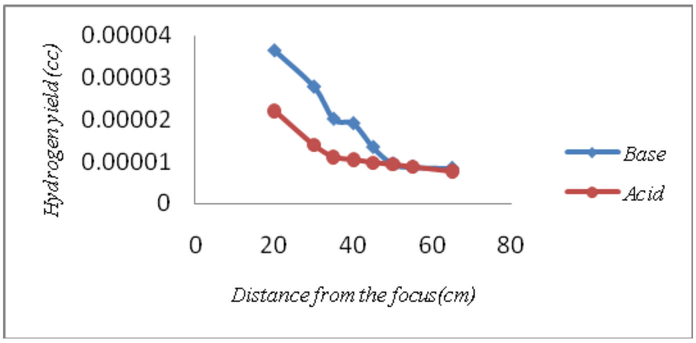

Fig. 3. A graph of Hydrogen yield versus distance from the laser focus.

3.3 Effect of Laser power

The other important factor which affected the product yields was laser power. It has been detected that hydrogen yield increased linearly with increase in laser input power. In case of base catalyst, yield was better as compared to acid catalyst.

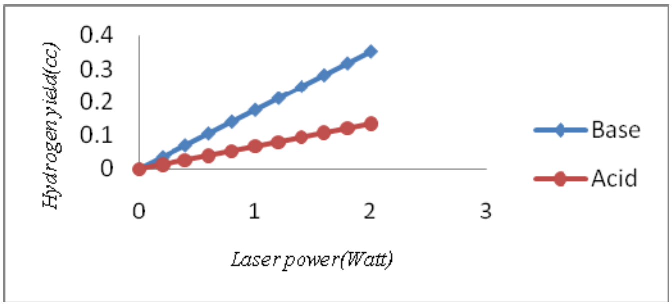

Fig. 4. A graph of Hydrogen yield versus laser power.

4. Conclusions

Our experimental results revealed that, the diode pumped solid state laser with second harmonics having a green light of wave length 532nm was highly efficient in photo splitting of water into hydrogen and oxygen during plasma electrolysis of drinking water. The laser focusing effect and laser power have ability to enhance the hydrogen production. The relevant data and results exhibited that the production of hydrogen can be enhanced by the use of electrolyte as photo catalysts. The base catalysts had a grater tendency to green light laser than acids. The laser focusing effect on the geometry of the reactor and the surface corrosion of electrodes were also important .These effects is our next goal in the future.

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