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Hydrogen production via water electrolysis process using (ZnO, Al_2O_3 and MnO_2) assisted with solar energy

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Abstract

Hydrogen production by water electrolysis using renewable energies with the addition of some metal oxides as photocatalyst are an alternative solution to problems related to the use of fossil fuels.

In this paper, an experimental study was conducted to test the effect of some factors influencing hydrogen production rates and water electrolysis performance, namely. Nature and concentration of metal oxides, when we use three metal oxides (ZnO, Al_2O_3 and MnO_2) as photocatalyst materials in water electrolysis process assisted with solar energy, was carried out at Ouargla University (Algeria).

The results showed that 10g/l of MnO_2 with a concentration of 30g/l KOH as an electrolyte, increases hydrogen generation by 30% compared with the yields of conventionel electrolyser. These results are encouraging to develop research and contribute to future challenges in this field, especially on practical operation.

Keywords: Water electrolysis, Hydrogen production, solar energy, Metal oxides, Photocatalyst materials.

1. Introduction

The problems of climate change, air pollution, and energy insecurity are due primarily to the combustion of fossil fuels mainly coal, oil, and natural gas [1]. In order to avoid serious environmental and economic damages from energy use, humans must stop using fossil fuels altogether, as soon as possible [2].

Hydrogen is the ideal fuel for the future because it is clean, energy-efficient, and abundant in nature [3-4]. While various technologies can be used to generate hydrogen, only some of them can be considered environmentally friendly [5].

Recently, hydrogen generated via water electrolysis using metal oxides as photocatalyst assisted by solar energy has attracted tremendous attention and has been extensively studied because of its great potential for low-cost and clean hydrogen production [6-7].

Many factors affect the water electrolysis process in presence of some metal oxides namely: temperature [8], electrolyte concentration [9], metal oxides concentration, and their nature [10].

In this research, an experimental study on hydrogen production from water electrolysis assisted by solar energy, using a ZnO, Al_2O_3, and MnO_2 as photocatalyst.

The study consists of seeing the influence of various parameters and conditions affecting production efficiency during the water electrolysis process.

2. Experimental procedure

The experimental set up consists of four electrolyzers connected in parallel (E_1), (E_2), (E_3) and (E_4), an electric current source, a voltmeter (V), DC generator, four Amperemeters (A_1), (A_2), (A_3) and (A_4) and a stopwatch, see **Fig. 1**. The four electrolyzers have the same characterization; their electrodes are connected directly to the DC power supply array.

The generated gases (hydrogen and oxygen) are recovered separately in glass cruets. they operate under the same thermodynamics conditions (ambient temperature and atmospheric pressure). All runs started at 8.00 am and terminated at 5.00 pm local time.

During experiences, the measurements of solar irradiance, ambient temperature were made regularly. Electrolyte temperature, the volume of generated hydrogen were also monitored.

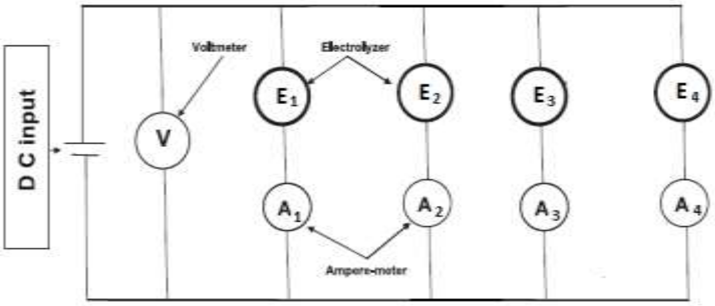

Fig. 1. Cross section of schematic sketch.

2. Results and Discussion

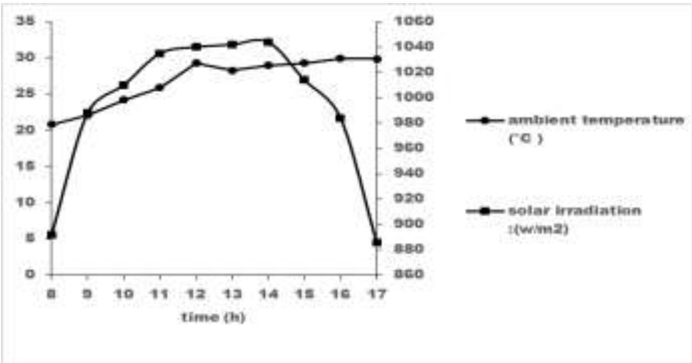

Fig. 2. Typical measured of ambient temperature and solar irradiance curves versus time.

Fig. 2 displays. Ambient temperature change and solar radiation. I increased in the first half of the day to the maximum values at around 13.00 hours; before, they started dropping again in the afternoon.

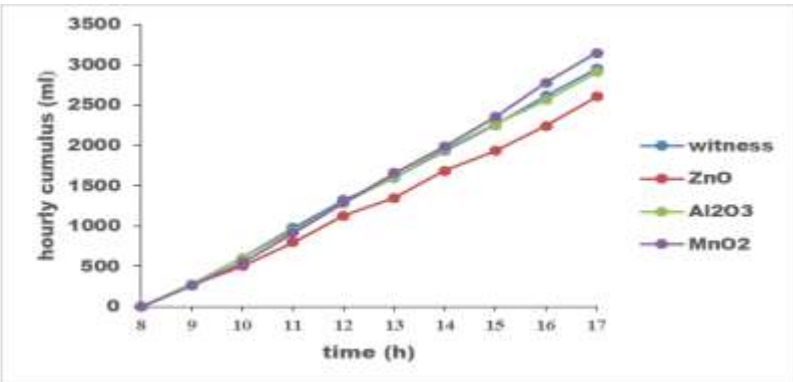

Fig. 3. Hourly production of hydrogen volume versus time.

Fig.3 displays. The hourly cumulus of hydrogen production has changed over time with the presence of photocatalysts, where we note that the best amount of production is due to the presence of MnO_2, while the amount of production is less with the presence of both Al_2O_3 and ZnO compared to conventional electrolysis.

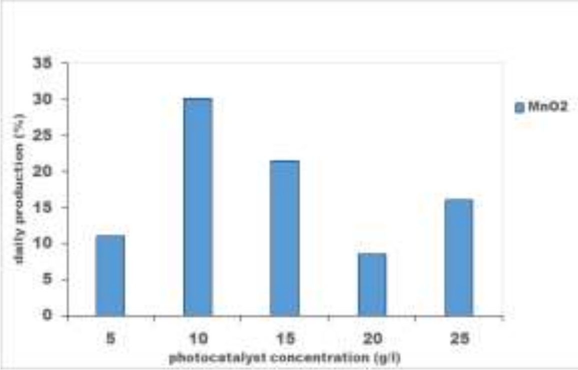

Fig.4. Daily of hydrogen production vs concentration of the best photocatalyst

Fig.4. The daily yield of hydrogen production has changed with the increase in the concentration of photocatalysts, where we note that the highest production amount for the best photocatalyst returns to the concentration of 10 g / l, while the amount of production is fluctuating with the increase of the photocatalyst concentration.

4. Conclusion

This paper present an experimental study on hydrogen production from water electrolysis assisted by solar energy, using three metal oxides (ZnO, Al_2O_3 and MnO_2).

The aim of this work to observing the influence of various parameters and conditions affecting hydrogen production during the water electrolysis process.The results showed that 10g/l of MnO_2 increases hydrogen generation by 30% and generally, These results are encouraging to develop research and contribute to future challenges in this field, especially on practical operation.

References

1. Abada, Z., & Bouharkat, M. (2018). Study of management strategy of energy resources in Algeria. *Energy Reports*, *4*, 1-7.

2. Nacer, T., Hamidat, A., & Nadjemi, O. (2016). A comprehensive method to assess the feasibility of renewable energy on Algerian dairy farms. *Journal of Cleaner Production*, *112*, 3631-3642.

3. Sharma, S., & Ghoshal, S. K. (2015). Hydrogen the future transportation fuel: From production to applications. *Renewable and sustainable energy reviews*, *43*, 1151-1158.

4. Sellami, M. H., & Loudiyi, K. (2017). Electrolytes behavior during hydrogen production by solar energy. *Renewable and Sustainable Energy Reviews*, *70*, 1331-1335.

5. Holladay, J. D., Hu, J., King, D. L., & Wang, Y. (2009). An overview of hydrogen production technologies. *Catalysis today*, *139*(4), 244-260.

6 . Boudjemaa, A., Rebahi, A., Terfassa, B., Chebout, R., Mokrani, T., Bachari, K., & Coville, N. J. (2015). Fe2O3/carbon spheres for efficient photo-catalytic hydrogen production from water and under visible light irradiation. *Solar Energy Materials and Solar Cells*, *140*, 405-411.

7. Chi, J., & Yu, H. (2018). Water electrolysis based on renewable energy for hydrogen production. *Chinese Journal of Catalysis*, *39*(3), 390-394.

8. Ahmad, H., Kamarudin, S. K., Minggu, L. J., & Kassim, M. (2015). Hydrogen from photo-catalytic water splitting process: A review. *Renewable and Sustainable Energy Reviews*, *43*, 599-610.

9. Tayyebi, A., Soltani, T., & Lee, B. K. (2019). Effect of pH on photocatalytic and photoelectrochemical (PEC) properties of monoclinic bismuth vanadate. *Journal of colloid and interface science*, *534*, 37-46.

10. Baniasadi, E., Dincer, I., & Naterer, G. F. (2013). Measured effects of light intensity and catalyst concentration on photocatalytic hydrogen and oxygen production with zinc sulfide suspensions. *International journal of hydrogen energy*, *38*(22), 9158-9168.