



Hydrogen Production during Glucose Fermentation Process

Mehrdad Najafi^{1*}, Mohammad Ghanbari²

1- Department of Chemical Engineering, Sharif University of Technology, Azadi Ave, Tehran, Iran

2- Department of Energy Engineering, Sharif University of Technology, Azadi Ave, Tehran, Iran

*najafi.mehrdad@che.sharif.edu

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Abstract

According to the environmental impacts and fossil fuel resources being depleted in the future, the tendency to use of renewable energy sources has increased. This kind of energy is collected from various resources such as wind, sunlight, rain, waves, and geothermal heat. Among different renewable energies, hydrogen is one of the best fossil fuel alternatives. Hydrogen is produced using several sources such as fossil fuels and biomass. Biological hydrogen production (BHP) is a good process compared to others. These processes are at an early stage of research, but in the long term have the potential for sustainable, low-carbon hydrogen production. It should be noted, that these technologies have disadvantages such as low efficiency and hydrogen production rate. In this paper, hydrogen production from glucose fermentation is investigated. The simulation results show that separation of produced hydrogen provides a significant energy source for mentioned biological pathway.

Keywords: Hydrogen production, Glucose Fermentation, Bioethanol.

1- Introduction

The main part of energy demand in the world is provided by fossil fuels. As we know, fossil fuels including natural gas, coal, and oil have limited reservoirs. Furthermore, these energy sources have serious and devastating environmental impacts [1, 2]. Hydrogen as a green energy with high efficiency is one of the best alternatives for fossil fuels [3]. Hydrogen is a carbon free fuel with higher energy content than hydrocarbons which is extensively used in fuel cells [4]. The main advantage of hydrogen is its flexibility for using in automotive engines and power plants [5]. Hydrogen can be produced from non-renewable sources including fossil resources, such as natural gas and coal, and as well as renewable resources such as water and biomass. Several processes are proposed for hydrogen production including chemical, biological, electrolytic, photolytic and

thermo-chemical reactions. Each technology is in a different stage of development, and each offers unique opportunities, benefits and challenges [6].

One these technologies is biological hydrogen production processes which can be divided into two basic concepts: photo fermentation and dark fermentation [7-9]. This process depends on different factors including substrate, microorganism specifications and operating conditions such as temperature, pH and residence time in reactor [10]. The main purpose of this paper is to investigate the feasibility of hydrogen production from glucose fermentation process.

2- Literature Review

The global hydrogen production mainly relies on processes that extract hydrogen from fossil fuel feedstock as shown in Fig. 1. As concern increases about possible climate change and reductions in greenhouse gas emissions in response to the Kyoto protocol, ways of producing hydrogen without emitting CO_2 will be needed.

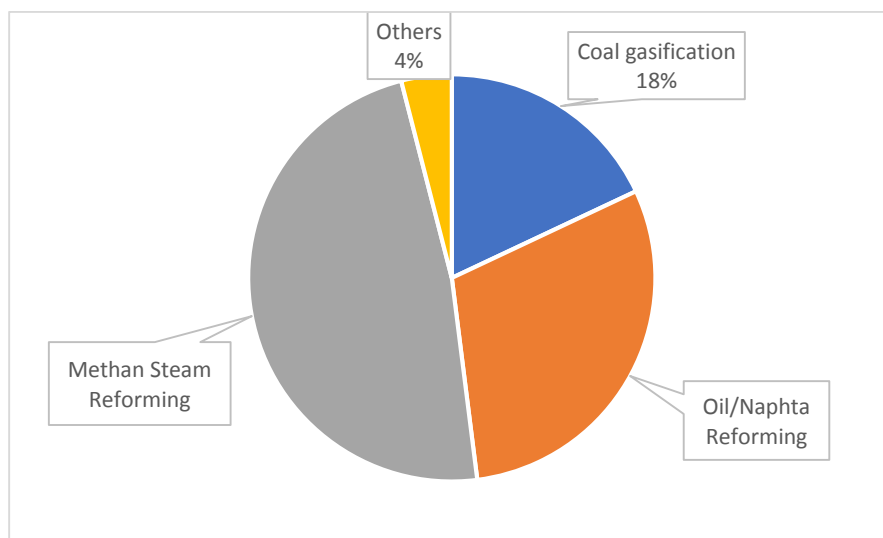


Fig 1-Primary energy distribution through the sources for the production of hydrogen [20]

Most of the hydrogen is produced by steam reforming of Natural gas (which is mainly methane) and other fossil fuels as following:



This process happened in high thermal efficiency (>80%) and higher relative amount of H_2 relative to CO in the produced gas ($H_2/CO = 3$). The purity of produced H_2 is more than 99.95%. High energy consumption (endothermic reaction), CO_2 emissions (due to fuel combustion to heat the vapor), catalyst deactivation by coke deposition process and high operating costs are the weaknesses of this process, that required more efficiently and environmentally friendly process [21].

Currently, biological hydrogen production processes which can be divided into two basic concepts: photo fermentation and dark fermentation are focused as novel process for hydrogen production method [7-9]. Photo-fermentation is a fermentative conversion of organic substrates by a diverse group of photosynthetic bacteria that use sun light as energy to convert organic compounds into hydrogen and CO_2 . Dark fermentation is the fermentative conversion of organic substrate,

including organic waste, and biomass materials to produce biohydrogen which takes place in anaerobic conditions and without the presence of light [22-23].

Dark hydrogen fermentation has several Strengths compared with other biological methods of hydrogen production such as photosynthetic and photo fermentation because of its ability to produce hydrogen continuously without the presence of light, higher hydrogen production rate, process simplicity, lower net energy input and utilization of low-value waste as raw materials.

3-Process Description

Glucose has been the most prevalent carbon substrate in the biological production of hydrogen. At first, glucose is fed to a fermentation reactor. In this reactor, glucose to ethanol be accomplished during chemical reaction as following [11]:



The gaseous products are sent to the vessel in order to recovery of residual bioethanol as well as carbon dioxide captured in the absorption section. However, the crude bioethanol stream sent to the reformer to react with water as following [12,13]:



Undesirable ethanol steam reforming as following [12,13]:



Which is compensated in the water gas shift by the following [12]:



The amount of steam enters the process as stoichiometric [14,15]. Although the excess steam eliminates the carbon deposition, it is not desirable in terms of energy consumption, so the condensed water in the condenser is low [16-18]. the syngas enters to the CO-PROX reactor as following [19]:



Finally, top stream of mentioned reactor is sent to the carbon capture and storage (CCS) section for separation of carbon dioxide and hydrogen.

4. Results and Discussion

The simulation is performed by Aspen HYSYS V8.8. The NRTL equation of state is used for determination of thermodynamic properties of materials. A schematic of hydrogen production process is illustrated in Fig. 1. During the real process, small amounts of byproducts like methane, carbon monoxide, acetaldehyde, ethylene are produced. In this study, we assumed the side reactions are negligible. It is shown that Ni/La₂O₃-Al₂O₃ and Ni/CeO₂-Al₂O₃ catalyst the yield of hydrogen production be 2.6 and 2.1 mol of H₂ per mole of glucose, respectively. The optimal temperature with the high yield of hydrogen production that result maximum purity of produced hydrogen was reported 33°C, 130°C and 750 °C for fermentation reactor, CO-PROX and reformer, respectively.

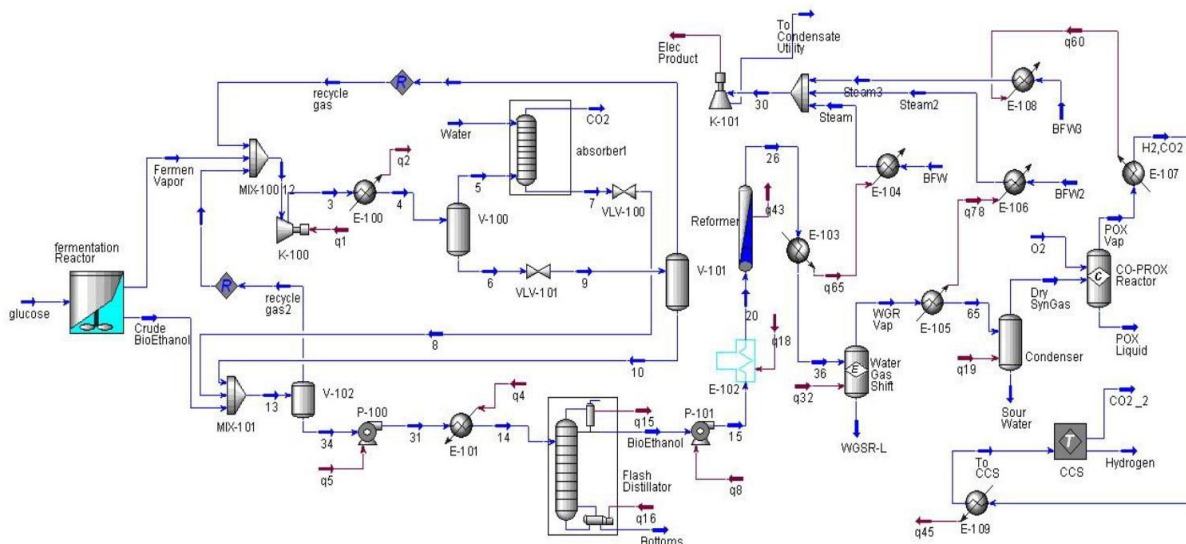


Fig 2- Schematic of hydrogen production process

5. Conclusions

In this work, the hydrogen production during glucose fermentation is investigated. It is shown that the hydrogen value is significant and produced with purity of 99.97%. In practice, the produced hydrogen after separation from carbon dioxide is sent to flare that emitted pollutant to the atmosphere. However, it is shown that it can be recovered and processed as a renewable and very clean energy.

6. References

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