ISSN 2250-3153

Continuous Hydrogen Production by Dark Fermentative Process in a Big Lab Scale

Hazbije Sahiti[*], Linda Grapci-Kotori[*], Kemajl Bislimi[*], Ramadan Sopa[**] Ferdije Zhushi-Etemi[*]

[*] Faculty of Mathematical and Natural Science, Department of Biology
[**] Faculty of Medicine, Department of Biology

Abstract- Noting that most of investigations about hydrogen production were done in a small bioreactor volume (from few milliliters – 5 liter) the aim of this investigation was to observe possibility of biological hydrogen production in a continuous culture in a big lab scale with volume of 25 liter. First task of investigation was to design and set up of bioreactor for continuous biological hydrogen production. The bacterial culture used was cultivated in a batch reactor from identified bacterial mixture taken from sludge of plant wastewater treatment. Cultivation was done under anaerobic condition. Synthetic minimal medium was used as a feeding, which contained 5 gram of glucose per liter. The current investigation demonstrates the possibility of hydrogen production by dark fermentative processes in a big lab scale.

Index Terms- hydrogen production, big lab scale, mixed bacterial culture, continuous culture, dark fermentative processes.

I. INTRODUCTION

Elemantary conditions for life in earth such as concentration of CO_2 and O_2 in atmosphere, thickness of ozone layer in stratosphere and climatic temperature results from ecosystem balance established from accumulation of life activity for many thousands and millions of years.

Burning of fossil fuels such as oil and coal results in increasing of CO_2 level in atmosphere. This atmospheric pollution is not only unhealthy but it might cause significant climate change globally. Concerns about global warming have increased interest in hydrogen as a fuel. Also during the energy crisis of the 1970s, hydrogen was touted as the ‘’fuel of the future’’. (Benemann, 1996).

Hydrogen is the most plentiful element in the universe, making up about three-quarters of all the matter. The atmosphere contains about 0.07% hydrogen, while the earth’s surface contains about 0,14% hydrogen. The main product of its combustion is water, thus hydrogen is regarded as a clean non-polluting fuel. As compared to other gaseous fuels, hydrogen is harmless to human and the environment (Das and Veziroglu, 2001).

One attractive way to produce hydrogen is biological production, and it can be done through either by dark fermentation of low cost substrate from waste or by photo processes through photolysis by splitting water. However, production of H_2 by dark fermentative processes is technically much simple than photo processes. The dark processes generate hydrogen from a large number of carbohydrates frequently obtained as refuse or waste products (Nandi and Sengupta, 1998).

Biological process for hydrogen production is very complex and the most important factors that influence process are: pH, temperature, type of substrate, bacterial culture and partial pressure of hydrogen.

As far as substrates are concerned, current hydrogen studies mainly focus on household solid waste or pure substrate, like glucose. One difficulty related to these waste types is that they contain ligninocellulosic material. Lignin is non-biodegradable and strongly hampers the utilization of cellulose and hemicelluloses under anaerobic conditions. Lignin is often inhibitory to microbial growth (Reith et al., 2003).

Conversion of waste to hydrogen has the environmental advantage because it contributes to decreasing of amount of waste. However, it is still too early to predict which of the many possibilities will be ultimately successful, or how they would appear in practice – as large-scale production process or roof-top conversion devices (Benemann, 2001).

II. MATERIALS AND METHODS

As bacterial culture was used sewage of sludge for methane fermentation taken from plant for waste water treatment. In Table 1 are given some physical-chemical parameters of sludge used for the current investigation.

Table 1: Physical-chemical parameters of sludge

Physical-chemical parameters	Values
pH	7.1
Sasia e ujit (%)	96.7
Sasia e substances se thatw (%)	3.5
Sasia e substancws sw avulluar (%)	55.3
Sasia e substancws sw mbetur (%)	44.7

Sewage sludge represents a naturally occurring mixed culture of microorganisms which are able to produce hydrogen by degradation of organic compounds (Mossophin, 2008).

In these mixed bacteria in adition to facultative anaerobic bacteria the strict anaerobic bacteria (methanogenic) were also present. These type of bacteria are very sensitive in presence of oxygen, therefore in order to avoid their growth, cultivation were done under forced aeration using an air pomp for few hours. For optimum growth of facultative anaerobic bacteria during cultivation, the pH was set to 7.

Minimal synthetic medium was used as substrate, which contained 5 gr/l of glucose, some mineral salts and trace

elements. To amortize pH shifts which can occur because of formation of organic acids during fermentation, in working medium were added also some buffer. Chemical composition of medium is given in table 2.

Table 2: Chemical composition of medium

Type of chemical substance	Amount (gr/l)
Glucose	5
K_2HPO_4	7
KH_2PO_4	5
NaCl	2.5
$MgSO_4 \times 7H_2O$	1
$FeSO_4$	0.0022
$CuSO_4$	0.00044
$MnSO_4$	0.0014

While cultivation of microorganisms was done at pH 7, process of hydrogen production was done at pH 6 in temperature of 45-50°C. In case of pH oscillations, NaOH 30 % solution or H2SO4 20% solution was used to maintained pH.

Reactor set up

First task of investigation was to design and set up a reactor for continuous culture (chemostat) with a volume of 25 liters. Reactor was made up of stainless still and wrapped with thermal insulation. Constant temperature as an important parameter was maintained by a electrical heater, which is installed into the reactor. The pH was measured by a pH electrode which is inserted in reactor. The fed flow from reservoir to reactor was provided by a peristaltic pomp, and the constant liquid level in reactor was maintained by overflow of the effluent through a port on the upper side of the reactor. The schematic description of reactor for continuous culture, type of chemostat is presented in fig. 1.

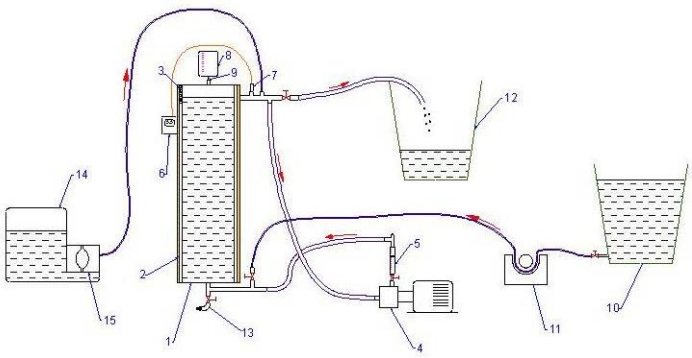

Fig. 1: Schematic view of the reactor for the continual production of hydrogen, 1-Bioreactor, 2-Thermal insulation, 3-Electrical heater, 4-Recirculation pump, 5-Liquid flow meter, 6-pH meter, 7-pH detection electrode, 8-Gas sumpling bag, 9-Reactor filling inlet, 10-Feeding reservoar, 11-Peristaltic pump, 12-Effluent collection reservuar, 13-Reactor descharch, NaOH container, 15-Dosier pH pump

Gas analysis

Produced gas was collected in plastic bag (PHYWE- Gotingen), its volume was 1.5 liter. Amount of hydrogen was measured by means of Drager sampling tubes.

III. RESULTS

Peristaltic pomp was switched after 24 hours means immediately after cultivation of microorganisms with dilution rate of 0.06 h^{-1}. In Fig. 2 it is shown that production of gas stared after 24 hour and it is stopped after 120 hours. At the same period of time, hydrogen is produced but its amount is small compared to the amount of gas (Fig. 3).

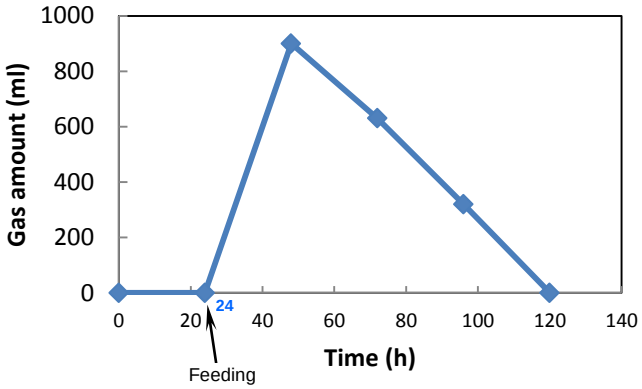

Fig. 2: Gas productin in function of experiment duration time

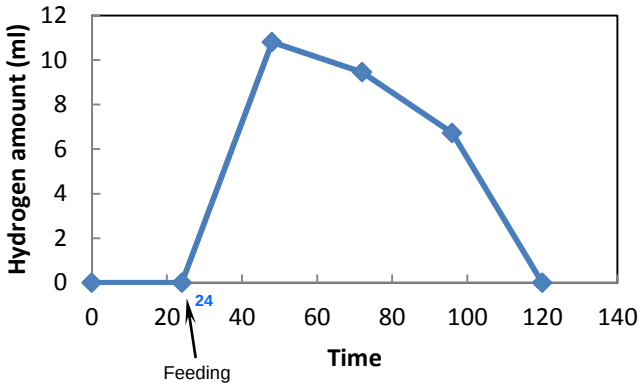

Fig. 3: Hydrogen productin in function of experiment duration time

The correlation between pH and hydrogen production as an important parameter influencing hydrogen production is presented in Fig. 4.

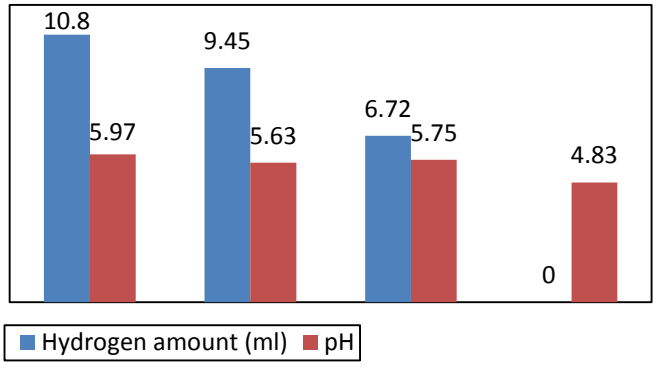

Fig. 4: Correlation between hydrogen and pH value

IV. DISCUSION

The aim of the present work was hydrogen production by dark fermentation process in continuous culture type of chemostat in a big lab scale in order to provide data for industrial hydrogen production plants.

Hydrogen production was investigated from many authors in batch or continuous culture. However in the current work as continual culture was used chemostat which may offer a significant increase in productivity over batch or fed-batch operation. Increased productivity is the result of reduced fermentor down time per unit of product manufactured (Herbert, Elsworth and Teilling, 1956)

One of the most important aspects of industrial microbiology and biotechnology is transfer of process from laboratory plants to industrial plants. This procedure goes to several steps, beginning from small laboratory vessel (few milliliters) till commercial reactor with volume of 10 000 – 50 000 liters. Understanding of difficulties of up-scaling process is especially important because microbial process do not develop equally in big reactor and small lab vessel.

Seeing from this aspect, current investigation is an attempt toward process commercialization.

The results of current work indicates that hydrogen can be produced in a big lab scale through dark fermentative process with mixed culture of microorganisms using glucose (5gr/l) as a substrate.

Biological hydrogen production is very complex and is influenced from many parameters one of the most studied parameter is pH. Results of many authors showed that maximal hydrogen production is achieved in pH 4-7 (Kumar and Dass, 1999; Tanisho, Suziki and Wakao, 1987)

Related to this in the present work, maximal hydrogen production is achieved in pH 5.97.

In the future focus should be on optimization of working parameters on order to achieve increased hydrogen production.

REFERENCES

[1] J. Beneman, "Hydrogen biotechnology", Progres and prospects. Nature biotechnology, volume 14, september 1996

[2] D. Das, N. Vezieoglu, Hydrogen production by a biological precess: a survey of literature. International journal of hydrogen production of energy. Voume 26, 2001, pp 13-28

[3] R. Nandi, S. Sengupta, Microbial production of hydrogen an overview. Critical reviews in microbiology. Vol.

[4] J. Reith, R. Wijffels, H. Bartebs, Bio-methan and Bio-hydrogen: Status and prespectives of biological methane and hydrogen production. 2003

[5] K. Moosophin, Investigations of a biological hydrogen production process. Der Technischen Fakultat der Universitat Erlangen- Nurnberg, 2008

[6] D.Herbert, R. Elsworth and R. C. Telling, the continuous culture of bacteria; a theoritical and experimental study. J. Gen. Microbial. 1956, pp 601

[7] N. Kumar, D. Dass, Enhancment of hydrogen production by Enterobacter cloacae. Process biochemstry, 1999, Vol. 35, pp. 589-593

[8] S. Tanisho, Y. Suzuki, N. Wakao, Fermemtative hydrogen evolution by Entrobacter aerogens strain E. 82005. Hydrogen energy. Vol. 12, No 9, 1987, pp. 623-627

AUTHORS

Hazbije Sahiti – Assistant Professor, Faculty of Mathematical and Natural Science-Department of Biology, hsahiti@yahoo.com.

Linda Grapci-Kotorri– Associated Professor, of Mathematical and Natural Science-Department of Biology, linda.grapci@uni-pr.edu

Kemajl Bislimi–Associated Professor, of Mathematical and Natural Science-Department of Biology, kemajlbislimi@yahoo.com

Ramadan Sopi – Assitent o f Faculty of Medicine- Department of Biology, ramadan.sopi@uni-pr.edu

Ferdije Zhushi-Etemi–Associated Professor, of Mathematical and Natural Science-Department of Biology, ferdijezhushi2010@gmail.com

Correspondence Author – Hazbije Sahiti, hsahiti@yahoo.com, 00377-44 413311.