Development of Conversion Technology of Biomass Into Bioenergy: Studies on Biohydrogen Production in Anaerobic Fermentation Process

Morimoto, M.[1], Atif, A. A. Y.[2], Tanisho, S.[3], Ngan, M. A.[1], Fakhru'l-Razi, A.[2] Iyuke, S. E.[2], and Atsuko, M.[1]

[1] Malaysian Palm Oil Board (MPOB), No. 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia

[2] Department Of Chemical and Environmental Engineering, Faculty of Engineering, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia

[3]Department of Environmental Sciences Yokohama National University Hodogaya-ku, Yokohama 240-8501, Japan

Abstract

Natural anaerobic microflora in compost was examined to produce hydrogen from palm oil mill effluent (POME) without addition of any other nutrients. Syringe method was used for the fermentation experiment. It was observed that the dilution effect on the production of biogas rates was considerably large in relative to the effect of microflora concentration. The maximum dilution effect on the rate was observed at 20% of POME with microflora concentration over 5% (w/v)

Key Words: biohydrogen Production, anaerobic microflora, compost, POME

Introduction

The interest in production of hydrogen from biomass has been vitalized, particularly in Japan, Germany and to some extent in the United States (1). Hydrogen is reviewed as a clean and renewable energy source. Microbial production of hydrogen using wastewater and biomass as inputs has gained much attention. The environmental friendliness of the process derived from its cleanness has been a major source for the escalating recognition for biomass-based production of hydrogen. On the other hand, its independence of fossil fuels has given a clear advantage both on cost effectiveness and environmental quality promotion grounds. POME's nutrient content, which is low for aerobic treatment process is sufficient for anaerobic treatment processes (2). The concept of effluent treatment has continuously been changing from that of (?) treatment and disposal to initiation and fostering of beneficial utilization (3). This study aims to develop not only the technology of the production of hydrogen from biomass (contained in POME) by anaerobic microflora but also the wastewater treatment technology.

Material and Methods

POME was obtained from a palm Oil Mill. Compost was collected from CREST manufacturing centers in Manila (Philippines) it is a municipal solid waste consisting of mostly kitchen wastes and urban wastes mixed with cow manure. 50 ml syringe with silicon tube (7 mm diameter and 20 cm long) to the syringe nozzle was used to cultivate POME with microflora and collect biogas from it. Reaction media was pushed up to the end of the attached tube. Syringe was kept

downward but the tube upward by fixing it to the syringe by a rubber band. Prepared syringes were kept in the plastic container at 60 °C. Evolved gas was collected in the syringe and pushed out equal volume of the reaction media from the syringe through the silicone tube.

Results and Discussion

The biohydrogen production potential was determined by the capacity to displace the volume of the 30 ml medium in the 50 ml syringe as a result of gas evolution during incubation at 60 °C for a period of 120 hours. Figure 1 show the time course of fermentation pattern from POME with microflora in compost at 60 °C. The results shown in Table 1 show the evolved gas from POME with microflora in compost. The evolved gas contained 68% of hydrogen (5,6). No methane gas was detected. This might be due to deactivation of methanogens caused by low pH. The pH was not controlled in these batch cultures. Consequently, the pH decreased during the fermentation due to formation of acids caused by the proliferation of hydrogen producing. Product formation depended on the microorganism that is dominant in the microflora.

At low concentration of microflora 1% and 2.5%, low amount of biogas was obtained from 100% POME, while the amount of biogas increased with increase in the level of microflora. At 12.5% microflora no measured of biogas after 48 hr, gas overflow due to shock loading. 20% of POME was taken to study the dilution effect on the production of biogas. At 1% and 2.5% microflora the biogas started

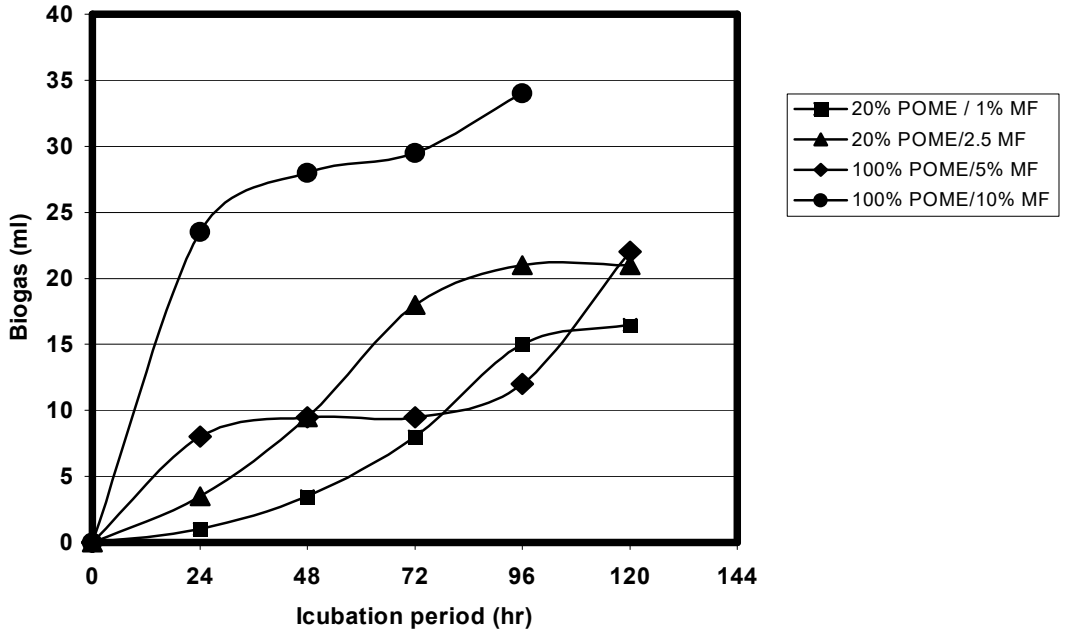

Figure 1: Time Course of POME Fermentation Pattern during Cultivation of Anaerobic Microflora in Compost at 60 ^{O}C Using Syringe Method.

Table 1: Gas Evolved from POME by Anaerobic Microflora in Compost Using Syringe Method

Inoculum	Feed	Gas Evolved				
		24 hr	48 hr	72 hr	96hr	120 hr
1%	100% POME	0	0.5	2	2	2
	20% POME	1	3.5	8	15	16.5
2.5%	100% POME	2	2	2	2	3.5
	20% POME	3.5	9.5	18	21	21
5%	100% POME	8	9.5	9.5	12	22
	20% POME	9.5	OF	OF	OF	OF
7.5%	100% POME	11.5	13	OF	OF	OF
	20% POME	19	OF	OF	OF	OF
10%	100% POME	23.5	28	29.5	34	OF
	20% POME	14	OF	OF	OF	OF
12.5%	100% POME	27	28	29.5	34	OF
	20% POME	12	OF	OF	OF	OF

OF = Overflow

production from 20% POME after 24 hr, the amount of biogas increased gradually with the time, the production of biogas almost stop after 96 hr. At 5%,

7.5%, 10% and 12.5% microflora the high production of biogas from 20% POME was obtained, and the biogas overflow after 24 hr. In the kinetic equation:

[Rate] = k_{app} [Microflora] [POME]

The following apparent rate constant value of k_{app} was obtained, extremely large, 86.5 (20 % dilution of POME / 1% microflora), 38.8 (20 % dilution of POME / 2.5% microflora), 2.54 (100 % POME / 5% microflora), 1.38 (100% POME / 10% microflora) and nearly zero (100% POME / 2.5% &1.0% microflora). No measurement of biogas evolved (20 % dilution of POME / > 5% microflora). It must be noted that the maximum dilution effect on the rate is observed at 20% of raw POME with microflora concentration over 5%. In the previous works, we also observed the same result using raw POME and pure strain of 7P001 (4) and using microflora containing in palm oil mill sludge or compost produced total1522 ml/L-med of hydrogen collected after 80 hours from artificial wastewater containing 1% glucose and nutrients (5,6). It was observed that the dilution effect of POME on the rate was considerably large in relative to the effect of microflora concentration using compost under no mechanical stirring. These results yield valuable engineering data to design the most economical process on dilution effect vs. fermenter capacity and the mechanical stirring vs. bubbling effect of biogas.

It is necessary to work on large-scale fermentation under mechanical stirring or no stirring to elucidate the relation of this function.

Conclusion

The anaerobic microflora in the compost was found to produce biogas (hydrogen) from POME without addition of any other nutrients by using syringe methods. The dilution effect of POME and the effect of microflora concentration on the production rate of biogas were studied.

Acknowledgement

This work was conducted with financial support from New Energy and Industrial Technology Development Organization (NEDO) of Japan. We also wish to gratefully acknowledge MPOB for their encouragement and permission to conduct research at MPOB facilities.

References

1- Lay, J. J. (2001) Biohydrogen generation by mesophilic anaerobic fermentation of microcrystalline cellulose. Biotechnol. And Bioeng, vol. 74, No. 4. pp280-287.

2- Chin, K. K., Lee, S. W. and Mohammad, H. H. (1996) A study of palm oil mill effluent treatment using a pond system. Wat. Sci. Tech. Vol 34. No. 11. pp 119-123.

3- Nagan, M. A., Tajima, Y., Asahi, M. and Hanif, J. (1996) PORIM Technology, Anovel treatment process for Palm Oil Mill Effluent. Palm oil research institute of Malaysia.

4- M Morimito, B A Mohammad, Atif A A Yassin and A N Ma (2002) 25th Malaysian Microbiology Society Symposium, Kota Bharu, 8-11 September 2002.

5- M. Morimoto, A. N. Ma and M. Ukita, HYPOTHESIS IV, Stralsund Germany, 9-14 September 2001

6- M. Morimoto, Atif A A Yassin and A N Ma (2002) National Seminar on Palm Oil Milling Refining Technology, Quality and Environment, Kota Kinabalu, Malaysia, 19-20 August 2002.