OPTIMIZING HYDROGEN PRODUCTION FROM ORGANIC WASTEWATER

Yogesh Sharma Baikun Li * (baikun@engr.uconn.edu)
Department of Civil and Environmental Engineering, University of Connecticut, Storrs, CT 06269

CONTEXT OF THE RESEARCH

Increased global demand for oil and national energy security are driving the search for alternative to fossil fuels. Different measures are being implemented to deal with the problem of global warming.

Hydrogen (H_2) is expected to be a substitute for fossil fuels as clean energy since it only generates water when burnt. Hydrogen can be produced by the process of anaerobic fermentation. The production of hydrogen coupled with utilization of waste materials containing high concentrations of organics such as wastewater and agricultural waste may provide economic and environmental benefits.

MAJOR QUESTIONS

The maximum reported hydrogen yield is about 50% of the total attainable yield. The yield should be increased to justify the feasibility of the process on large scale. The aim is to increase the yield by manipulating the following parameters.

- Reactor configuration
- Concentration of organics
- Temperature
- Acidity of the medium

APPROACH

- Glucose was used to simulate the highly concentrated organic wastewater
- Soil was collected from an organic farm, heat shocked and used as an inoculum for the fermentation process
- A continuous reactor of 2L Volume and batch reactors of 125 mL Volume were used in separate studies (Figure 1, Figure 2)

Sample	COD (mg/L)	pH	Temperature(^{0}C)
1(Baseline)	5000	5.5	37
2	5000	5.5	25
3	5000	4.5	37
4	5000	6.5	37
5	1000	5.5	37
6	10000	5.5	37

Table1. Parameters Used to test Hydrogen Production in Batch Reactors

- A matrix of parameters listed in Table 1 was analyzed to determine the optimal condition for hydrogen production
- Hydrogen content in biogas was measured with a Gas Chromatograph (GC) equipped with a packed column and thermal conductivity detector
- The liquid fermentation products were measured with a GC equipped with a capillary column and flame ionization detector

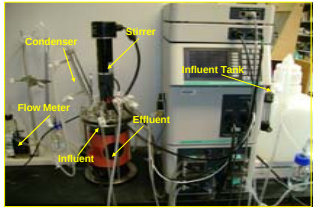

Figure1. H_2 Producing Continuous Flow System

Figure2. H_2 Producing Batch Reactor

- Biogas volume was measured using an electronic flow meter
- Glucose concentration was measured by spectrophotometer using phenol-sulfuric acid assay

RESULTS

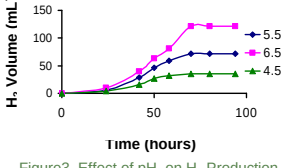

Figure3. Effect of pH on H_2 Production

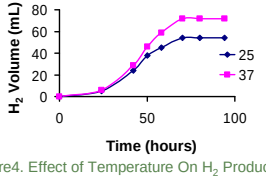

Figure4. Effect of Temperature On H_2 Production

- At a pH of 6.5, hydrogen generated was highest at 121 mL followed by 72 mL and 35 mL at pH of 5.5 and 4.5 respectively (Figure 3)
- At 37^0 C, volume of hydrogen generated was 33% higher than that at 25^0 C (Figure 4)

Sample (COD-pH-Temperature)	% Glucose Removed (After 72 hours)	Hydrogen Yield (mole Hydrogen/mole of Glucose)
5000-5.5-37	98	1.06
5000-5.5-25	93.8	0.83
5000-6.5-37	99	1.76
5000-4.5-37	62	0.81
10000-5.5-37	89	1.01
1000-5.5-37	99.3	0.74

Table2. Glucose Removal and Hydrogen Yield at different conditions in a Batch Reactor

- Almost all the glucose was consumed in all the reactors, except when the reactor was operated at a pH of 4.5 (Table 2)
- The highest yield of 1.76 mole H_2/mole of glucose was obtained in batch reactors (Table2)
- Hydrogen content of the biogas in all the batch reactors was 58%-60%.

HRT (Hours)	COD (mg/L)	%Glucose Removed	H_2 Yield (mole H_2/mole glucose)	% H_2
24	10	98	2.4	63
24	5	99	2.6	67

Table3. Performance of Continuous Flow System at Different Organic Loading Rates

- Biogas was composed of hydrogen and carbon dioxide
- In continuous flow systems, at lower COD of 5 g/L, the hydrogen yields and hydrogen content of biogas were higher at 2.6 mole H_2/mole of glucose and 67% respectively (Table 3)

CONCLUSION

- Organic matter in the water can be efficiently removed by the process of anaerobic fermentation. This can help to mitigate the wastewater treatment costs while providing hydrogen as a valuable energy resource
- Continuous reactors produce higher yields of hydrogen than batch reactors
- Heat shocking proved to be efficient in removing, methane producing bacteria as evident from the absence of methane in the biogas