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EFFECT OF DIETHANOLAMINE CONCENTRATION ON PURIFICATION OF BIOGAS PRODUCED FROM COW DUNG FOR DOMESTIC USE

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ABSTRACT

This paper was aimed at investigating the effect of diethanolamine (absorbent) concentration on the purification of biogas and the primary objective was to remove carbon dioxide and hydrogen sulphide from the biogas and specifically to improve the combustion characteristics of the biogas produced to serve as an alternative to petroleum based products in used. The sample of gas produced was passed through a gas chromatography column to determine the percentage composition (Mol % dry basis) of the biogas contents. The results obtained showed that the biogas sample before purification contained 52.50 mol % dry methane , 42.00 mol % dry carbon dioxide, and 1.00 mol% dry hydrogen sulphide. After purification, the composition of the biogas showed that at 10%, 20%, 30% and 40% concentration of diethanolamine solution; 64.28%, 97.62%, 91.66% and 75% of CO_2, and 60%, 99%, 92% and 70% of H_2S were removed from the biogas respectively. The highest removal for both CO_2 and H_2S was 97.62% and 99.00% respectively, and this was recorded at 20% concentration of diethanolamine solution. Therefore, this results show that the best concentration for the purification is 20% concentration.

Keywords: Biogas, Cow Dung, Diethanolamine, Purification

INTRODUCTION

Since ancient times, biogas is produced by the decay of vegetable and animal and was earlier identified as combustible swamp gas (Ronald *et al.*, 1982).This highly desirable fuel was obtained by fermentation of sewages as early as in 1934 and was used for heating an internal combustion engine for pumping (White and Plaskette, 1981). Biogas otherwise referred to as "Bio fuels", is an alternative source of renewable energy. Biodiesel is also a biodegradable and renewable source of energy (Ma and Hanna, 1999). It has a lower environmental impact (Zhang *et al.*, 1996). However petroleum is non-renewable; and it has been confirmed that non-renewable sources of energy could only last for about another 25 years or more (John and Twidell, 1981). This uncertainty has created a lot of anxiety for industrialized and developing nations like Nigeria. Though the total amount produced may be small but of great significance locally in Nigeria and other parts of the world. Stakeholders are now looking back to the past and alternative methods of using biomass as one of the most viable solutions in the energy sector to avoid a complete breakdown should the fossil fuels be depleted suddenly. It is on record that several large demonstration plants are already in operation and many other smaller units are installed daily (Malcom and Chris, 1979). But currently the world attention is focused on biogas generation from abundant biomass materials because of their numerous potentials. Presently, countries like Brazil, India, United States, Pakistan and China have actualized this idea and are still thriving well (Minami *et al.*, 2001).

The production of biogas from biomass, produced a gaseous product which on analysis contained methane, carbon dioxide and hydrogen sulphide in adequate proportions (Austin, 1984).These hydrogen sulphide and carbon dioxide present in the biogas are called acid gases because they form acidic solutions in the presence of water vapour .They have no heating value but cause problems to systems and the environment. Hydrogen sulphide is a toxic, poisonous gas and cannot be tolerated in gases that may be used for domestic fuels. Carbon dioxide is also corrosive and does not support combustion, and can cause carbon dioxide solidification in cryogenic plants (Boyun and Ghalambor, 2005). Therefore, this makes the removal of these two biogas components necessary and imperative. Thus, this brings us to the objective of this work which is to produce and purify biogas from cow dung for domestic purpose using diethanolamine. In Nigeria biogas can be produced from animal and human excreta, crop residue, poultry droppings, cow dung, pig dung, but in this work cow dung was used because is available in Nigeria.

MATERIALS AND METHODS

Preparation of Sample

A total solid concentration of one thousand grams in four litre solution was prepared using the sieved cow dung. The slurry was warmed using steam bath with constant stirring to remove air bubbles. The pH was measured and adjusted to 7.5. The remaining air bubbles were removed by aspiration and subsequently by application of pressure to compress the plastic digester (Dim, 2002). The outlet was immediately closed tightly to prevent the entrance of air into the digester.

Delivery tubes were connected from digester to the two 1000 cm^3 conical flask containing 500 cm^3 of diethanolamine solution for absorbing hydrogen sulphide and carbon dioxide respectively. The gas collection bag was connected to the flask containing water for gas collection over water. The collection was done at four different absorbent concentrations of 10%, 20%, 30% and 40% respectively (Dim, 2002), after which four samples of 1000 cm^3 of biogas were collected in the collection bag. The digester was maintained at room temperature and the content was shaken daily. and pH was monitored through a pH meter connected to a sampling point.

Analysis of Biogas

Each of the four samples of 1000cm^3 of biogas collected was passed through a gas analyzer of model P7450 to determine the percentage composition of the biogas.

Total Solid Analysis of Sample

The evaporating dish was washed clean with detergent solution and rinsed with distilled water. It was ignited for two minutes in the oven at 100 ^0C. The content was allowed to cool at room temperature and the weight taken again using an electronic weighing balance. This was kept until ready for use. Some quantity (25g) of the sieved cow dung was transferred to the pre-weighed evaporating dish, and weighed together and recorded. It was then dried at 105 ^0C in the oven for two hours. The dish and its contents were then cooled at room temperature and weighed again using the same electronic weighing balance.

Volatile Solid Analysis of Sample

The dried sample was put in a petri dish and was transferred to muffle furnace and heated at 500 ^0C for two hours. The loss in weight of sample represents the volatile solids.

Moisture Content Analysis of Sample

The test sample was weighed and dried in an oven at 100 ± 20 ^0C until approximately constant mass was attained. After drying, the sample was reweighed immediately, recorded and the moisture content of the sample was calculated.

RESULTS

The results of total solid, volatile solid and moisture contents are presented in Table 1.0. respectively. Table 2.0 shows the result of biogas analysis before and after purification at different diethanolamine concentrations. And Table 3.0 showed the result of the percentage removal of CO_2 and H_2S at different diethanolamine concentration.

Table 1.0 Results of Sample Analysis

Cow dung	Weight (g)	(%)
Moisture Content	19.80	79.25
Total Solid Content	5.17	88.20
Volatile Solid	4.55	75.20

Table 2.0 Result of Biogas Analysis after Purification at Different Absorbent Concentration

Biogas	Before Purification	After Purification			
		10%	20%	30%	40%
CH_4	52.50	52.50	52.50	52.50	52.50
CO_2	42.0	15.00	1.00	3.50	10.50
H_2S	1.00	0.40	0.01	0.08	0.30
O_2	0.05	0.02	0.03	0.02	0.03
NH_3	0.97	0.05	0.04	0.05	0.06
H_2	0.50	0.50	0.40	0.50	0.45
N_2	2.80	2.68	2.50	2.54	2.67
Others	0.18	28.85	43.52	40.81	33.49

Table 3.0 Percentage Removal of CO_2 and H_2S at Different Diethanolamine Concentration

Diethanolamine concentrations	Gas Content	Before	After	Percentage Removal (%)
10%	CO_2	42.00	15.00	64.28
	H_2S	1.00	0.4	60.00
20%	CO_2	42.00	1.00	97.62
	H_2S	1.00	0.01	99.00
30%	CO_2	42.00	3.50	91.66
	H_2S	1.00	0.08	92.00
40%	CO_2	42.00	10.50	75.00
	H_2S	1.00	0.30	70.00

DISCUSSION

From Table 1 it can be seen that the cow dung sample gave a high total and volatile solid content with 88.20% and 75.20% respectively. This is very adequate for biogas production (Uzodinma *et al.*, 2007).This implies that the cow dung will produce more biogas at the normal operational conditions of temperature and pressure (Eze *et al.*, 2007).

It can be observed from the results that the percentage composition of methane, carbon dioxide and hydrogen sulphide before purification were 52.50%, 42.00% and 1.00% as against the literature values of 50-60%, 30-50% and 0.1-1.0% (Odunaiyi, 2000). While the composition of the gases after purification at different diethanolamine (absorbent) concentration were, 52.50, 52.50, 52.50, and 52.50 mol % dry CH_4,15.00, 1.00, 3.50, and 10.50 mol % dry CO_2, 0.40, 0.01, 0.08, and 0.30 mol % dry H_2S respectively. Table 3.0 shows the percentage removal of CO_2 and H_2S at different concentration of diethanolamine solution. From the Table it can be observed that, the composition of the gas after purification at different diethanolamine concentration of 10%, 20%, 30% and 40%, showed that, 64.28%, 97.62%, 91.66% and 75% of CO_2, and 60%, 99%, 92% and 70% of H_2S were removed from the biogas respectively. However, the utilization of cow dung and purification of biogas is important not only for energy and material recycling but also for preventing environmental pollution (Akinbami *et al.*, 2001). The result of biogas analysis after purification shows a great reduction in carbon dioxide and hydrogen sulphide content present in the gas sample. However the highest removal of 97.62% and 99% was recorded at 20% concentration of diethanolamine solution. Basically biogas purification is all about the removal of CO_2 and H_2S present in the gas sample by using aqueous solution of diethanolamine (Dim, 2002).This removal of CO_2 and H_2S, from the produced biogas has an additional effect of reducing other green house gas (CH_4 & N_2O) emission from conventional treatment of livestock residue (Akinbami *et al.*, 2001). It is usually desirable to remove both gases to prevent corrosion problems and to increase heating value of the gas (Abdel-Aal *et al.*, 2003). The basic reactions for the absorption of CO_2 and H_2S by diethanolamine are given below as equations 1, 2 and 3.

$$2R_2NH + H_2S \leftrightarrow (R_2NH_2)_2S \quad (1)$$

$$(R_2NH_2)_2S + H_2S \leftrightarrow 2R_2NH_2SH \quad (2)$$

$$2R_2NH + CO_2 \leftrightarrow R_2NCOONH_2R_2 \quad (3)$$

From Table 3.0, it can be seen that the results show that 20% concentration of diethanolamine used in the purification were capable of removing, 97.62% and 99.00% of H_2S and CO_2 respectively. From the findings, it was observed that 20% aqueous solution of diethanolamine is the best for the removal of H_2S and CO_2. The purification process was based on the equilibrium reaction between diethanolamine and the acid gases H_2S and CO_2 and 20% weight of diethanolamine aqueous solution was employed as the absorbent concentration (Enjugu, 2008). While at 10%, 30% and 40% concentration, less absorption of CO_2 and H_2S was recorded respectively. This may be due to effect of excess or limiting reactant in the absorbing medium (Abdulkareem, 2005).

CONCLUSION

From the result obtained it can be deduced that, the analyzed cow dung sample contained 5.17g, 4.55g, and 19.80g of total solids, volatile solid and moisture content respectively. This was also expressed in percentage as 75.20%, 88.22% and 79.28% respectively. The result of biogas analysis showed that at 20% concentration of diethanolamine solution, 97.62% and 99.00% of CO_2 and H_2S were removed respectively. At this concentration the highest amount of removal was recorded for both gases. Therefore 20% concentration diethanolamine is the best recorded for purification of the biogas in the work.

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