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Research Papers

Evaluation of Homemade Activated Charcoal Biogas Purifier

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ABSTRACT: ***The readiness of biogas for local use and industrial use in Nigeria cannot be guaranteed except dangerous impurities accompanying with biogas production are efficiently removed during production. In this research work, evaluation of homemade activated charcoal biogas purifier was carried out. A locally obtained cylindrical plastic was used to produce a homemade biogas purifier. Activated charcoal that served as the reagent produced from palm kernel shells was experimentally used to removed impurities from raw biogas. The test was conducted ten (10) consecutive times and the results obtained showed that activated palm kernel shells absorbed the hydrogen sulphide, water vapour and carbon dioxide while allowing the purified biogas to pass through to the storage cylinder. These results showed that the homemade biogas purifier is adequate and efficient.***

Keywords: *Biogas, Activated Charcoal, Palm Kernel Shells, Hydrogen Sulphide, Carbon (IV) oxide*

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INTRODUCTION

Biogas purification has to do with the processes that involve the enrichment of the methane content of the gas by removal of the incombustible gas present in biogas [1-3]. Purified biogas provides reductions in the greenhouse gas (GHG) emissions. Biogas mainly consists of methane and carbon dioxide together with smaller amounts of other gases and vapours, such as hydrogen, nitrogen and hydrogen sulfide (H_2S) [4-8]. The main component of biogas is methane; other combustible hydrocarbons of biogas do not contribute much to the calorific value of the gas [9]. However, removing CO_2 increases the heating value and leads to a consistent gas quality, similar to natural gas [10-11, 21]. The removal of CO_2 averaged 51%, this equates to an increase of 9% and the combustion value of the biogas. Although, biogas has become a major source of renewable energy(fuel) in advance countries where they are been used on industrial scale but that is not the case with Nigeria and most developing countries [12-15]. Nigeria, which is one of the most favorably suited, for the production and domestication of the use of biogas has not yet developed local technologies that are used for the production, purification and storage of biogas. m[25] studied the removal of CO_2 from biogas through a packed column using water solvent. From an initial concentration of CO_2 equal to 33%, it was possible to remove 45% of CO_2. It was also suggested that quicklime can be used in chemically scrubbing of biogas [21]. According to [21], the present of hydrogen sulphide in small quantities in biogas usually prohibits the direct use of the gases because of its toxic properties, the formation of SO_2 upon combustion (acid rain), and the problems it (usually) gives in downstream processing. Besides, H_2S is frequently encountered in the field of odour monitoring because of its high odorous power. However, the type and the number of pollutants depend upon the biogas source and determine which cleaning and upgrading techniques are the most suitable for gas purification [22]. According to [23], biogas can be rid of the sulphide using iron oxide filters, as given in the following equations.

$$FeO\,(s) + H_2S\,(g) \longrightarrow FeS\,(s) + H_2O\,(l)$$

$$2FeS\,(s) + O_2\,(g) \longrightarrow 2FeO(s) + 2S(s)$$

A simple method for hydrogen sulphide utilizing steel wool in a glass bottle is modeled in Fig. 1 and seems to be the most viable option for low cost, easy implementation hydrogen sulphide removal. In this method of sulphide removal, the gas reacts with the steel wool, creating black iron sulphide. The iron sulphide generation begins at the bottom of the container, and once the steel wool is 75% black (i.e., 75% of it has been turned into iron sulphide), the wool should be removed and replaced. The used wool can be reused after exposure to air. This oxidizes the wool to rust, which can be reused in the system, as it will react with the hydrogen sulphide.

Fig. 1: Model device for homemade hydrogen sulphide scrubber

MATERIALS AND METHODS

In this research work, the following materials, equipment, and reagents were used, biodegradable portion of household waste (50 kg), plastic container, mild steel digester, thermometer, activated charcoal (produced from palm kernel shells), a water plastic, electric oven (for drying the activated charcoal), pressure gauge (accuracy±0.02), 100kg universal weighing scale (accuracy±200 g), rubber hose, burning silk (for burning the palm kernel shells), draining tray (for removing moisture from the charcoal), sterilized water, gas chromatograph, and a pH meter. The processes are shown in the block diagram of Fig. 2.

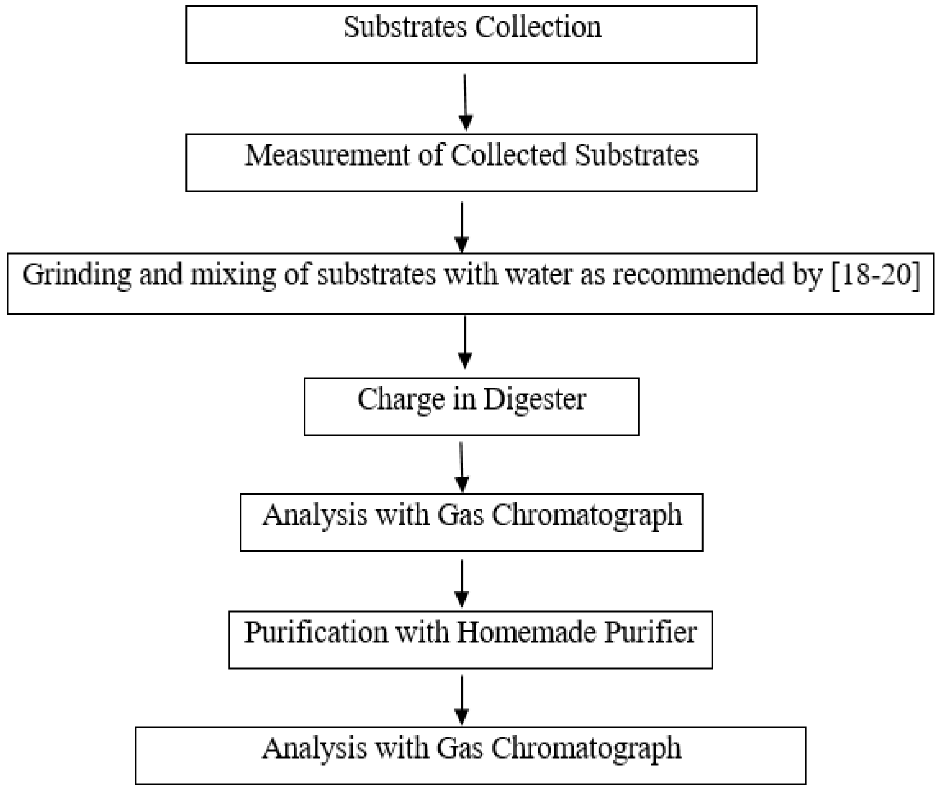


Fig. 2: Block diagram showing the various processes

Preparation of Activated Charcoal

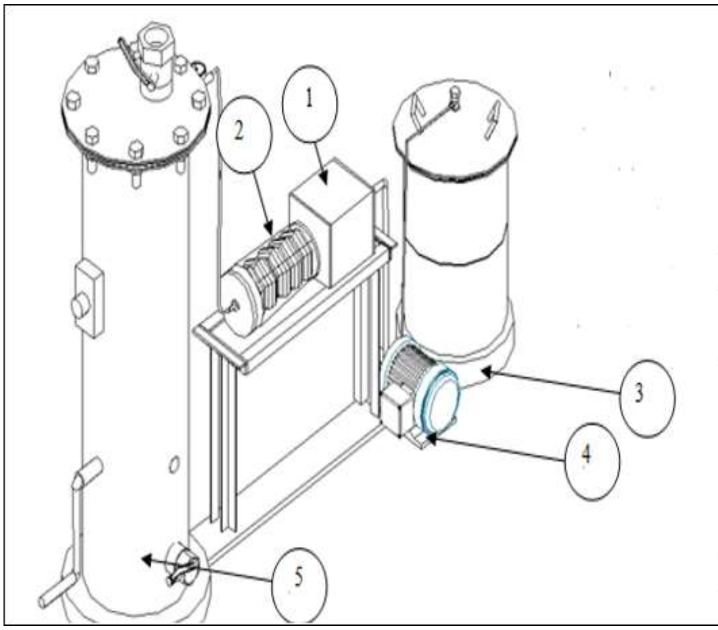
The palm kernel shells were washed thoroughly with sterilized water and allowed to dry completely in order to facilitate combustion. The palm kernel shells were burned completely into ashes. A standard preparation 250 g of Calcium Chloride was dissolved in 1000ml of water as chemical activator as recommended by [18]. The dissolved Calcium Chloride solution was poured into a plastic pail containing the cooled palm kernel shell ash. The pail was covered and left to cool for one day. During this process, the chemicals are impregnated into the ash and it will transform the ash into activated charcoal [18]. This is referred to as chemical activation which makes it highly porous and adsorbent. The charcoal produced from the palm kernel shell was removed from the chemical solution and thus, transferred into a draining tray and allowed the treated charcoal to drain for an estimated 1 hour. The charcoal was washed in sterilized water repeatedly and this was mainly to remove chemicals. The charcoal was then transferred into an oven, setting the temperature to about 105°C to adequately dry it. After drying, the charcoal from the oven was crushed in a blender. Then it was used to impregnate the Iron sponge in the filter [18] and this served as sample A. Another purifier that served as sample B using reagents such as quicklime and iron oxide served as control.

Experimental Setup

The biogas digester with dimensioned of 1000 mm height and 300 mm diameter cylindrical mild steel was used to digest the collected substrates collected from household. Only 50 kg biodegradable portion was used. The digester consists of the following components;

i. Pressure gauge; for determining the pressure of the gas inside cylinder.
ii. Thermometer; for reading the temperature of the gas in the cylinder.
iii. Stirrer; for mixing the substrate and water thereby allowing the produced gas to move up the chamber.
iv. Valves; the valves are used to control the flow of materials in and out of the digester.

Fig. 3 shows the experimental setup.



SN	Parts
1	Control unit
2	Homemade Purifier
3	Gas storage unit
4	Pump
5	Digester

Fig. 3: Experimental setup.

Purification with Gas Chromatograph

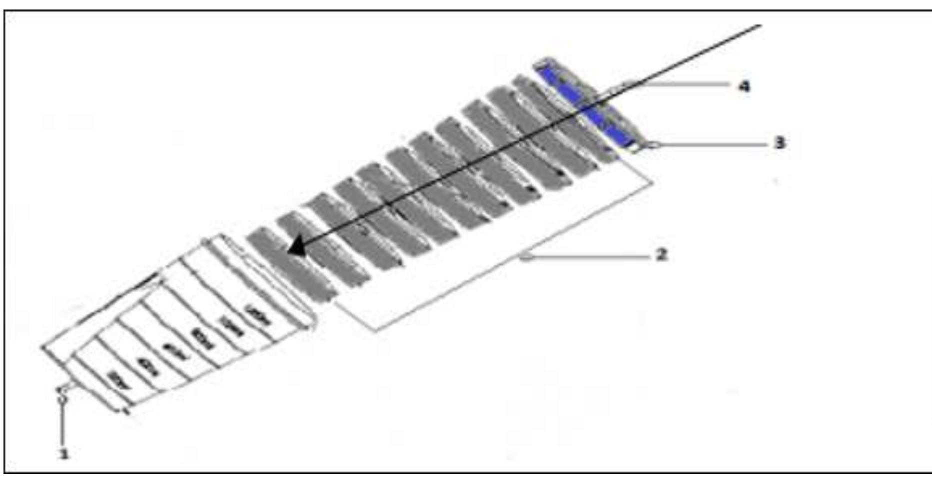
The impure biogas sample enters the gas stream which transports the sample into a separation tube known as the column. Helium gas was used as the called carrier gas. The various components were separated inside the column.

TEST

The evacuated impure biogas (0.012 m^3) was for gas analysis to know the percentage composition of the constituents of biogas present and also the potency of the produced homemade purifier. This was divided into two portions. The first portion was evaluated with the homemade purifier using activated palm kernel shells and the second portion using control reagents such as quicklime and iron oxide. The raw biogas was analyzed four times (separately for methane, carbon (IV) oxide, hydrogen sulphide and water vapour).

RESULTS AND DISCUSSION

The biogas purification filter arrangement of the homemade purifier is shown in Fig.4. the results obtained is shown in Table 1.



S/N	Description
1	Outlet nipple
2	Reagent
3	Cover
4	Inlet nipple

Fig. 4: Biogas purification filter arrangement

Table 1. Result of raw and purified biogas

S/N	Impure Biogas				Biogas purified with control reagents				Biogas purified with activated palm kernel shells			
	CH_4	$C0_2$	H_2S	H_20	CH_4	CO_2	H_2S	H_20	CH_4	$C0_2$	H_2S	H_20
1	68.05	30.99	0.68	0.28	88.70	11.30	0.00	0.00	84.89	15.10	0.01	0.00
2	68.05	30.99	0.68	0.28	88.71	11.29	0.00	0.00	84.55	25.41	0.02	0.00
3	68.05	30.99	0.68	0.28	88.69	11.31	0.00	0.00	84.05	15.92	0.03	0.00
4	68.05	30.99	0.68	0.28	88.73	11.27	0.00	0.00	84.01	15.94	0.04	0.01

As depicted in Table 1, the composition of raw biogas, and biogas purified with control set up (quicklime and iron fillings) and with activated palm kernel shells shown that the composition of the raw biogas was affected. Hydrogen sulphide (H_2S) and water vapour were completely purified from raw biogas. Although, there were traces of hydrogen sulphide after the first and second test and also trace of water after the third test using the activated palm kernel shells. This can be attributed to the over use of the filter as reported by [21]. However, the percentage composition of methane (CH_4) and carbon (1V) oxide (CO_2) were changing by 0.1±0.5. Also, close observation of the raw biogas, biogas purified with the activated palm kernel shells and the sample of biogas purified with control set up show that there was a gradual increase in the percentage composition of methane. On the other hand, the percentage compositions of carbon dioxide and water were decreasing by 0.1±0.5. The increase in the percentage composition of methane confirmed the removal of impurities from the biogas while the decrease in the compositions of carbon dioxide and water vapour confirms purifying ability of the activated palm kernel shells. This goes in line with the work of [22-24] who reported that activated carbon has the ability to absorb impurities from raw biogas.

CONCLUSION

This research work carried out to investigate the purification of biogas using homemade purifier shows that impure biogas can be purified with activated palm kernel shells. The results obtained show that the activated palm kernel shells have the ability of removing carbon dioxide, hydrogen sulphide and water vapour from biogas. The percentage composition analysis of biogas before and after purification with the activated palm kernel shells shows an improvement of methane. From the foregoing, it can be deduced that complete cleaning of the biogas for domestic usage is achievable. More so, the technology is simple, safe and cost effective. In Nigeria if the design, testing and production of this filter is optimized, the commercial production of biodigesters can be undertaken.

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