Utilization of Potential of Melon Shells for Pyrolysis as Biomass Fuels

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Abstract: In Nigeria, a lot of agricultural residues abound and these residues contain appreciable amount of biomass energy. In this work, investigations were carried out on properties of medium-grade fuels produced from melon shell. 1.0 kg sample of melon shell was fed into the retort, which was placed in the brick furnace and connected through a flange coupling to the condensate receiver. The condensate receiver was placed in an ice bath to enable quick condensation of the condensable product of the pyrolysis. The condensate receiver was connected to the gas chamber through the rubber hose that was made airtight by the use of jubilee clips. The gas collection chamber is made up of an outlet for the gas collection. About 1.5 kg pieces of firewood were packed closely around the retort and small quantity of kerosene was sprinkled on the fire wood to initiate ignition. The fire produced was used to generate the heat needed for the pyrolytic conversion of melon shell into biomass fuels. The firing lasted for about 30 minutes and the gas commenced to evolve. The valve was turned on and the incoming gas moved directly into the gas chamber where scrubbing took place. The experiment was terminated when production of the gas ended. Both the char in the retort and the condensate (tar oil/pyroligneous acid) in the condensate receiver were collected and weighed after the whole pyrolysis process had already cooled off. The pyrolytic conversion of melon shell yielded 36.56 % char, 34.44 % mixture of tar oil/ pyroligneous acid and 29.00 % pyrogas. Further chemical analysis revealed that the constituents of pyrogas were made up of 77.73 % carbon and 22.27 % hydrogen. Finally, the paper concluded that the quantity and products of pyrolysis depend on the type of the biomass feedstock used, its quality and operating conditions.

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1. Introduction

Energy availability in the rural as well as urban areas of Nigeria is fast becoming a great challenge with the high cost of cooking gas and kerosene and environmental problems associated with firewood (Oladeji, 2011a). A large number of waste products are generated in rural areas both on the farm and from household activities. Most of these wastes are mainly deposited on the farm or burnt with all the ecological problems associated with their disposal methods (Jekayinfa and Omisakin, 2005; Oladeji, 2011b). However, studies had revealed that, most of these wastes have been found to represent valuable energy (Jekayinfa and Scholz, 2009).

Melon, botanically known as *cucumis* is one of popular crops being grown in every part of Nigeria. Processed melon is used as additive for cooking soup and oil could be extracted from it as well. Melon shell, a residue from melon is available in large quantities on the farm constituting a waste disposal problem in mills after processing. Therefore, any attempt at upgrading its usefulness will be readily accepted by the farmers (Oladeji, et al. 2009). However, melon shell in its natural form cannot be utilized as fuel economically. The reasons are not farfetched as melon shells are loose and of low density materials, which make them difficult to burn in a controlled and effective manner (Oladeji, 2011b). Subjecting melon shells into a process of pyrolysis could provide a means of producing fuels that are more convenient to burn (Musa, 2007; Oladeji et al., 2009).

According to Bridgewater (2002) pyrolysis is the thermal breakdown of organic materials in the absence of air. Boateng et al. (2007) further defined pyrolysis as thermal decomposition of the biomass fuels in the absence of oxygen. During pyrolysis, three types of products are released: solids, liquids and gases. The proportions of these products, however, depend on the chemical composition of the biomass residue, the working conditions and the quality of the biomass residue. Pyrolysis normally occurs under pressure and at operating temperature above 450^0C (Bridgewater, 2002). Over a million pyrolysis systems were developed and used during the Second World War (Bridgewater, 2002). In developing countries, most pyrolysis processes are carried out in piles, earth mound and pit kilns. Some residues that have been subjected to pyrolysis are maize cob (Bamigboye and Oniya, 2003; Ogunsola and Oladeji, 2009), wood residues (Fapetu, 2000a), poultry litter (Livingstone, 2004; Poultry Tech. 2008) and oil palm waste (Guo and Lua, 2001). The products of pyrolysis can be put to use in various ways namely; charcoal could be used as domestic fuel for cooking and industrial cottage application in most parts of Nigeria (Fapetu, 2000b). Tar oil is widely as fuel and can be fractionated into gasoline and diesel fuels to run engines (Ogunsola and Oladeji, 2009).

1.1 Objective of the Study

The broad objective of this paper was to identify various products of pyrolysis of melon shells and determine the constituents of the pyrogas.

2. Materials and Methods

The biomass feedstock used was obtained from melon processing mill at Kima area of Ogbomoso**.** 1.0 kg sample of melon shell was fed into the retort. The retort was placed in the brick furnace and connected through a flange coupling to the condensate receiver. The condensate receiver was placed in an ice bath to enable quick condensation of the condensable product of the pyrolysis. The condensate receiver was connected to the gas chamber through the rubber hose that was made airtight by the use of jubilee clips. The gas collection chamber is made up of an outlet for the gas collection. About 1.5 kg pieces of firewood were packed closely around the retort and small quantity of kerosene was sprinkled on the fire wood to initiate ignition. The fire produced was used to generate the heat needed for the pyrolytic conversion of melon shell into biomass fuels. The firing lasted for about 30 minutes and the gas commenced to evolve. The valve was turned on and the incoming gas moved directly into the gas chamber where scrubbing took place. The experiment was terminated when production of the gas ended. Both the char in the retort and the condensate (tar oil/pyroligneous acid) in the condensate receiver were collected and weighed after the whole pyrolysis process had already cooled off. All the materials used were sourced locally.

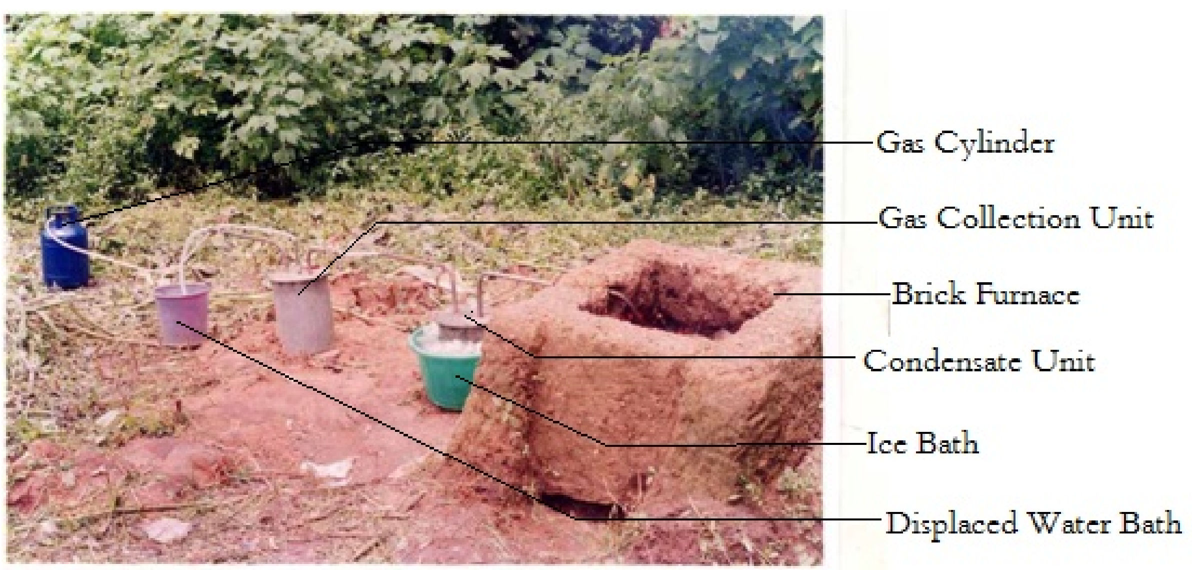

Plate 1. Pyrolysis chain assembly

Part No	Part Name	Materials	Quantity
11	Flange	Galvanised Steel	2
10	Retort	Mild Steel	1
9	Gas Cylinder	Galvanised Steel	1
8	Water Bath	Plastic	1
7	Valve	Brass	1
6	Pipe	Galvanised Steel	16
5	Bolt and Nut	Steel	60
4	Gas Collection Unit	Galvanised Steel	1
3	Ice Bath	Plastic	1
2	Condensate Receiver	Galvanised Steel	1
1	Furnace	Brick	1

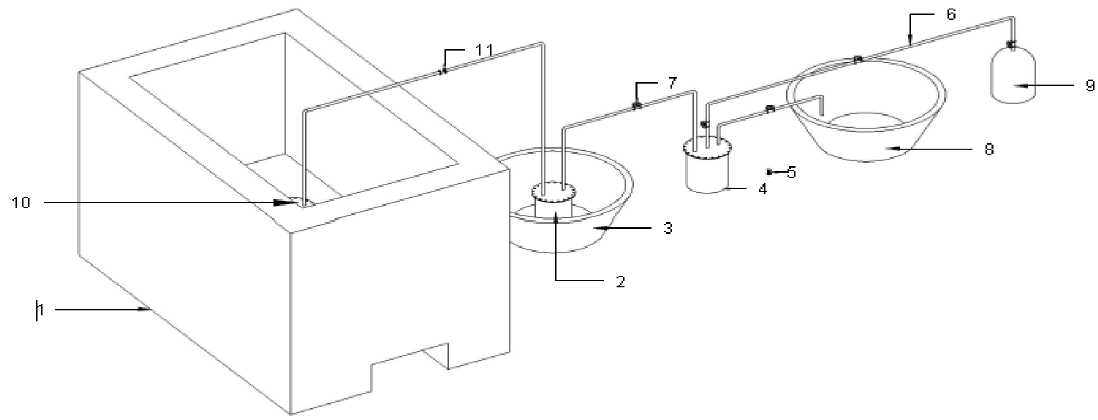

Figure 1. Isometric view of pyrolysis assembly

3. Results and discussions

The results of pyrolysis are shown in Tables 1 to 3.

Table 1. Compositions of products of pyrolysis of rice husk

Parameters	Value
Weight of oven dried of residue (kg)	1.00
Weight of firewood used (kg)	1.50
Weight of char obtained (kg)	0.364
Weight of mixture of oil and pyrolytic acid (kg)	0.340
Weight of gas (kg)	0.290
Higher Heating Value of Char (MJ/kg)	30.20
Conversion efficiency %	99.40

Table 2. Products of pyrolysis expressed as percentage of input feedstock

Products	Value (%)
Char yield	36.56
Mixture of tar oil and pyrolytic acid	34.44
Pyrogas	29.00

Table 3. Constituents of pyrogas

Products	Value (%)
Carbon	77.73
Hydrogen	22.27

Three pyrolytic products were obtained. These are:-

1. Char which is black in colour. It is the remains that is collected from the retort after complete pyrolysis
2. Pyrolytic oil and pyroligneous acid which is dark black in colour. It is sticky and becomes nearly solid on cooling
3. Pyrolytic gas which is non-pleasant smelling gas that burns with a blue flame of fire when ignited

Upon further chemical analysis, the constituents of pyrogas were found to be 77.73 % carbon and 22.27 % hydrogen.

The char has the highest yield of 36.56 % of the total product, which was closely followed by the mixture of pyrolytic oil and pyroligneous acid while the pyrogas has the least yield.

The char yield of 36.56 % appears to deviate from the work of Fapetu (2000b), where the char yields from pyrolysis of palm kernel, ekki wood and coconut shell gave values of 28.07%, 25.07% and 29.62% respectively. However, the yield obtained for the mixture of pyrolytic oil/pyroligneous acid appeared closer to the one obtained by Bamigboye and Oniya (2003), where value of 38.47% was obtained during the pyrolysis of corncob. The 23.00% value of pyrogas obtained in this work appears closer to the value obtained by Bamigboye and Oniya (2003) and falls short of the value obtained by Ogunsola and Oladeji (2009), where a value of 34.51% was obtained for pyrogas during pyrolysis of corncob. The implication of this is that the products of pyrolysis depend on the type of biomass residue used, its chemical constituents, quality, quantity and operating conditions.

4. Conclusions and Recommendation

From the study, the following conclusions can be made

(i) Melon shell easily lent itself to process of pyrolysis

(ii) The pyrolytic conversion of melon shell yielded 36.56 % char, 34.44 % mixture of tar oil/ pyroligneous acid and 29.00 % pyrogas. Further chemical analysis revealed that the constituents of pyrogas were made up of 77.73 % carbon and 22.27 % hydrogen.

(iii) The quantity and products of pyrolysis depend on the type of the biomass feedstock used, its quality and operating conditions.

The study recommends the following:

i. The biomass feedstock utilized in this study could be further subjected to process of briquetting. This will ensure judicious use of agro-residues and will ensure proper waste management and control.

ii. Future study should concentrate on how to separate the mixture of tar oil/ pyroligneous acid through the process of fractional distillation.

iii. In the similar manner, the constituents of pyrogas should be determined

References

1. Bamigboye AI. and Oniya O. Pyrolytic Conversion of Corncobs to Medium Grade Fuels and Chemical Preservatives" FUTAJEET 2003 Vol. 3 No. 2 pp 50-53.
2. Boateng A.A., Daugaard DE. Goldberg NM. and Hicks KB. Bench-Scale Fluidized-Bed Pyrolysis of Switch grass for Bio-Oil Production Industrial and Engineering Chemistry Research 2007 46 (7): 1891-1897.
3. Bridgewater AV. An Introduction to fast pyrolysis of biomass for fuel and chemicals in the fast pyrolysis of biomass: - A handbook CPL Press, Newbury, U.K 2002.
4. Fapetu OP. Management of Energy from Biomass Nigerian Journal of Engineering Management 2000a Vol. 1 No. 1 pp 14-19.
5. Fapetu OP. Production of charcoal from Tropical Biomass for Industrial and Metallurgical Process Nigerian Journal of Engineering Management 2000b Vol. 1 No.2 pp 34-37.
6. Guo J. and Lua AC. Kinetic study on pyrolytic process of oil palm solid waste using two step constructive reaction model Biomass and Bioenergy 2001 Vol. 20 pp 223-225.
7. Jekayinfa SO. and Omisakin OO. The energy potentials of some agricultural wastes as local fuel materials in Nigeria 2005 Agricultural Engineering International, the CIGR E-Journal of Scientific Research and Development, Vol. III, Manuscript EE 05 003:10
8. Jekayinfa SO. and Scholz V. Potential Availability of Energetically Usable Crop Residues in Nigeria Energy Sources 2009 Part A, Vol. 31: 687-697.
9. Livingstone A. (2004) Formulated Biomass Fuel using Poultry Litter, Poultry Litter & Renewable Resources Seminar 2004 May 5-6, Fayetteville, AR.
10. Musa NA. Comparative Fuel Characterization of Rice Husk and Groundnut Shell Briquettes NJRED 2007 Vol. 6 No. 4 pp 245-262.
11. Ogunsola AD. and Oladeji JT. The Development of a Pyrolysis unit for Conversion of Corncobs to Improved Biomass Energy 2009 IJAAAR Vol.5 No.1, pp 17-21.
12. Oladeji JT. Enweremadu CC. and Olafimihan EO Conversion of Agricultural Wastes into

Biomass Briquettes 2009 IJAAAR 5 (2): 116-123.

13. Oladeji JT. Pyrolytic Conversion of Cow Dung into Medium-Grade Biomass Fuels International Journal of Pure and Applied Sciences 2011a Volume 4 number 2, pp173-178.
14. Oladeji JT. The Effects of Some Processing Parameters on Physical and Combustion Characteristics of Corncob Briquettes, An Unpublished Ph.D Thesis of the Department of Mechanical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria 2011b.
15. Poultry Tech. Renewed Interest in Utilizing Poultry Litter for Energy, Poultry Tech. 2008 Vol. 20, No.

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