**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).

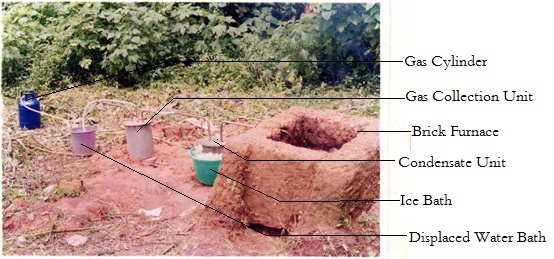
According to Bridgewater (2002) pyrolysis is the thermal breakdown of organic materials in the absence of air. Boateng et al. (2007) further defined pyrolysis as thermal decomposition of the biomass fuels in the absence of oxygen. During pyrolysis, three types of products are released: solids, liquids 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 4500C (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**

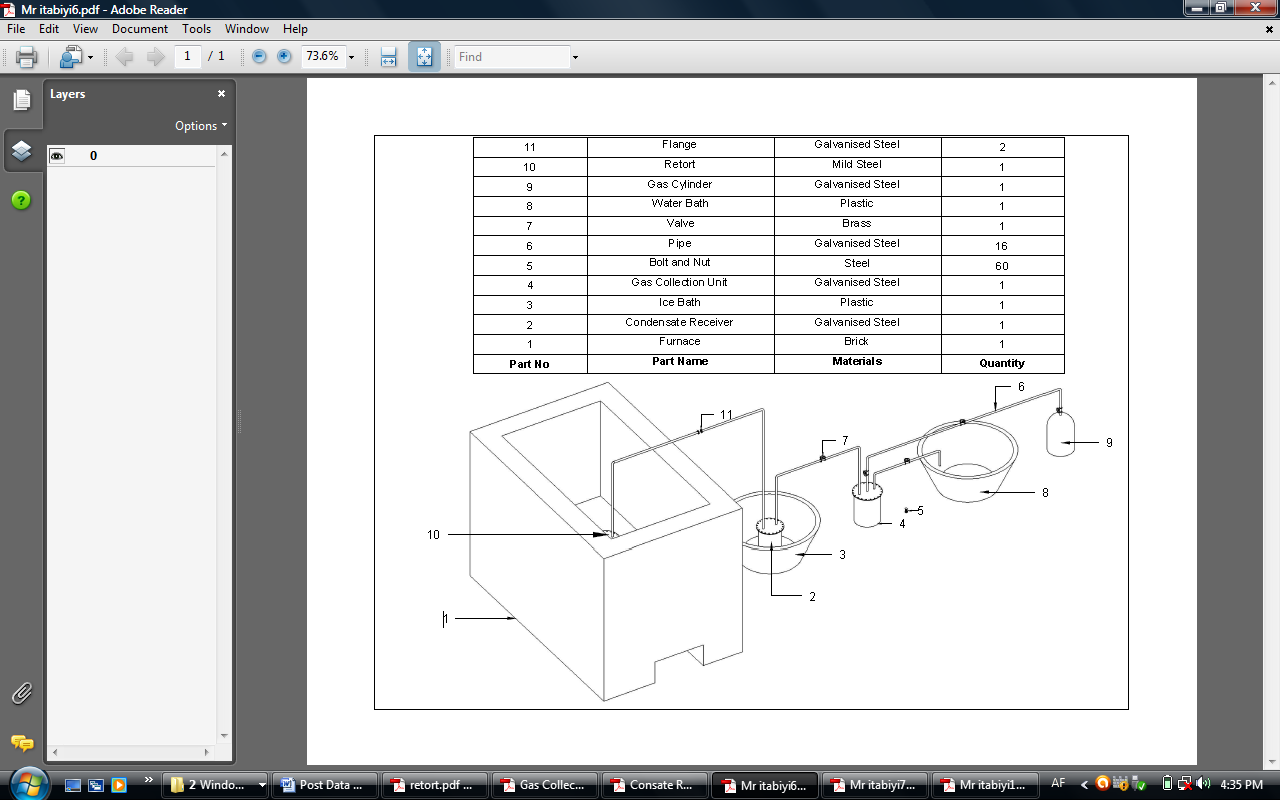
The broad objective of this paper was to identify various products of pyrolysis of melon shells and determine the constituents of the pyrogas.

**2. Materials and Methods**

The biomass feedstock used was obtained from melon processing mill at Kima area of Ogbomoso**.** 1.0kg 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.

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**Plate 1**. Pyrolysis chain assembly

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

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

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

**Table 3.** Constituents of pyrogas

|  |  |
| --- | --- |
| **Products** | **Value (%)** |
| Carbon  Hydrogen | 77.73  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

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