

Pyrolytic Conversion of Poultry Litter into Medium-Grade Biomass Fuels

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Abstract: Efficient utilization of energy is of paramount importance for economic and social development of a nation. A nation cannot develop beyond her energy generation capacity. Power generation from animal biomass is considered one of the best alternatives to the growing issue of poultry litter management. This work, therefore, investigated the products of thermo-chemical conversion of poultry litter to medium grade-fuels and chemical preservatives. A pyrolysis chain that consists of brick furnace, condensate receiver, retort and gas collection unit was developed and used for the experimental aspect of this work. The moisture content of poultry litter was determined, while the weight of pieces of wood used for pyrolysis was measured and recorded. Oven-dried sample of poultry litter was heated up in the furnace chamber. The products collected were weighed and recorded. The pyrolytic gas collected was taken to laboratory for further chemical analysis in order to establish constituents of the gases. It took 35 minutes for complete pyrolysis to take place. The products of the pyrolysis expressed in percentage of the oven-dried weight of feedstock were 42.56% char, 38.76% mixture of pyrolytic oil / pyroligneous acid and 18.68% of pyrolytic gas. The pyrolytic gas was further analyzed and it contained 74.78% of carbon, 25.22% of hydrogen. The pyrogas produced was found to contain 20.17% by volume of methane (CH₄), 32.50% by volume of ethyne (C₂H₂), 21.82% by volume of ethane (C₂H₆), and 10.88% by volume of carbon monoxide CO. The study concluded that, poultry litter lent itself easily to process of pyrolysis and the products obtained could be used for domestic and industrial cottage applications.

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1. Introduction

Poultry litter is mixture of manure and bedding material such as wood shavings, sawdust and other dry absorbent low-cost organic materials. Over the years, it has found use in agriculture and it has been highly value as a nutrient-rich fertilizer. Composting and land applications are still the most common means of disposing poultry litter. However, land application of poultry litter is associated with environmental consequences such as excess phosphates in water bodies and potential human health risks (Poultry Tech, 2008). Therefore, it has become increasingly important to find environmentally sound, economically sustainable, technologically feasible alternative disposal mechanism that offers best social benefits.

Power generation from animal biomass is considered one of the best alternatives to the growing issues of poultry litter management (Oladeji, 2011a). Recent fluctuations in cost of petroleum-based fuels and attention to greenhouse gas emissions have made poultry litter a potentially stable green fuel source that can help displace the demand for fossil fuels (Poultry Tech, 2008). Conversion of poultry litter into biomass energy is carbon dioxide neutral. Apart from that it is a renewable type of energy. Furthermore, poultry litter has good burning qualities due to its composition, making it potentially excellent source of fuel (Livingstone, 2004). Reported calorific

values for boiler litter on an “as produced” basis ranged from 30 MJ/Kg to 45MJ/Kg. Under moisture and ash free conditions, it can even be far higher than that (Poultry Tech, 2008).

In Nigeria, animal husbandry is a very popular occupation and a lot of animal waste products in form of poultry litter are generated constituting a waste disposal problem. However, poultry litter is in a form that cannot be utilized as fuel economically. The reason is not farfetched, as the biomass residue is difficult to burn in a controlled and effective manner (Oladeji, 2011b). The dried poultry litter also has low density. Energy generation from the poultry litter can be achieved by anaerobic digestion, direct combustion, co-firing, pyrolysis, and gasification (Livingstone, 2004). At present, these techniques are practiced on the experimental scale and to some extent, on the commercial scale. Subjecting poultry litter into a process of pyrolysis could provide a means of producing fuels that are more convenient to burn and environmentally friendly. Pyrolysis is a form of gasification and according to Boateng, 2007 is defined as the thermal degradation of waste in an oxygen free environment. Pyrolysis is an endothermic reaction (unlike gasification and combustion which are exothermic reactions) and requires an input energy, which is typically applied indirectly to the walls of the retort in which the waste material is placed for pyrolytic conversion. Pyrolysis

typically occurs under pressure and at operating temperature above 430°C (Bridgewater, 2002). The process generally produces char, mixture of tar oil/pyroligneous and pyrogas. The ratio of each however, depends on the type of feedstock and the specific pyrolysis operating conditions (temperature, residence time, heating rate, pressure and degree of mixing) that are used. In developing countries, most pyrolysis processes are carried out in piles, earth mound and pit kilns. Some residues that had been subjected to pyrolysis are maize cob (Bamigboye and Oniya, 2003; Ogunsola and Oladeji, 2009), wood residues (Fapetu, 2000), oil palm waste (Guo and Lua, 2001), cow dung (Oladeji, 2011a) among others.

The main aim of this work was to subject poultry litter to a process of pyrolysis and to determine and quantify its products of thermo-chemical conversion.

2. Materials and Methods

The cow dung that was used for the purpose of this work was obtained from Folawiyo farm settlement, Ilorin. The biomass feedstock was sun-dried until stable moisture content was obtained and its mass was determined. It was later oven-dried at a temperature of about 103±2°C and its moisture content was determined according to the procedure highlighted in ASAE269.4 (2003). A simple pyrolysis chain was set up and developed to facilitate the process of pyrolytic conversion of the feedstock to biomass fuel. The pyrolysis chain (Pate 1 and Figure 1) consists of retort, brick furnace, condensate receiver and the gas collection unit. One kilogramme by weight of cow dung was placed inside the retort. In the similar manner, the retort was placed inside the

brick furnace around which 8.5 kg of firewood was placed to initiate combustion. The whole pyrolysis chain was heated up and the retort became gradually red hot and the biomass residue began to pyrolyze. The pyrolyzed products slowly went into the condensate receiver, where the mixture of tar oil/pyroligneous acid was collected. The pyrogas was collected in the gas collection unit (cylinder). The products collected were each weighed and recorded. The pyrogas collected was further subjected to chemical analysis to establish its constituent gases.

3. Results and Discussion

The results of the pyrolysis are presented in Tables 1-4. The pyrolysis of poultry litter yielded 47.26% char, 29.70% mixture of tar oil/pyroligneous acid and 23.00% pyrogas. The results show that the char has the highest yield, while the pyrogas has the least yield. The char yield of 47.26 % appears to deviate from the work of Fapetu (2000a), 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. The same thing could be said of the value obtained for the mixture of pyrolytic oil/pyroligneous acid where Bamigboye and Oniya (2003), obtained 38.47% for the pyrolysis of corncob. The 23.00% value of pyrogas obtained in this work also 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 and operating conditions.

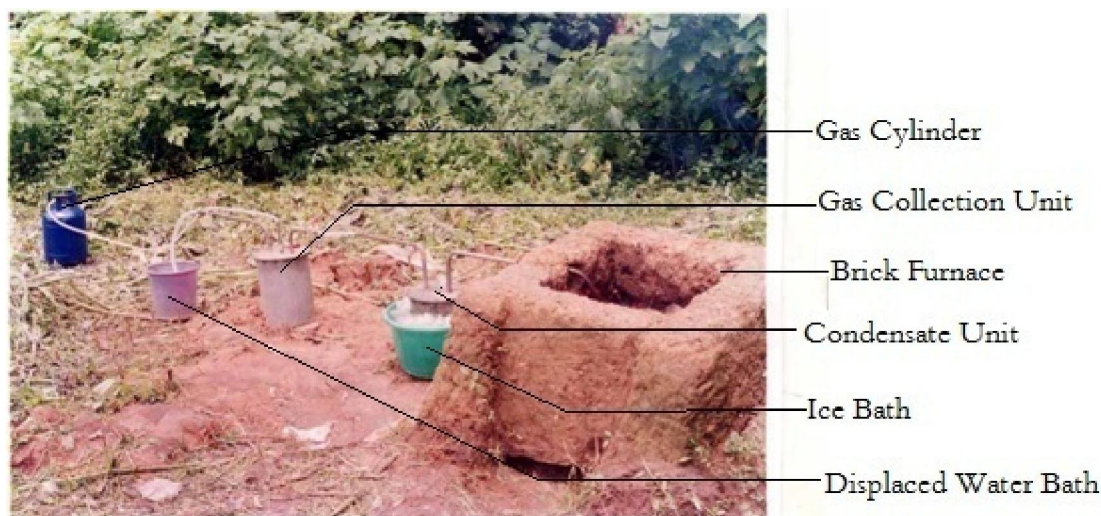


Plate 1. A pyrolysis chain set-up

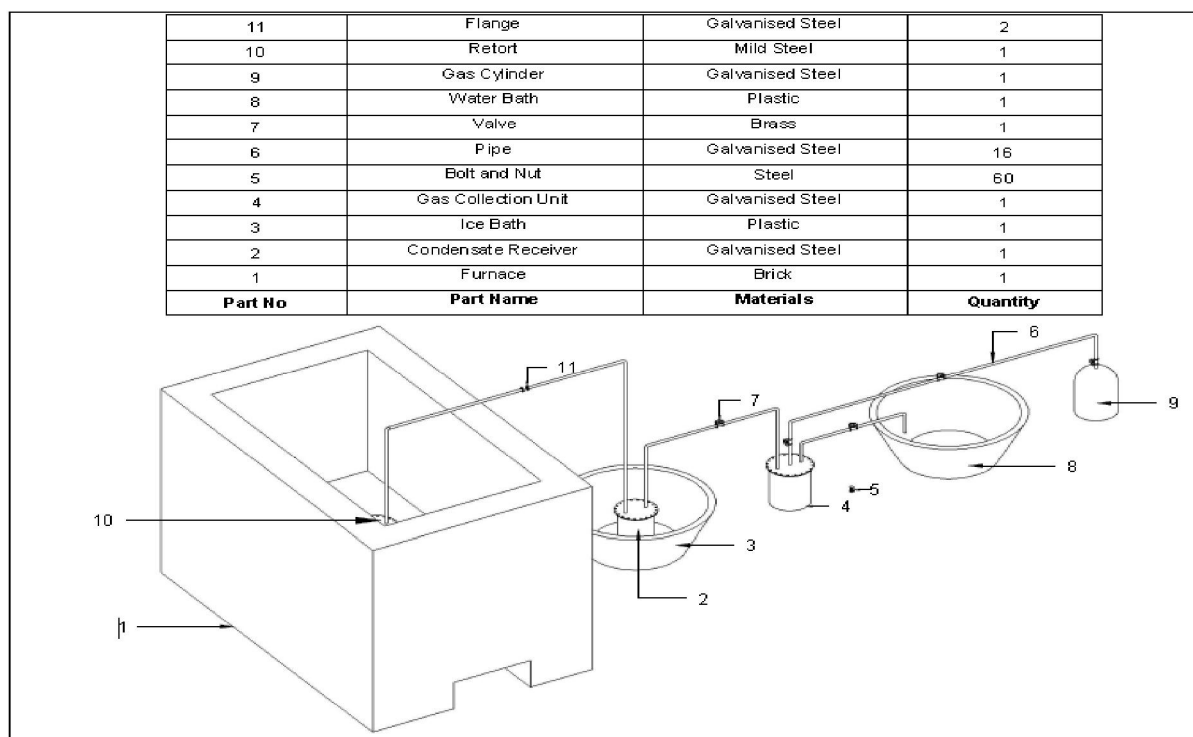


Figure 1. Isometric view of pyrolysis assembly

The constituents of pyrogas are 74.789% carbon and 25.22% hydrogen. Further chemical analysis revealed that the pyrogas of cow dung contained five different gases i.e 20.17% by volume of methane (CH_4), 32.50% by volume of ethyne (C_2H_2); 21.82% by volume of ethane (C_2H_6) and 10.88% by volume of carbon monoxide CO. The char product obtained could be used for traditional and industrial cottage applications such as in domestic

cooking and as a fuel in open earth furnace for blacksmithing and goldsmithing operations (Fapetu, 2000b). The pyrolytic gas could be used as household cooking gas and as fuel for gas lamps (Bamigboye and Oniya, 2003), while the pyrolytic oil can be used as fuel in the internal combustion engines (Bridgewater, 2002).

Table 1. Compositions of products of pyrolysis of poultry litter

Parameters	Value
Weight of oven dried of residue (kg)	3.00
Weight of firewood used (kg)	8.50
Weight of char obtained (kg)	1.42
Weight of mixture of oil and pyrolytic acid (kg)	0.89
Weight of gas (kg)	0.69
Conversion efficiency %	99.60
Higher heating value (MJ/kg)	39.30

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

Products	Value
Char yield	47.26
Mixture of tar oil and pyrolytic acid	29.70
Pyrogas	23.01

Table 3. Constituents of pyrogas

Products	Value
Carbon	74.78
Hydrogen	25.22

Table 4. % Composition by volume of gases formed

Gas	Chemical formula	% Composition
Methane	CH ₄	20.17
Propane	C ₃ H ₈	14.63
Ethyne	C ₂ H ₂	32.50
Ethane	C ₂ H ₆	21.82
Carbon Monoxide	CO	10.88

4. Conclusion and Recommendation

From the study, the following conclusions can be made

- (i) The biomass feedstock examined in this study easily lent itself to process of pyrolysis
- (ii) The pyrolytic conversion of poultry litter yielded 47.26% char, 29.70% mixture of tar oil/ pyrolytic acid and 23.00% pyrogas. Further chemical analysis revealed that the pyrogas was made up of 20.17% methane, 14.63% propane, 32.50% ethyne, 21.82% ethane, and 10.88% carbon monoxide.
- (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/ pyrolytic acid through the process of fractional distillation.

References

1. ASAE 269.4 Cubes pellets and crumble definitions and methods for determining density, durability and moisture content. 567-569 St. Joseph Mich. USA. 2003.
2. 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.
3. Boateng, AA. 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.

4. 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
5. Fapetu, OP. (2000a) Management of Energy from Biomass Nigerian Journal of Engineering Management 2000a Vol. 1 No. 1 pp 14-19.
6. 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.
7. 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
8. Livingstone, A. Formulated Biomass Fuel using Poultry Litter Poultry Litter & Renewable Resources Seminar 2004 May 5-6, Fayetteville, AR
9. Ogunsola, AD. and Oladeji, JT. The Development of a Pyrolysis unit for Conversion of Corncobs to Improved Biomass Energy IJAAAR 2009 Vol.5 No.1, pp 17-21.
10. Oladeji, JT. Pyrolytic Conversion of Cow Dung into Medium-Grade Biomass Fuels International Journal of Pure and Applied Sciences 2011a Volume 4, number 2, pp173-177.
11. 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, Ladoko Akintola University of Technology, Ogbomosho, Nigeria 2011b.
12. Poultry Tech. Renewed Interest in Utilizing Poultry Litter for Energy, Poultry Tech. 2008 Vol. 20, No.2.

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