

BIOFUEL YIELDS FROM SAWDUST PYROLYSIS OF DIFFERENT WOODS IN A FIXED BED REACTOR

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ABSTRACT: Increase in energy demand and the need to generate energy in the most environmentally friendly manner have triggered interest in renewable energy for sustainable development. Biomass conversion to biofuels through thermochemical processes is a promising option in renewable energy considerations. In this work, effect of different biomass feedstock on biofuel yields during pyrolysis in a fixed bed reactor was studied. Sawdust samples of *Gmelina arborea*, *Anogeissus leiocarpa*, *Parkia biglobosa* and *Adansonia kilima* were obtained from Paki-Otan Sawmill, Ogbomoso, South-Western Nigeria. 40 g of each sample was weighed and pyrolyzed in a fixed bed reactor at 550 °C for 15 minutes at atmospheric pressure. Results showed that pyro-oil, pyro-gas and char yield were in the range 17.2 – 25.7%, 47.2 – 62.0% and 14.0 – 27.5%, respectively. *Parkia biglobosa*, *Anogeissus leiocarpa* and *Gmelina arborea* gave the highest yield of pyro-oil, pyro-gas and char, respectively while the lowest yield of pyro-oil, pyro-gas and char were obtained from *Adansonia kilima*, *Gmelina arborea* and *Anogeissus leiocarpa*, respectively. This study showed that through pyrolysis, sawdust, which otherwise could constitute nuisance to the surroundings, is a potential source of biofuels for sustainable development.

Keywords: pyrolysis, fixed bed reactor, sawdust, sustainable development

1. Introduction

Globally, demand for energy has been on the increase as a result of increasing human population which consequently requires a commensurate supply of energy to meet the ever growing energy need. Coupled with this high energy demand are concerns for the longevity of fossil fuels and the need to mitigate greenhouse gases released to the atmosphere by their use. Therefore, energy from renewable sources has attracted a lot of attention in the past few decades. Biomass is expected to be a major source of sustainable energy in the future [1]. Aside from its abundant availability, its use releases low emissions of oxides of sulphur, carbon and nitrogen [2, 3, 4]. Developing countries have a greater interest in biomass because their economies are largely based on agriculture and forestry [5]. In biomass energy systems, thermochemical conversion is often employed. Pyrolysis is a key process in thermochemical conversion as it is not only an independent process for biofuel production but also an important phase in other processes. Many researchers have worked on the effect of process parameters on pyrolysis characteristics of biomass feedstock [6,7,8]. Others have studied the effect of different types of biomass materials on pyrolysis products [9,10,11,12]. However, studies on biomass materials of West African origin are scanty. Since biomass characteristics are significantly influenced by climatic conditions, soil types and soil fertility treatment in their respective environment [13], there is need for studying pyrolysis characteristics of biomass materials found in Nigeria. Therefore, in this study, biofuels yield spectra from sawdust pyrolysis of four different wood types were studied.

2. Materials

Sawdust samples of *Gmelina arborea*, *Anogeissus leiocarpa*, *Parkia biglobosa* and *Adansonia kilima* from sawmilling operations were obtained from Paki-Otan Sawmill, Ogbomoso, South-Western Nigeria.

Experimental set-up and procedure

Figure 1 shows the exploded view of the fixed bed reactor used for the pyrolysis experiment. The reactor comprises of a cylindrical retort (crucible), volatiles discharge pipe and hose, pyro-oil receivers and pyro-gas collector. Details of the experimental set-up have been given elsewhere [14,15]

For each run, the reactor temperature was preset to 100 °C above the desired temperature in order to compensate for the heat loss during insertion of the preloaded retort. The products collectors were weighed to determine their initial weight. The retort was loaded

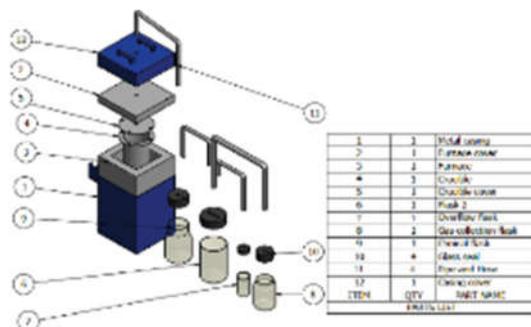
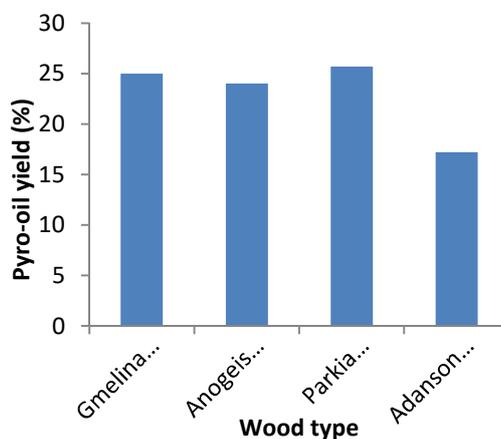


Figure 1: Exploded view of the pyrolysis reactor

with 40 g of each sample per run and was firmly closed with its lid secured with bolts and nuts to prevent volatiles leakage. As the reactor temperature assumed the preset value, the reactor cover was opened and the preloaded retort was inserted for the commencement of the pyrolysis process. The reactor was then covered and reset to the desired temperature (550 °C) and then

Figure 2: Pyro-oil yield from sawdust pyrolysis of different wood types



progressed for a residence time of 15 mins. The retort was then removed from the reactor and was allowed to cool down for 10 mins before the lid was loosed and char was let out. Pyro-oil and char yields were weighed and expressed as percentages of initial weight of the sample. Pyro-gas yield was obtained by the principle of conservation of mass.

4. Results and Discussion

4.1 Pyro-oil yield

Figure 2 shows the pyro-oil yields from the sawdust pyrolysis of the four wood types used. From the figure, *Parkia biglobosa* gave the highest yield of 25.7% while *Gmelina arborea*, *Anogeissus leiocarpa* and *Adansonia kilima* gave 25, 24 and 17.2%, respectively. Pyro-oil yields from *Parkia biglobosa*, *Gmelina arborea* and *Anogeissus leiocarpa* are not significantly different, suggesting that the three have similar percentages of cellulose. This is because the main source of pyro-oil in pyrolysis process has been identified as cellulose [16]. In processes where pyro-oil is desired, *Parkia biglobosa* should be the most preferred.

4.2 Pyro-gas yield

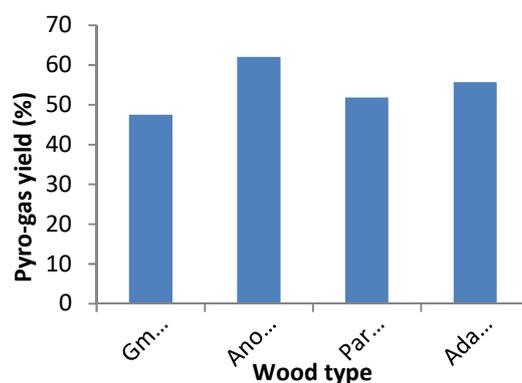


Figure 3: Pyro-gas yield from sawdust pyrolysis of different wood types

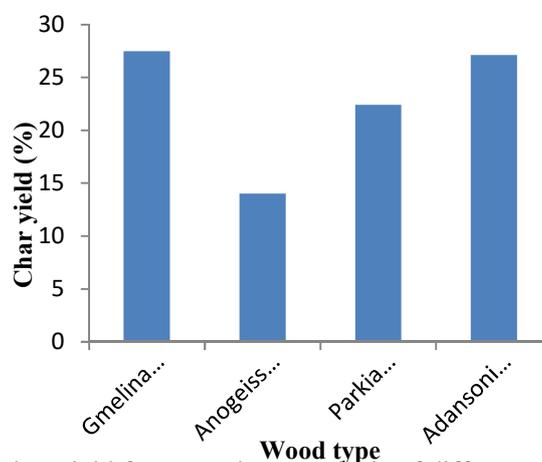


Figure 4: Char yield from sawdust pyrolysis of different wood types

Figure 3 shows the pyro-gas yields from the pyrolysis process. From the figure, it is seen that *Anogeissus leiocarpa* gave the highest yield of 62% while *Adansonia kilima*, *Parkia biglobosa* and *Gmelina arborea* gave 55.7, 51.9 and 47.5%, respectively. For all the samples, pyro-gas yields were much higher than pyro-oil yields. This is indicative of the possibility of significant extra-particle secondary reactions between the primary products of pyrolysis, resulting in more pyro-gas yield at the temperature considered (550 °C). Besides, high yield of pyro-gas can also suggest high percentage of hemicellulose in the samples. Findings have shown that hemicellulose and cellulose is responsible for high pyro-gas yields [17].

4.3 Char yield

Figure 4 shows the char yields from the sawdust pyrolysis of the four different types of wood. From the figure, it can be seen that *Gmelina arborea* gave the highest yield (27.5%) while the lowest yield (14%) was obtained from *Anogeissus leiocarpa*. It has been reported that char yield during pyrolysis is mainly from thermal degradation of lignin [16,18,19]. This suggests that *Gmelina arborea* will be a good feedstock for charcoaling or carbonization where solid residue is of prime importance.

5. Conclusions

The yield of biofuels from sawdust pyrolysis of four different wood types has been studied in a fixed bed reactor. Findings revealed that *Parkia biglobosa*, *Anogeissus leiocarpa* and *Gmelina arborea* gave the highest yield of pyro-oil, pyro-gas and char, respectively. Extra-particle secondary reactions were identified to have played a significant role in high yield of pyro-gas for all the samples. The percentage composition of cellulose, hemicellulose and lignin in biomass materials influences biofuel yield distribution during pyrolysis. In selecting biomass feedstock for pyrolysis, choices should be based on the biofuel type (solid, liquid or gaseous) most desired.

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