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PHYSIOCHEMICAL PROPERTIES OF WASTE PLASTIC MATERIAL CONVERTED TO FUEL

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ABSTRACT

A polyethylene terephthalate (PET) waste plastic was recycled into liquid fuel by thermal pyrolysis to recycle it into liquid fuel. The physiochemical properties of the fuel were determined and compared with petrol. The results of the research indicated that the fuel from the waste plastic (WPO) has flash point of 72.50°C, as against 21°C of petrol, implying that the former has less hazard than the latter. The WPO's density is 0.804 g/cm^3 while that of the petrol is 0.740 g/cm^3. WPO and petrol has heating value of 39.5MJ/Kg and 44.18MJ/Kg, respectively. The conversion of waste plastic into fuel will alleviate problems associated with depletion of conventional energy sources.

KeyWords
Fuel, Petrol, Physiochemical, Recycle, Thermal pyrolysis, Waste plastic

Introduction

It has been emphasized that it is only a matter of time before the reserves of conventional energy become exhausted [1]. Thus, mankind has to rely on the alternate energy sources. Conversion of waste plastic to fuel is one of such alternate energy sources. Due to the increase in generation of waste plastic, it is becoming a major stream in solid waste. After food waste and paper waste, plastic waste is the major constitute of municipal and industrial waste in cities. Even the cities with low economic growth have started producing plastic waste due to production of plastic packaging, plastic shopping bags, PET bottles and other goods/appliances which uses plastic as one of major components. Examples of plastic include polyethylene, polypropylene, nylon, polycarbonate, phenol formaldehyde, etc. [2].

The presence of plastic waste has turned into a major challenge for local authorities responsible for solid waste management and sanitation. Due to lack of integrated solid waste management, most of the plastic waste is neither collected properly nor disposed of in appropriate manner to avoid its negative impacts on environment and public health and waste plastics. The disposal of the plastic wastes means a huge problem because their degradation takes a very long time in the nature. Therefore, it will be encouraging to recycle the waste plastic, as doing so will serve as a means of collecting and disposing waste plastic in environmentally-friendly way by converting it into a fuel [3].

A number of researches have been carried out on fuel derived from waste plastics. Siddiqui and Redhwi [4] explored the effects of various conditions such as catalyst type, amount of catalyst, reaction time, pressure and temperature on the product distribution of co-processing of waste plastic. It was discovered that the rate of conversion in the co-processing system depended upon the chemistry and composition of the particular plastic material. Panda et al. [5] submitted that production of liquid fuel from plastic waste would be a better alternative as the calorific value of the plastics is comparable with that of fuels of 40MJ/kg energy. They revealed that waste was reduced and natural resources were conserved.

Nikolett et al. [6] reported on pyrolysis of clear and contaminated waste plastics in a tubular reactor. They established that the catalyst could increase the yields of volatile products, but its effect was significant only in case of clear, non-contaminated raw materials. In the absence of catalyst, the pre-treating of raw materials had only moderate effect on the quantity and quality of the products. Moinuddin and Mohammad [7] applied thermal degradation process with none-coded waste plastics with muffle furnace and reactor without using catalyst or chemical. The obtained products were liquid fuel 85%, light gas 9% and black carbon residue 6%. Gas chromatography and mass spectrometer analysis result showed that hydrocarbon compound and light gas were present in the range of C3- C28 and present C1-C4, respectively.

Butler et al. [8] studied the recycling of waste polymers in standard FCC units. Low density polyethylene (LDPE) was dissolved into commercial vacuum gas oil at 2 and 6 wt% and converted over two equilibrium FCC catalysts of the octane barrel and resin types in a CREC riser simulation laboratory reactor. The study indicated that there was a typical conversion of 70 wt% and that the gasoline yielded an increase of about 10 wt%. In the present work, thermal pyrolysis method was used to convert waste plastic to fuel and then the physiochemical properties of the fuel were determined and compared with petrol.

Experimental Setup

The experimental setup for the thermal pyrolysis is shown in Fig. 1. The setup includes a pyrolytic reactor which is a cylindrical vessel made of mild steel of 282mm height, 235mm internal diameter, and 238mm outer diameter, sealed at one end, and having a lid to which an outlet tube is joined at the other end. It also consists of a condensing unit which is a measuring cylinder half filled with water. The outlet pipe from the reactor leads into the measuring cylinder and goes down a bit below the water level therein. The measuring cylinder serves as a

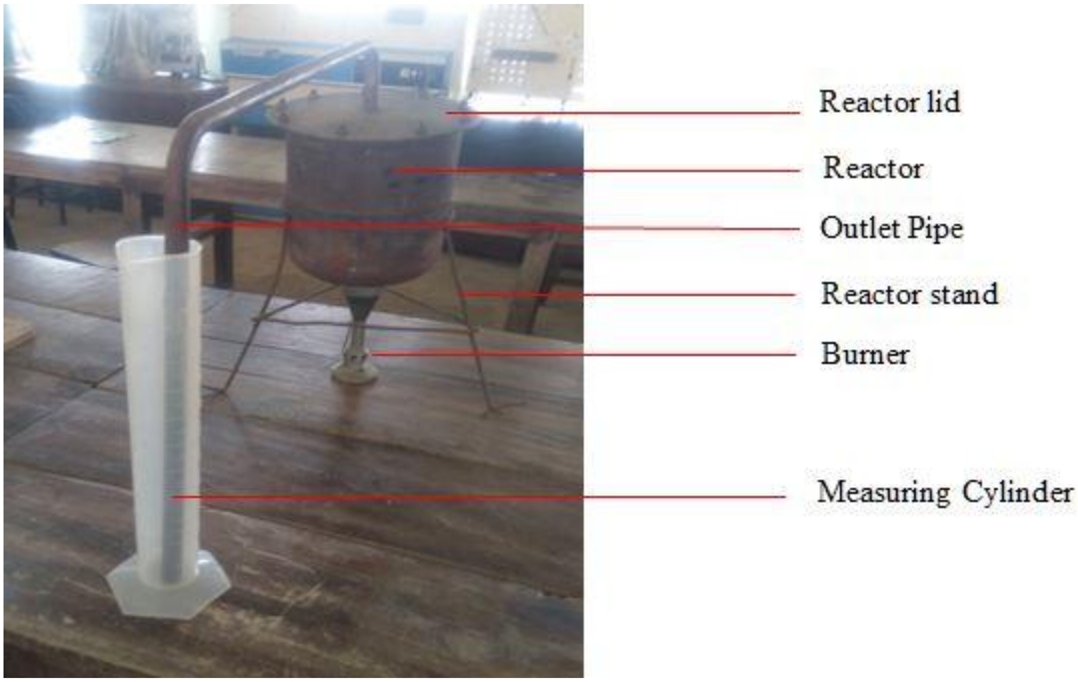

Fig. 1. Experimental setup for the thermal pyrolysis.

condenser and also prevents oxygen from finding its way back into the reactor through the outlet pipe. A gasket was used to secure air tight contact between the reactor's perimeter surface and the perimeter surface of its metal plate lid prior to fastening them with bolts and nuts. A heat source from a gas cylinder supplied heat to the reactor via the burner.

Methodology

A polyethylene terephthalate (PET) waste plastic was subjected to thermo-chemical degradation process called thermal pyrolysis to recycle it into liquid fuel. Pyrolysis is a thermal cracking reaction of a large molecular weight polymer carbon chains under an oxygen free environment to produce a small molecular weight polymer carbon [9].

A polyethylene terephthalate (PET) waste plastic sample were collected. Thereafter, feedstock was prepared by manually cutting the PET into small sizes of about 2 by 3mm sizes by using scissors. By cutting it into smaller sizes, the surface area of contact of the waste plastic material during melting process in the reactor will be increased. After this, the pyrolysis reactor, in Fig. 1, was loaded with the feedstock and heat was supplied to the reactor via its burner to begin the pyrolytic process. The fuel produced at the end of the pyrolytic process was collected and tested in a laboratory to analyse its physiochemical properties.

Physiochemical Properties of the Fuel from the Waste Plastic

The physiochemical properties of the waste plastic oil, which were tested, were flash point, density, and heating value.

Determination of flash point

Pensky-Martens closed flash tester (Kehler-Model K-16270) was used to determine the flash point of the fuel. The test sample was dried to remove traces of moisture in it. The dried sample was poured into the cup of the tester. The tester was then put on and the heater temperature was regulated. The flash occurred when a large flame was observed on the cup and the temperature at which this occured was measured and recorded as the flash point of the oil sample.

Determination of density

40ml of the sample was poured into a clean 500ml measuring cylinder. Hydrometer was lowered gently into the sample and avoid being lean on the wall of the cylinder. When the hydrometer has become stable, the reading was taken.

Determination of heating value

The heating value of the fuel is the amount of heat released by its specified quantity, taking into account the latent heat of vapourisation of water in the combustion products. Model 6200 microprocessor-controlled isoperibol oxygen bomb calorimeter was used for the test. It involved the removal of the bomb and buckets from the calorimeter and then manually refilled for the test.

Results and Discussions

After the results of the tests have been obtained, comparisons were made between the values of the physio-chemical properties of the waste plastic fuel, otherwise known as waste plastic oil (WPO) and petrol as follows:

Table 1. Comparisons between the values of the physio-chemical properties of the waste plastic oil and petrol.

Flash point, °C	72.50	21
Density, 15°C g/cm³	0.804	0.740
Higher heat value, MJ/Kg	39.5	44.18

From Table 1 above and Fig. 2 below, it can be inferred that the waste plastic oil (WPO) has flash point of 72.50°C while the petrol has flash point of 21°C. Since it has been established by Chanda [9] that the lower the flash point, the greater the fire hazard, it then indicates that WPO (72.50°C) has less fire hazard than petrol (21°C).

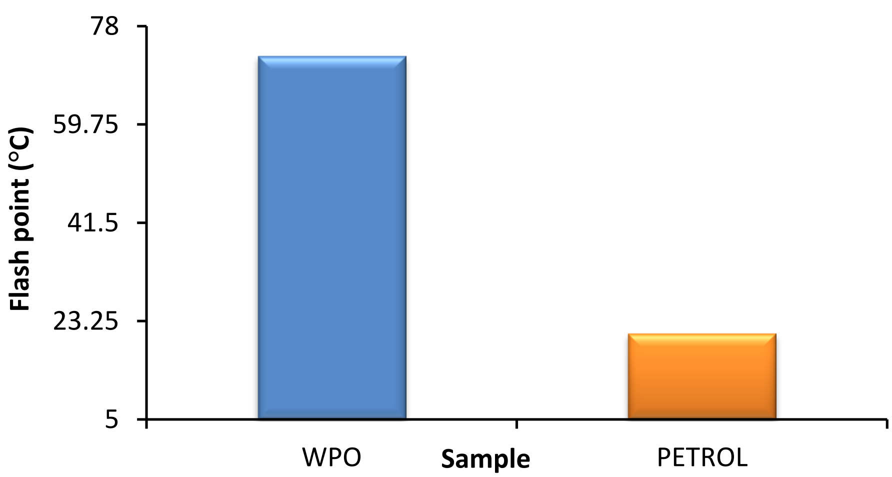

Fig. 2. Flash point of WPO vs. petrol.

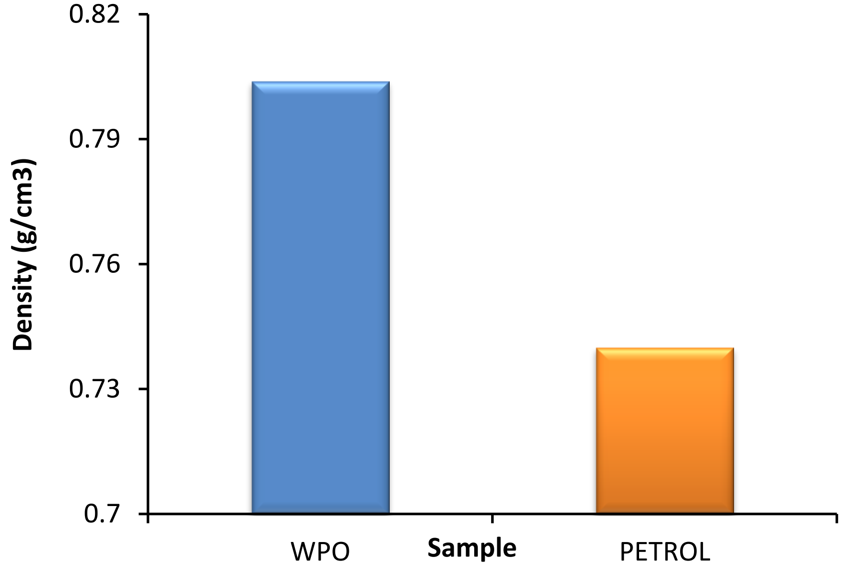

Fig. 3. Density of WPO vs. petrol.

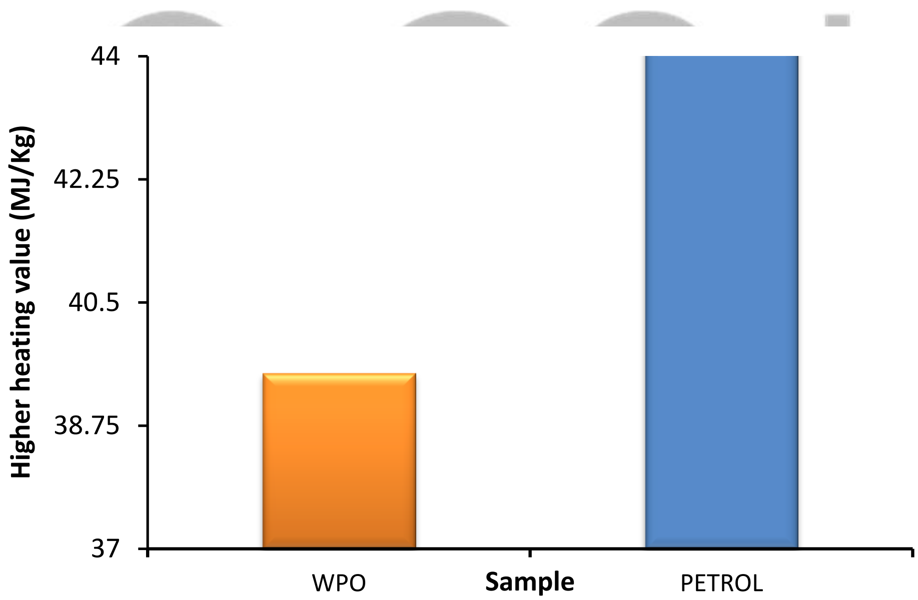

Fig. 4. Heating value of WPO vs. petrol.

Fuel density generally increases with increasing molecular weight of the component atoms of the fuel molecules. From Fig. 3 above, fuel density of WPO is 0.804 g/cm^3 while that of petrol is 0.740 g/cm$^{3.}$ This shows that the molecular weight of WPO molecules is higher than that of petrol. It means that the mass of WPO that can be stored in a given tank and its mass of fuel that can be pumped are greater than that of petrol.

It is demonstrated in Fig. 4 that WPO and petrol has heating value of 39.5MJ/Kg and 44.18MJ/Kg, respectively. The implication is that a complete combustion of one kilogramme of WPO produced 39.5MJ of heat, whereas for a complete combustion of one kilogramme of petrol, 44.18MJ was produced. This confirms that the conversion of waste plastic into fuel is able to supply an appreciable quantity of energy. Hence, the WPO is able to alleviate problems associated with depletion of conventional energy sources.

Conclusion

The benefits that can be derived from recycling waste plastic into fuel have been investigated in this research. The conversion of waste plastic into fuel will alleviate problems associated with depletion of conventional energy. From the analyses of the physiochemical properties carried out on the fuel and its comparison with that of the petrol, it has been established that the fuel obtained from the waste plastic can serve as an alternative energy source.

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