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PRODUCTION AND CHARACTERIZATION OF FUELS PRODUCED FROM POLYETHYLENE PLASTIC WASTE

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ABSTRACT

The goal of this effort is to convert low–density polyethylene (LDPE) plastic bags into liquid fuel through pyrolysis and characterize the resulting fuel. Recycling waste plastic is the one way to decrease the negative impacts by turning it into useful fuels like gasoline, diesel, etc. My findings from this study are useful and important because of two reasons:

- to get fuel from plastic waste.
- to reduce environmental problems.

Pyrolysis at 300 c in the absence of oxygen, with resulting fuel analyzed for density, pour point, cloud point, flash point, viscosity, TAN, sulfur content and cetane index. The fuel oil produced had properties comparable to conventional fuels like petrol and diesel.

KEYWORDS: Pyrolysis, Plastic waste, Low-density polyethylene, Fuel and Environmental problems.

1. INTRODUCTION

Plastic is versatile, light weight, flexible, moisture resistance, strong and relatively inexpensive. Those are attractive quality lead us around the world, to such voracious appetite and over consuming of plastic goods. Plastic products have become an integral part of daily life as a result of which the polymer products massive scale worldwide. [1] Several studies on managing organic waste have begun to be undertaken through several methods, such as methods on handling manure wastes [2] and agriculture crops [3].

In last 65 years' global disposable plastic production (GDP) increases to 7 million tonnes. India being second highest GDP and highest GDP growth rate among BRICS countries has +7.1% growth in 2016 [4]. Plastic bag waste littering causes health, environmental, and esthetic problems. It is significantly increasing in Sudan and has become a pressing issue, especially with the increasing trend of using plastic bags. plastic's low cost, non-biodegradable nature, simplicity of availability and management, and wide range of applications, its production and consumption rates have expanded dramatically. The Association of Plastic Manufacturers Europe (APME) estimated that the world's plastic manufacturing exceeded 280 million tons in 2011 and is still growing exponentially [5]. Due to disposal issues, the growing demand for plastic products also leads to a growth in the amount of plastic garbage, which poses a threat to the environment [6]. The need to find a more affordable and environmentally friendly fuel or to permit the use of secondary fuels in place of primary fuels to reduce the consumption of fossil fuels stems from the increase in energy demand and the depletion of conventional energy sources like fossil fuel reservoirs [7]. Since plastics are made from petroleum products, they have the potential to be used as an alternative energy source when their useful lives and production have grown worldwide due to factors such as rapid urbanization, economic development, and convenience in usage and manufacturing. In 2008, 245 million metric tons of plastic were produced worldwide [8]. Since 1950, the world's plastic manufacturing has grown by 10% year on average due to ongoing innovation and research into new and improved products. Because of the plastic's exceptional qualities—such as its low weight and non-corrosive nature—the metal and wood industries were severely impacted [9].

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Table 1 displays how long it takes for various waste products to degrade. Plastic garbage from developed nations like Canada, Denmark, Germany, the United Kingdom, the Netherlands, Japan, France, and the United States has been dumped in India [10].

Table no. 1

Type of litter	Time for degradation
Organic wastes, paper, etc.	1 – 3 weeks
Cotton cloth	8 – 20 weeks
Wood	10 – 15 years
Tin, aluminum, etc.	100 – 500 years
Plastic	A million years

2. EXPERIMENTAL WORK

A. Materials

The type of waste plastic is low-density polyethylene (LDPE) was collected from supermarkets and the preparation was done by washing drying and cutting.

B. Methodology

For the pyrolysis studies, finely chopped waste polyethylene shopping bags (made of LDPE) with a 2 cm2 area were employed, Figure 1 describe low density Polyethylene after cleaning and cutting. The pyrolysis was carried out in the chemical engineering faculty unit operation lab at the University of Khartoum, Sudan.

The pre-processed waste plastic materials were poured into a 1000 ml glass flask with an empty spherical bottom. The round bottom flask weighed 343.12 g when it was emptied. Following the loading of the raw materials into the flask with a circular bottom, the condenser was attached to the aperture and the receiving adapter was linked to the condenser. A heating mantle holds the flask with a round bottom in place. At the lower end is where the oil is collected. The temperature was kept between 30 and 240°C throughout the entire process, and a vacuum pressure of roughly 300 mm Hg was maintained. The spherical bottom flask was sealed off with a vacuum created by a vacuum pump. The gradient was used to raise the temperature.

In (Fig. 2), the experimental setup is displayed. The oil collector was used to gather the condensed oil. 110°C is the melting temperature of polyethylene. The gathered oil underwent reflux and further distillation. Low-density polyethylene is the raw material, and its density and melt flow index are both 0.910.

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Figure 1: LDPE after cleaning and cutting

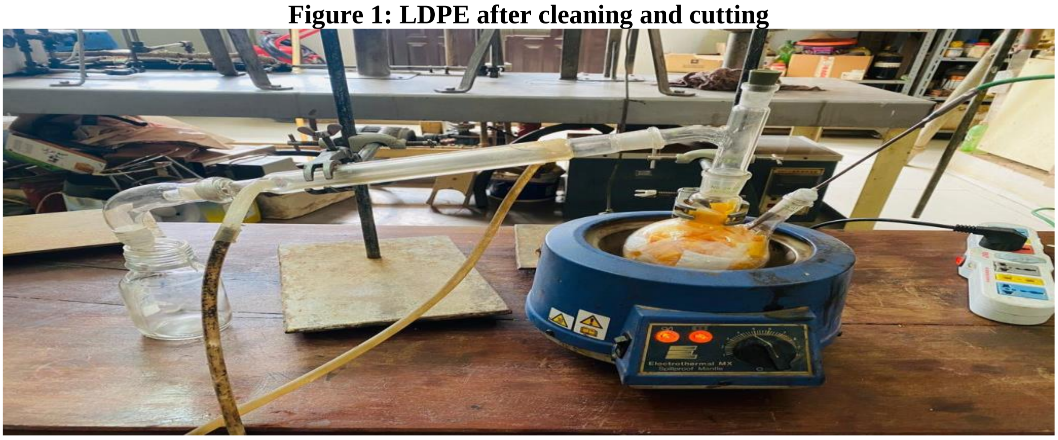

Figure 2: Pyrolysis process for conversion of waste plastic into fuel

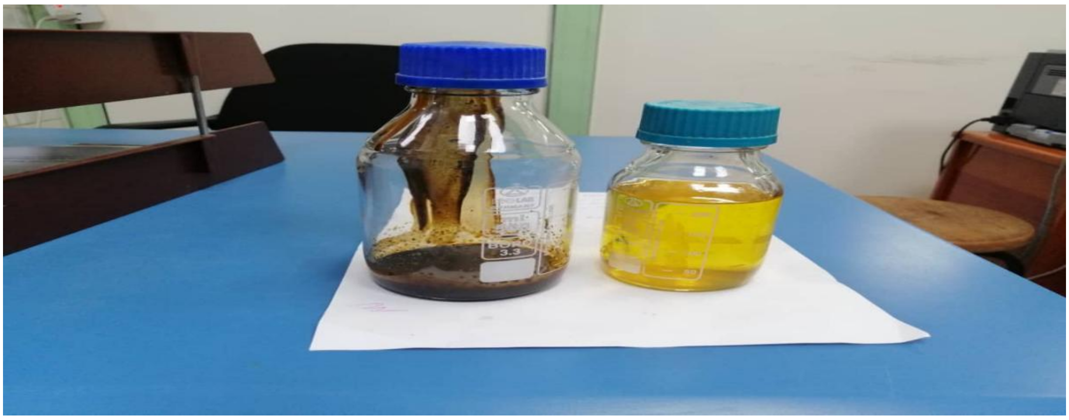

Figure 3: Oil and residue from the LDPE pyrolysis process

The pyrolysis of the plastic wastes was carried out in a batch pyrolysis reactor of 200 g capacity. The reactor was made out of heavy heat resistance round-bottomed glass, which contained provisions for the temperature logger and the connection point for the fractionating column. The column was connected to the condenser with running water for cooling the vapors from the process into a liquid. Plastic wastes (100 g) were put in the reactor. The reactor was heated up to 370 °C. The temperature was observed in the narrow range of 250 to 370 °C. The

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produced vapors from the reactor were liquefied with the help of 28 of the condensers and the liquid was collected in a batch. Then the liquid was weighed and recorded to compute the yield per batch.

C. LABORATORY TESTS

The density, pour point, color, flash point, kinematic viscosity, sulfur content, total acid number (TAN) and cetane index of plastic oil products were measured.

3. RESULTS:

The standard tests were performed on the collected oil sample in Petroleum Laboratories Research and Studies (PLRS), Ministry of Petroleum, Sudan. After that checked with the refinery lab of Khartoum Refinery Company (KRC). Tables 2 and 3 show the results.

Table 2: Khartoum Refinery Company report (KRC)

Properties	specification		results	Test methods
Distillation				ASTM D86
50%vol.recovered at °C	300.0	max	246.4	
90%vol.recovered at °C	355.0	max	333.3	
95%vol.recovered at °C	370.0	max	353.0	
Kinematic viscosity at 40 °C, CST (mm2/s)	1.9 - 4.1	/	1.496	ASTM D7042[11]
Sulphur, total, %mass	0.05	max	0.0003	ASTM D5453[12]
Cetane index,(calculate)	45.0	min	68.2	ASTM D4737[13]
Acid number, mgKOH/g	Report	/	0.071	ASTM D974[14]
Density at 15°C, kg/m3	Report	/	780.6	ASTM D4052[15]

Table 3: Petroleum Laboratories Research and Studies Report (PLRS)

Test name	Test method	Unit	Result
Density @15°C	ASTM D4052	g/ml	0.77923
SG			0.77999
API			49.91
Distillation	ASTM D86		
50% recovered		°C	246.4
90% recovered		°C	333.3
95% recovered		°C	353.0
Cetane index	ASTM D976	Cal	68.2
Pour point	ASTM D97[16]	°C	-9
Cloud point	ASTM D97	°C	+2
Color	ASTM D1500[17]		1.5ASTM color
Kinematic viscosity@40°C	ASTM D445	Cst	1.496
TAN	ASTM D664	mgkoH/g	0.07
Sulfur content	ASTM D4294	%m	0.05

4. DISCUSSION:

The results of the collected LDPE oil from pyrolysis were compared to the parameters of standard oil, and it gave results within the standard range. Following are the conclusion drawn from the experiment/project:

• Higher plastic oil yield occurs at 350°C, which equal to 784 grams/kg.
• Plastic oil consists of additional oxygen molecules (hydroxyl group) in its structure.

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• Density, calorific value for plastic oil is lower and viscosity is higher than that of diesel.
• Flash and fire point of plastic oil are well comparable with diesel.
• Brake thermal efficiency is higher than of pure diesel.

From the results of testing the plastic waste pyrolysis oil our findings show that analyzed for its characteristics as in table 4 below:

Table 4: COMPARISON LDPE OIL WITH PETROL AND DEISEL OIL

Fuel properties	LDPE	PETROL	DIESEL
Density	780.6 kg/m3	711 to 737 kg/m3	820 to 900 kg/m3
Specific gravity	0.7528	0.82	0.81 to 0.96
Viscosity	1.496 poise	1.5 to 4 poise	1 to 3.97 poise
Flashpoint (°C)	23	22	26
Cloud point (°C)	+2	1 to 3	2.5 to 4
Pour point (°C)	-9	-4 to -20	-2 to-12
Color	Orange	Brown transparent	Dyed blue

5. CONCLUSION

The results of this study indicate that the conversion process of LDPE plastic waste into oil fuel is very promising. The results showed that the pyrolysis process was able to convert almost 90% of LDPE plastic into oil fuel at a temperature of 350 °C. This pyrolysis process of converting this plastic waste also does not require a large heating temperature, thus saving energy.

This process can improve the physical properties of oil yields. The increase in pyrolysis temperatures will result in an increase in oil yield densities, viscosities, flash points, calorific values, and octane numbers affected by the change in atomic mass, chemical structure, carbon chain, amount of PAH formed, and alkyl groups of constituent compounds. In summary, this study recommends that 350 °C is the appropriate pyrolysis temperature because it has the highest product capacity of oil yields, wherein their properties are within the range of the standard oil fuels properties. However, further studies are necessary to utilize pyrolytic oil as liquid fuel or feedback.

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