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Production of Combustible Fuel Using Waste Polythene Bags

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Abstract: *The worlds energy consumption is projected to 580 million tera joules of which fossil fuels accounts for 83% of the energy used in 2022, globally roughly 500 billion plastic bags to an astounding 5 trillion are being utilized annually. Nigeria produces about 32 million tons of waste every year and is ranked ninth worldwide among the countries contributing to plastic pollution. Maiduguri, Nigeria, grapples with a significant waste management challenge with over 825 tons of waste is produced monthly of which most are non-biodegradable. These non-biodegradable materials can be tremendously dangerous to the environment if improperly disposed of. In order to address this problem, a catalytic pyrolysis was been conducted at the Department of Mechanical Engineering, University of Maiduguri, Borno State to remove useful fuel from waste plastic (polythene) bags. An electricity-powered pyrolysis reactor that could treat up to 700g of waste polythene bags was used in this study. 500g of waste polythene bags were combined with 125g of manganese dioxide and 62.5g of ammonium molybdate. The mixture was then put into the reactor and cooked for 25 minutes, or until 315^{o}C was reached. Following condensation and separation, the combustible fuel, oil, and byproduct (insulating materials) were collected in 0.06 litres (33.33g), 0.2 litres (45.67g), and 335.33g, respectively. The obtained fuel had a yellowish colour, a flash point temperature of 32^{o}C, and a calorific value of 45 MJ/Kg. Additionally, the results indicated that 670.660 kg of insulation material and about 120 litres of combustible fuel and 400 litres of oil could be retrieved from 1000 kg of waste plastic.*

Keywords: *Renewable energy, biofuel, pyrolysis, waste management and polythene bags.*

1.0 INTRODUCTION

The need for energy is increasing continuously due to increased industrialization activity and population growth. In addition to the issue of global warming, scientists are encouraged to develop fuel substitutes that are renewable and sustainable. By 2030, the world's energy needs are predicted to rise by 50% (Greicili, et al., 2023). According to United Nations in 2019 the world's population has shot up from about 2.53 billion in 1950 to over 7.79 billion in 2020, a massive 207.9% increase (Amirhossein, et al., 2023). Another report says there was about a 55% increase in the global population between 2018 and 2020, these numbers are expected to keep going up, with projections estimating more than 10.9 billion people by 2100, which is a 40% increase (Amirhossein, et al., 2023). This population growth is a concern because it could lead to the depletion of our current primary energy resources within the next 133 years. (Amirhossein, et al., 2023). According to the Federal Ministry of Environment, Nigeria produces about 32 million tons of waste every year (FATE Foundation, 2022) and is ranked ninth worldwide among the countries contributing to plastic pollution. Only 12% of plastic waste in Nigeria is currently recycled, 88% is being dumped in unauthorized places, landfilled or incinerated all of which are not environmentally friendly. However, it is possible to produce up to 800 liters of liquid fuel from one ton of waste plastic (Bosnjakovica, et al., 2022). This shows that up to 25.6 billion liters of liquid fuel can be obtained from waste plastic generated in Nigeria annually. There is still a long way to go and still face several challenges (Pathak, et al., 2020; R. Palos, 2020). The importance of planning energy supply for the future becomes evident when you take into account that the annual global energy consumption rose during the 20th century. Future Energy System studies the energy technologies of the near future, looks at how they fit into the infrastructure of the present, and takes into account the effects they will have on society, the economy, and the environment. The worlds energy consumption is projected to 580 million tera joules of which fossil fuels accounts for 83% of the energy used in 2022, globally roughly 500 billion plastic bags to an astounding 5 trillion are being utilized annually (Yue, et al., 2023). The main driver of climate change leading to global warming is the combustion of fossil fuels, which releases harmful gases into the atmosphere, recently the world has been burning approximately 1000 barrels of fossil fuel per second (Lund, et al., 2022). If the global temperature increases by 2ºC, millions of people are expected to suffer fatal consequences (Khandaker, et al., 2022). The tension between environmental concerns and the need for economic growth will intensify in the coming three decades (Londoño-Pulgarin & Muñoz-Leiva, 2021).Improper disposal of non-biodegradable materials can result in substantial environmental harm. Moreover, their incineration in open spaces contributes significantly to air pollution (International Energy Agency, 2014). With the ongoing escalation in plastic consumption, the disposal of used plastic materials presents a persistent challenge due to their non-biodegradable nature. Landfilling or incineration of these materials further exacerbates environmental pollution.

Pyrolysis is a widely used method for extracting fuel from waste plastic, particularly for the production of liquid fuel from waste polythene bags. This procedure entails subjecting the plastic to elevated temperatures of about 300°C, inducing its dissolution and consequent alteration in chemical structure (Kumaravel, et al., 2016). The macromolecular structure of the polymer breaks down into smaller hydrocarbon chains of petroleum products. Pyrolysis is a straightforward technique that yields more efficient outcomes compared to alternative methods. Chemical recycling, synonymous with pyrolysis, involves the breakdown of the complex structure of waste polythene bags into smaller molecules, and in certain instances, into individual monomeric units. The subsequent disintegration of these molecules relies on various factors such as the presence of catalysts, duration of stay, temperature, and other process-specific conditions. The pyrolysis reaction can be carried out with or without the presence of a catalyst, and it can be thermal or catalytic; Moreover, liquid fuel enhances lubricity, potentially leading to an extended lifespan for engine components (Chen, et al., 2014; Fukuda, 2011; Jain & Sharma, 2010; Rajput, 2005). Extensive research has been conducted on pyrolysis, employing various traditional reactors ,which includes; fluidized bed (Ly, et al., 2015; Yanik, et al., 2013); fixed bed (Aguiar, et al., 2008; Islam, et al., 2008; Quan, et al., 2016), rotary kiln, vacuum (De Jongh, et al., 2011), and free fall (Zhang, et al., 2007) reactors and many more. However, using a catalyst can improve the cracking reaction during pyrolysis. The selection of an appropriate catalyst plays a vital role in determining both the oil yield and quality derived from the pyrolysis of plastic waste. Implementing a catalyst can decrease the necessary reaction temperature and time, while also amplifying the production of gaseous products, thereby reducing the overall process cost and enhancing economic feasibility (Sadegh, et al., 2021). The aim of this study is to eliminate non-biodegradable waste, specifically polythene bags, from our surroundings. Furthermore, the aim is to utilize these waste polythene bags to produce valuable combustible fuel, contributing to economic development. Moreover, the by-product derived from this process can be utilized as an insulating material.

2.0 METHODOLOGY

2.1 Material

Polythene bags were specifically selected as the source of waste plastic due to their significant contribution to the total volume of plastic waste. The waste polythene bags utilized in the production of liquid fuel through the process of pyrolysis were sourced from the University of Maiduguri, Borno State.

2.2 Experimental set up

The experimental setup depicted in plate 1 shows several components, including a reactor, a ceramic electric heater, a metal container, condensers, a coil, a pressure gauge, a temperature sensor, and an oil collector.

Plate 1: Experimental set up

The reactor can accommodate up to 700g of waste polythene bags. These bags, packed at a density of 500g, are enclosed within a metal container, which is subsequently positioned inside the heater. The waste polythene bags were mix with the catalyst; Manganese dioxide and Ammonium molybdate at a ratio of 2:1.

The pyrolysis process was carried out using a waste polythene bag to catalyst ratio of 4:1, maintaining a reaction temperature of approximately 315°C. The reactor was oriented vertically, with the waste polythene bags first undergoing a drying process before being combined with the test catalyst. The metal container employed during the pyrolysis process is specifically engineered to endure high temperatures. The container is equipped with a high-powered heat source that rapidly attains and sustains elevated temperatures. After the waste polythene bags are cleaned, they are loaded into the container for subsequent processing. Once the polythene bags are placed inside, the container is heated using an electric heat source in an environment devoid of oxygen.

After achieving the target temperature, it is held steady for an allotted duration of 30 minutes. During the pyrolysis process, the bulky molecular structure of the waste polythene bags undergoes fragmentation, leading to the formation of smaller molecules. In the absence of oxygen, the combustion of polythene bags does not lead to ignition; rather, it results in a controlled burn, generating a gaseous state. The gaseous fuel is then directed to a condenser, where its temperature is lowered, inducing its transformation into a liquid state recognized as partial fuel. Following the designated reaction time, the heater is deactivated; however, the process persists for an extra 30 minutes to ensure that the maximum volatile fraction generated passes through two heat exchangers. After extracting the partial fuel from the waste polythene bags, it is reintroduced into the container for the subsequent distillation process. Ultimately, the fuel obtained from the container through distillation is gathered and stored in a bottle. Plate 3 and 4 after the pyrolysis process.

Plate 2: After the pyrolysis process

3.0 RESULTS

The outcome of the experiment shows that 0.06 liters (33.33g) of fuel were gathered, accompanied by 0.2 liters (45.67g) of oil and 335.33g of by-product (insulating material). The tested yellowish fuel exhibited a calorific value of 45 MJ/Kg, with a flash point temperature measuring 32°C. The plates 3 and 4 illustrate the liquid oil, along with the by-product, which can be used an insulating material respectively.

Plate3: Crude oil collected

Plate 4: Insulating material

The findings show that, following condensation and separation, 0.06 liters (33.33g) of fuel, along with 0.2 liters (45.67g) of oil and 335.33g of byproduct (insulating material), were collected. The extracted yellowish fuel underwent testing, revealing a calorific value of 45.13 KJ/Kg and a flash point temperature 32°C. The results suggest that approximately 120 liters of fuel and 400 liters of oil can be obtained from 1000 kg of waste plastic, alongside 670.660 kg of byproduct (insulation material).

4.0 CONCLUSION

The non-biodegradable waste in the form of polythene bags was successfully eliminated from the environment. As a result, it can be inferred that is possible to obtain combustible fuel from these bags. Additionally, the waste polythene bags can yield by-products that can be used as an insulating material. The produced oil derived from the waste polythene bags is combustible, and has a calorific value of 45 MJ/Kg and a flash point temperature of 32ºC.

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