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Pyrolysis of Various Plastic Wastes for Liquid Fuel Production and Analysis of Liquid Hydrocarbon Fuels

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ABSTRACT

The consumption of plastics has been on a sharp rise in the 21st century pyrolysis is a efficient method in dealing with single use and waste plastic which doesn't naturally breakdown, and ends up in landfills. Pyrolysis of polyethylene (PE), polypropylene (PP) & Ultra high molecular weight polyethylene (HM) plastic waste in the form of carry bags & packaging bags was carried out within a fabricated steel reactor in which no exchange of air takes place. Experiments were carried out individually for each type of plastic used as they possess different physical & chemical properties. For the reaction plastics of about 120-150 grams were used. A vacuum environment was created by using a seal in steel reactor. Reactor was kept in muffle furnace & temperature around 370˚C-550˚C was kept in the reactor. Reaction was carried out in the presence of Activated carbon as a catalyst. It was found that at temperature around 350˚C -370˚C liquid fuel started coming out from the reactor for polyethylene (PE), at temperature around 380˚C-390˚C for ultra-high molecular weight polyethylene (HM) & at 370 ˚C-410˚C for Polypropylene. Time required for completion of pyrolysis process was around 2.5-4.0 hrs. Analysis of oil samples of PE, PP and HM were done on Atomic Absorption Spectroscopy (AAS) for determination of heavy metals calorific value of oil sample was done by digital bomb calorimeter. The results showed that the oil samples contained nil amounts of lead & extremely low levels of sulphur contents.

Keywords: Polyethylene, polypropylene, ultra high molecular weight polyethylene, PE, PP, HM, Muffle furnace, Atomic absorption Spectroscopy, AAS

1. INTRODUCTION

With rapid industrialization and urbanization, there has been a rise in the production and usage of plastic-based products. In Asia and the Pacific, as well as in many other developing countries, the consumption of plastic has been increasing due to urbanization and economic growth. The world's plastic consumption has increased from around 5 million tons in the 1950s to nearly 400 million metric tons per year. 99 percent of plastic being produced uses natural gases, crude oil, and chemicals derived from fossil fuels. Plastics are non-biodegradable polymers mostly containing carbon, hydrogen, and a few other elements such as chlorine, nitrogen, etc., and also contain chemicals that are known to threaten human health. This plastic doesn't decompose, but it breaks down into micro-plastic, which enters the bloodstream and organs through food, skin penetration, and lung exposure. Due to its non-biodegradable nature, the plastic waste contributes significantly to the problem of municipal waste management. Due to the increase in generation, waste plastics are becoming a major stream in solid waste [2]. Plastic waste recycling can provide an opportunity to collect and dispose of plastic waste in the most environmentally friendly way, and it can be converted into a resource. In most of the situations, plastic waste recycling could also be economically viable, as it generates resources, which are in high demand [1].Waste plastics are mostly land filled or incinerated; however, these methods are facing large social resistance because of environmental problems such as air pollution and soil contamination [3]. Plastics pyrolysis, on the other hand, may provide an alternative means for disposal of plastic wastes with recovery of valuable liquid hydrocarbons [4]. Pyrolysis is also not a toxic or environmentally harmful emission, unlike incineration [5]. The present work focuses on the presence of heavy metals & properties of liquid fuels obtained from various plastics in comparison with petrol & diesel.

Fig. 1.1(a),(b),(c) Plastic Samples used in Pyrolysis

2. METHOD & MATERIALS

In this present work, experiment was carried out using activated carbon as a catalyst. Feed stock used for the process was carry bags & packaging bags of polyethylene (PE), polypropylene (PP) & ultrahigh molecular weight polyethylene (HM) were used individually for generation of liquid fuel.
These bags were manually shredded into small pieces of uniform size about 5-10mm using scissor. The amount of material used for each process was about 120-150 gram. The experiment was done in the presence of catalyst Activated carbon &with different plastics individually in separate experiments 30% of activated carbon was mixed.
This whole setup consisted of a reactor fabricated from steel in which shredded waste plastic mixed with activated carbon is kept in the steel reactor for pyrolysis after filling the material reactor is closed in such a way that the whole arrangement is airtight. This steel reactor is kept in muffle furnace. At the tip steel reactor condenser is placed for cooling of vapors.
The experiment was started with gradual increase in temperature up to 550˚C. At temperature around 370˚C we started getting the liquid fuel. The vapors coming out from the reactor were passed through the condenser & liquid was collected in bottle. Around 30-40 minutes were required to start receiving the distillates. The whole process continued up to 3hrs-4.5hrs. After which it was filtered using ordinary filter paper. From three types of plastics three samples were collected of PE, PP &HM for chemical analysis.

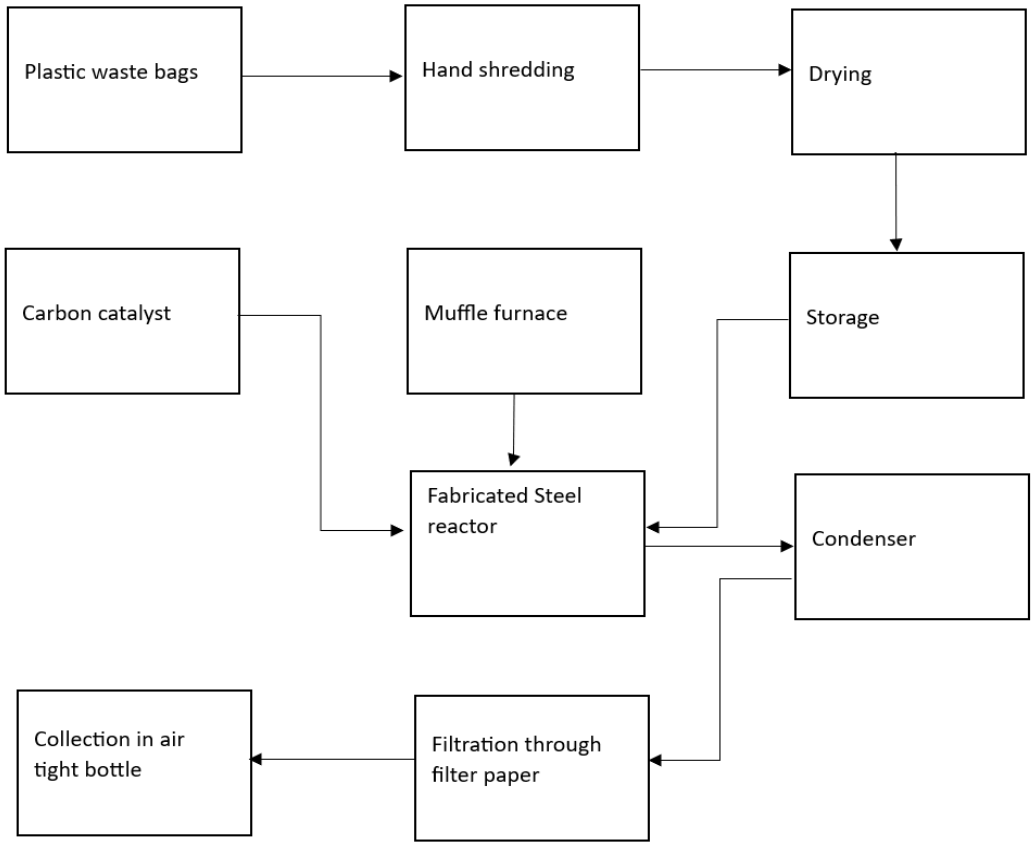

Fig.2 Flow Chart For Pyrolysis

3. PYROLYSIS

Pyrolysis is an effective method for recycling of inorganic plastic waste which are hard to decompose being non-biodegradable usually ending up in landfills. Pyrolysis as a method heats the plastic in a reactor in the presence of a catalyst at high temperatures. In pyrolysis, plastic wastes are converted into solid, liquid, or gaseous fuels via the thermal degradation of long-chain polymers into shorter and simple molecules in the absence of oxygen. The main products of pyrolysis are combustible gas with high calorific value, combustible oils, and carbonized char. [6] The pyrolysis process of synthesizing useful chemical products uses a technique that is the opposite of the Fischer-Tropsh (F-T) process. In the F-T process, carbonaceous material e.g. coal, is first combusted in order to give syngas (CO + H2). The syngas is then synthesized into targeted higher molecular chain hydrocarbons e.g. petrol, diesel and paraffin [7]

4. EXPERIMENTAL RESULTS

Properties of the liquid fuel obtained from the oil samples of polyethylene (PE), polypropylene (PP) & ultra-high molecular weight polyethylene (HM). Calorific values of oil samples of plastics were found out by using bomb calorimeter. Flash point of oil sample was found out by using Abel's flash point apparatus. The results of oil obtained from polyethylene (PE), polypropylene (PP) & ultra-high molecular weight polyethylene (HM) were compared with gasoline & diesel fuels in these results showed that oils produced from the PP, PE, HM were nearly similar as well as in the range of the diesel.

Table 1 Comparisons between Plastic Oils, Gasoline & Diesel

S.No.	properties	Polyethylene(PE)	Ultra high mol. wt. polyethylene (HM)	Polypropylene(PP)	gasoline	diesel
1.	Colour	Reddish yellow	Reddish yellow	Reddish yellow	Pale yellow	amber
2.	Density	0.798gm/cc	0.811gm/cc	0.805gm/cc	0.71-0.77gm/cc	0.833-0.855gm/cc
3.	Specific Gravity	0.797gm/cm^3	0.809 gm/cm^3	0.805 gm/cm^3	0.72-0.78gm/cm^3	0.85 gm/cm^3
4.	Calorific value	45.69MJ/Kg	44.98 MJ/Kg	45.58 MJ/Kg	46.9MJ/Kg	43.7MJ/Kg
5.	Ash content	0.02	0.01	0.02	0.01	0.01
6.	Carbon residue	0.29	0.27	0.26	0.25	0.25

Presence of heavy metals were determined using atomic absorption spectroscopy (AAS) in the oil samples of polyethylene(PE), polypropylene (PP) & ultra-high molecular weight polyethylene (HM).For oil sample of polyethylene showed nil presence of chromium. Also oil samples of PE, PP & HM showed NIL presence of Lead & Nickel also all the samples showed presence of very small amount of sulphur content.

Table 2 Presence of Heavy Metals in Plastic oil.

S.No.	Heavy metals	Polyethylene(PE) Mg/kg	Ultra high mol. wt. polyethylene (HM) Mg/kg	Polypropylene(PP) Mg/kg
1.	Chromium	NIL	0.051x100	0.041X100
2.	Manganese	0.1X100	0.018x100	0.11X100
3.	Iron	3.11X100	3.21x100	3.0X100
4.	Copper	0.02X100	0.017x100	0.0224X100
5.	Nickel	NIL	NIL	NIL
6.	Lead	NIL	NIL	NIL
7.	Zinc	0.088X100	0.178x100	0.229X100
8.	Sulphur	<.002X100	<.002X100	<.002X100

5. CONCLUSION

Pyrolysis of polyethylene (PE), polypropylene (PP) & ultra-high molecular weight polyethylene (HM) in the form of carry bags, shredded & mixed with activated carbon in the ration 1:3 gives yield in the form of liquid fuel, waxy & gaseous products. At the temperature around 370˚C oil is obtained. In the temperature around 390˚C-410˚C oil yield rate is fast.

The time required for completion of process is about 3.5hrs.-4hrs when temperature in muffle furnace is increased gradually. The oil obtained from catalytic pyrolysis of PE, PP & HM have higher calorific values as compared to that of diesel fuel.

Also the oil obtained from catalytic pyrolysis possesses Lead & Nickel in Nil amounts. Also in sample of oil obtained from polyethylene possess chromium in nil amounts. This paper shows that oils obtained from various plastic contains very small amount of heavy metals & extremely low level of sulphur content.

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