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Studies on Waste Plastics to Extract Oil By Pyrolysis Method and Its Applications

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This study investigates the conversion of waste plastics into useful petroleum product by vacuum pyrolysis method. The raw materials used in the present study has been collected and optimized at a temperature and pressure of 700 ºC and 3.5 Kpa, respectively. Experiment was conducted in a batch scale reactor to collect the products from the pyrolysis reactor. In the presence of catalyst, the hydrocarbon molecules were split up at 80- 300 ºC inside the pyrolysis reactor. This process has been carried out to produce the petroleum products such as oil for transport sector for the future generation. Large amount of yield was obtained by reduction process at a temperature of 600-700 ºC when it is used as single feed. Hence, this method has been carried out to extract oil from waste plastics from commercial and tourist spots and it can be used as a fuel for vehicles in fore coming years in transportation sector.

Keywords: Pyrolysis, Waste Plastics, Catalyst, Fuel, Transportation.

INTRODUCTION

Plastic is one such commodity that has been extensively used and is referred to as one of the greatest innovations of the millennium. Plastics are one of the essential commodities which provide surplus economic benefits to the society and to the environment. However, the non-biodegradability of these plastics has made their disposal a serious environmental issue. All the commonly employed disposal methods have inherent disadvantages and are not suitable for the ever increasing amount of waste plastics being generated. The littering of these wastes has resulted in a general deterioration of hygiene in urban areas as well as threat to the biodiversity in earth`s land and marine region alike. Due to this, plastics production has gone up by almost 10% every year on a global basis since 1950 [1]. There are two types of plastics. One is thermoplastics and other is thermosetting plastics. Thermoplastics make up 80 % of the plastics and thermoset plastics make up of remaining 20 % of plastics produced today. Thermo plastics can re-melt or remold and therefore it recyclable easily but thermoset plastics cannot re-melt or reshape and therefore it is difficult to recycling [2]. Use of different type of some thermo plastics is given in Table-1 below. Plastics are relatively cheap, easy available, easy to manufacture and their versatility replace to conventional materials. High-density polyethylene (HDPE), low-density polyethylene (LDPE) and linear low-density polyethylene (LLDPE), are the types of polyethylene used in beverage and food containers because their chemical composition makes them inert and, therefore, not likely to degrade or interact with any of the chemicals normally found in things we're going to eat [3]. Unfortunately, the standard industrial method to recycle such plastic waste usually involves less "friendly" forms of disposal. In fact, standard methods probably cause more harm than good as they employ caustic chemicals or require heating the materials to more than 700 ° F (370 ºC) to fracture the polymer's chemical bonds, and produce harmful by-products such as hydrocarbon gas, oil, wax, and char in uncontrolled amounts in the process [4].

Monomers are produced from condensation polymerization reaction such as polyethylene terepthalate and Nylon-6,6 to enhance the degradation [5]. Some catalysts which are solid in nature such as zeolite, alumina, ZSM-5, *etc*. also used for the production of liquid fuel [6]. Catalytic cracking is the most efficient method to produce the liquid fuel from the poly olefin compounds. By recycling these waste plastics, cleaner fuels can be produced.

EXPERIMENTAL

Collection of raw materials: Raw materials such as polythene covers, PET bottles, *etc*. has been collected in and around of East Coast Road, Chennai, India. High-density polyethylene (HDPE) was collected in the form of garbage containers, low-density polyethylene (LDPE) as used low-grade plastic bags, polystyrene (PS) in the form of disposable cutlery, polypropylene (PP) as used waste plastic containers, and polyethylene terephthalate (PET) as used plastic bottles [7]. The melt flow index (MFI) and the density of the raw materials are listed in Table-1.

TABLE-1
MELT FLOW INDEX AND THE DENSITY VALUE OF THE RAW MATERIALS

Waste plastics	Source	Density (g/cc)
Polypropylene	Plastic containers	60
Polystyrene	Disposable cutlery	11.5
High-density polyethylene	Garbage containers	8.6
Low-density polyethylene	Plastic bags	80
Polyethylene terephthalate	Plastic bottles	12

Catalyst: The catalyst influences not only the structure of the products, but also their yield [8]. Hence the results of pyrolysis in the absence of catalyst were compared with results obtained by pyrolysis which was carried out in the presence of catalyst *viz.* activated carbon, granulated charcoal and calcium oxide [9]. Due to its high degree of micro porosity, just 1 g of activated carbon has a surface area in excess of 500 m^2/g, as determined by nitrogen gas adsorption.

Pyrolysis process: It is one of the technology which is used to produce a fuel which is cleaner having a greater calorific value from a greater stream of biomass and other streams [10]. This is carried out in the absence of air at elevated temperature in which decomposition of organic waste will takes place. The long chain of hydrocarbon will break into smaller hydrocarbons under the conditions of temperature and pressure [11]. Decomposition of hydrocarbon molecules inside the reactor will takes place at 80-300 ºC under catalytic conditions [12]. Redox process takes place at a temperature of 300 ºC. The product yield was 96% in the form of liquid.

Experimental setup: The reactor used to convert the plastics to waste fuel is one of a batch reactor. The major difference between a batch and semi-batch operations is vacuum, which enhances the temperature loss of the reaction to take place inside the round bottom flask. In this study, two types of plastics were used. (a) Individual types of plastic and (b) mixed types of plastics (Fig. 1). The composition of individual and mixed plastic wastes is given in Tables 2-4.

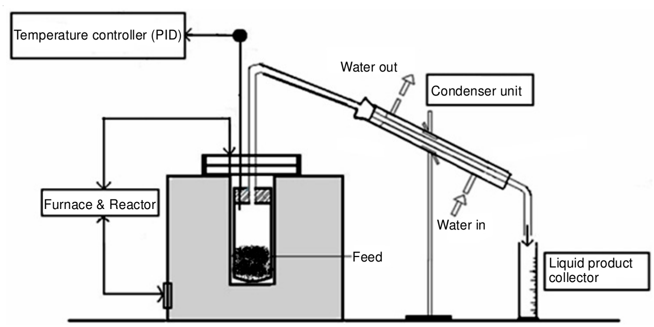

Fig. 1. Pyrolysis setup

TABLE-2
INDIVIDUAL WASTE PLASTIC FOR NON-CATALYTIC DEGRADATION PROCESS

Individual plastic materials	Weight (g)
Polyethylene	18.4
Polypropylene	30.4
Polystyrene	20.0

TABLE-3
MIXED WASTE PLASTICS FOR NON-CATALYTIC DEGRADATION PROCESS

Mixed plastic material composition	Weight (g)
Polyethylene	22.6
Polypropylene	25.0
Polystyrene	21.3

TABLE-4
MIXED WASTE PLASTICS CATALYTIC DEGRADATION PROCESS (ACTIVATED CARBON)

Mixed plastic material composition	Weight (g)
Polyethylene	23
Polypropylene	24.2
Polystyrene	18

The apparatus consists of an empty rounded glass flask having 1000 mL as volumetric capacity. The waste plastics are then transformed into it and the initial weight of the flask was estimated as 350 g. After this, the open was fixed to a condenser and then to a receiver. The flask was then placed in the heater. The liquid starts to collect at the lower end of the flask. To maintain the temperature and pressure, 30-280 ºC and 300 mmHg is optimized for the reaction.

RESULTS AND DISCUSSION

Amount of yield consumption by using different plastics without catalyst: It is observed that when a plastic material like polyethylene is used as solo material without the support of a catalyst, the yield is 74 % whereas in polystyrene material [13], the yield is about 82 %. When combination of plastics is used, the yield is about 66 % with less amount of residue [14] (Fig. 2).

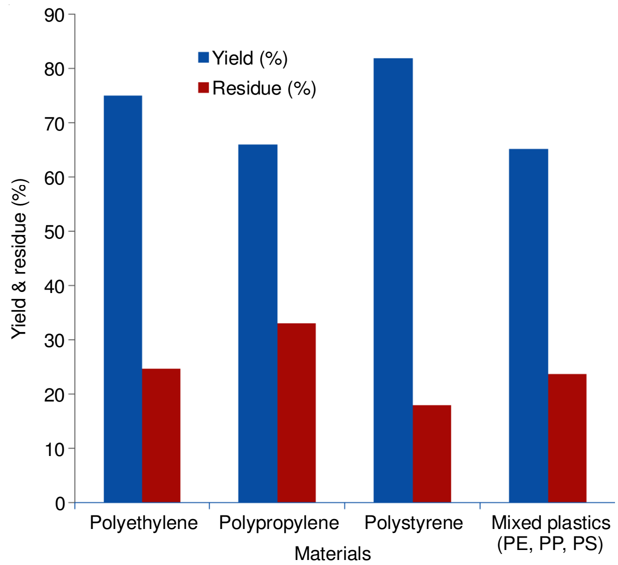

Fig. 2. Yield and residue percentage with different types of plastics

Amount of yield consumption by using different plastics with catalyst: It is observed that mixed plastics (polyethylene, polypropylene and polystyrene) in the presence of a catalyst the yield is 84% whereas in other mixed plastics containing polyethylene, polypropylene, polystyrene and polyethylene terephthalate, the yield is about 72% (Fig. 3, Table-5). The residue is less in all combination types of plastics used.

TABLE-5

Plastic materials	Catalyst	Yield (%)	Residue (%)	Temp. (°C)	Reaction time (min)
Polyethylene (PE)	No catalyst	75.00	24.78	300	25
Polypropylene (PP)	No catalyst	66.00	33.12	300	30
Polystyrene (PS)	No catalyst	82.00	17.94	300	35
Mixed plastics (PE, PP, PS)	No catalyst	65.23	23.78	300	40
Mixed plastics (PE, PP, PS)	Activated carbon	84.36	15.87	300	45
Mixed plastics (PE, PP, PS)	Charcoal	94.65	4.23	300	50
Mixed plastics (PE, PP, PS, PET)	Cao + activated carbon	78.12	21.45	300	55

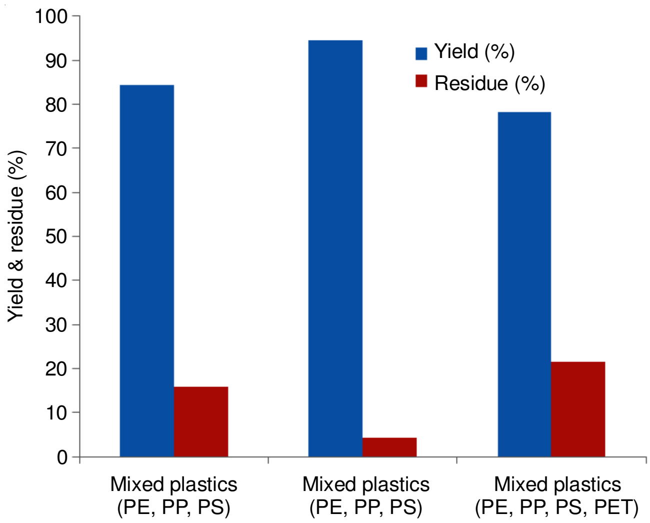

Fig. 3. Yield and residue percentage with different types of plastics

Conclusion

A simple catalytic and non-catalytic process was used for depolymerizing the waste plastics (individual and mixed plastics) to synthetic crude oil has been developed and further refined using a laboratory scale distillation followed by condensation process. The residue obtained from the distillation process can be used as lubricants for various purposes. The fuel produced by liquid fuel production method has more points of similarity with normal petrol. Liquid fuel production method is found to be cheaper and advantageous compared to the other methods. It is economical and has more number of similarities with normal petrol. Mileage of the fuel produced by the liquid fuel production method is also better. The heating value is also found to be comparable with the normal petrol.

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