Pyrolysis of Fuel from Waste Plastic

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***Abstract*— Over 1.3 billion metric ton of plastic is being manufactured every year to meet the demands of modern world. Plastic is made by polymerization of hydrocarbons. These hydrocarbons are of typically high molecular mass and may contain some other additives to enhance the capabilities of the final product. Plastic is an important material which is strong, durable, and cheap and has numerous other properties. The increased demand and high price for energy sources are driving efforts to convert organic compounds into useful hydrocarbon fuels. Although much of this work has focused on biomass, there are strong benefits to deriving fuels from waste plastic material. Waste plastic is abundant and its disposal creates large problems for the environment. Plastic does not break down in landfills, it is not easily recycled and degrades in quality during the recycling process, and it can produce waste ash, heavy metals, and potentially harmful gas emissions if incinerated at high temperatures. However, thermal processes can be used to convert plastics into hydrocarbon fuels such as gasoline, diesel, aviation / jet fuel, which have unlimited applications in airline industries, helicopter, heavy transportation, and electricity generation. The method and principle of the production/process will be discussed.**

***Index Terms:* Pyrolysis, Decomposition, Plastic Waste, Green Technology, Waste Management.**

1.INTRODUCTION

In the world a total of over 100 million tonnes of plastic is manufactured to meet global plastic demand. This much production and consumption of plastic is a threat to environment as it takes several years to decompose naturally.

According to ASTM (American Society for Testing and Materials) D5033-00, plastic recycling methods are of four types on the basis of final products. The tertiary or chemical recycling degradation is one of the categories. From this method of chemical degradation, liquid fuels and high value-added chemicals are produced by waste plastic fragments. One of tertiary recycling method is pyrolysis.

Pyrolysis

Pyrolysis is a process of decomposing plastics by heating in absence of oxygen generating gaseous and liquids products which can be utilized as fuels. This process can be thermal or catalytic and is an alternative that allows the conversion of polymers into gas and liquid hydrocarbons. The plastic waste is processed to produce petrochemical compounds.

1.1 Thermal Pyrolysis

The temperature of pyrolysis ranges from 350°C to 900°Cand generally following products are derived.

- Noncondensable gases
- Liquid fraction (paraffin, olefins, naphthene's, and aromatics) From liquid fraction following range products are obtained,
- Gasoline range(C_4-C_{12})
- Diesel Range(C_{12}-C_{23})
- Kerosene Range(C_{10}-C_{18})

2.PLASTIC WASTE MANAGEMENT

In India, during the period 2010-11 on general a total of over 3500 tonnes per day of plastic waste was generated in sixty major cities only.

2.1 Industrial and domestic Plastic waste management: Mostly it is done by recycling the waste and when it becomes unsuitable for recycling it is used for pyrolysis.

2.2 Marine Plastic Waste Management: Marine waste commonly known as Marine Debrisor Marine Litters is generally non-repairable/ out of use products of shipping industries. Every year about 10,000 containers are accidentally been lost in the sea because of storms. These types of waste kept floating in sea until it gets settled on a seashore. About 8.8

million metric tons of waste plastic is dumped in the oceans every year. Mass concentrations of marine debris in high seas‘ sink’ areas, such as the equatorial convergence zone, are of particular concern. In some such areas, ‘rafts’ of assorted debris, including various plastics, ropes, fishing nets, cargo-associated wastes such as dunnage, pallets, wires and plastic covers, drums and shipping containers can be seen spreading widely. In India ship-breaking operations are carried out over a distance ofabout-10 km on the beaches of Alonginone of the largest and busiest ship-breaking yards in the world. When a ship is dismantled it results in release of pollution causing components like Asbestos, PCB’s, PVC and PBB’s, which are directly dumped into the sea. All the recyclable plastic is sent to recycling units.

2.3 Tyre Waste Management: Tyre consists of vulcanized rubbers (including styrene butadiene (SBR), natural rubber (NR) and polybutadiene (BR)), carbon black, steel, textile cord and small number of other additives. The disposal of waste tyres is one of the important environmental concerns throughout the world. More than 3.4 x 106 tonnes of end-of-life tyres are generated annually in European Union, 2.5 x 106 tonnes in North America and 1 x 106 tonnes in Japan. India had over100 million vehicles registered on its roads in the year 2008.Pyrolysis of tires can produce oils, chars, and gases. Oil obtained from pyrolysis have high gross calorific value (GCV) of around 41-44 MJ/kg. In addition to fuels, these oils can be used as source of light aromatics such as benzene, toluene and xylene. Active carbon also can be prepared from tires. Carbon Black obtained from this can also be used as additive for road bitumen. It is being found that pyrolysis gas fraction contains high concentrations of methane, ethane, butadiene and other hydrocarbon gases with a GCV of approximately 37 MJ/m3. Different procedures can be used to obtain oils from tires like fixed-bed reactors, fluidized-bed pyrolysis units, vacuum pyrolysis units, spouted-bed reactors, etc.

3. EXPERIMENTAL

Dr. L Nageshwara Rao and team has performed an experiment for detecting the properties of the pyrolysis oil. A mixture of 1 ton of plastic waste is subjected to produce oil. The process involves washing of waste for several time to ensure dust elimination. After which the waste is dried up to room temperature to remove moisture content. The reaction is carried out in presence of catalyst ‘Aluminum silicate’. The volume of catalyst is kept to 2.5% of the mass of waste. The mixture is heatedat603-723K.Asaresultof this pyrolysis, three products are obtained Pyrolysis Oil (60- 70%), Gas (15-20%) and Carbon Black (20-30%). Further various mixture containing 40% oil+60% petrol, 10% oil + 90% diesel, 30% oil +70% diesel and 50% oil+50% diesel are subjected to various characteristic tests and are found similar to that of pure fuel oils Aishwarya and Sidhu studied the process of pyrolysis by using microwave oven. This system generates microwaves in continuous cycles. The setup is gravity feed and nitrogen is used to prevent oxygen to enter in the process. The plastic is heated by microwaves at a specified temperature. The product of the heating is then transferred to condenser where vapors are converted into liquid oil. Pyrolysis oil was obtained as product.

Muhammad et al. studied the process of pyrolysis in preparing fuel from the plastics waste generated from electric and electronics equipment. This type of waste consist of acrylonitrile butadiene styrene, polypropylene, polystyrene, polyethylene, polycarbonate, etc. Two-stages of pyrolysis catalystre action system was used to convert low Density polyethylene into fuel. In the first stage of the

Process the sample was heated the sample of plastic waste to a temperature of 5000 Cata rate of100C/min. The product is then sent to second stage i.e., second reactor where the catalytic temperature is 5000C is maintained and it is held for 30 minutes. Pyrolysis oil obtained was further tested for its properties.

Seoet al. studied Catalytic degradation of HDPE using a batch reactor at a temperature of450°C.Asshownintable 1, the pyrolysis performed with the catalyst zeolite ZSM-5 had higher yield of the gaseous fraction and smaller yield of liquid fraction when compared with thermal cracking explained by the properties of the catalyst. Most zeolites, including ZSM-5, showed excellent catalytic efficiency in cracking, isomerization and aromatization due to its strong acidic property and its micro porous crystalline structure. The ZSM-5 zeolite has a three-dimensional pore channel structure with pore size of 5.4 × 5.6 Å which allows an increased

cracking of larger molecules, beyond the high Si / Al ratio which leads to an increase in thermal stability and acidity.

Table1.Yield in thermal and catalytic pyrolysis of HDPE with ZSM-5[12]

ProductYield(%wt.)		Thermal Pyrolysis	Catalytic Pyrolysis
GasFraction		13.0	63.5
Liquid Fraction	Total	84.0	35.0
	C6-C12	56.55	99.92
	C13-C23	37.79	0.08
	>C23	5.66	0.0
SolidFraction		3.0	1.5

Zhangetal. Studied the conversion of LDPE into the jet fuel (C8-C16). The catalytic microwave degradation was carried out at 375°C with catalyst to feed mass ratio of 0.1 or 0.2 to produce different proportions of aliphatic and cyclic hydrocarbons. It is found that in catalytic microwave degradation of LDPE carbon yields were found 66.18%and 56.32% respectively. For obtaining optimal conditions for the production of fuels different parameters were changed in hydrogenation process. More catalyst loading could facilitate rate of catalytic cracking to form gaseous compounds. The gas was primarily composed of ethylene, ethane, hydrogen, and methane because of the large extent of catalytic cracking and oligomerization reactions

4.RESULTS AND DISCUSSION

By the process of Pyrolysis, plastics can be converted into fuel and in most scenarios three major products are obtained at the end of the process. These products are namely- Pyrolysis Oil, Carbon Black and a Gaseous mixture. All these three are arranged in order of their composition in the product. The properties of pyrolysis oil can be improved by hydrogenation. The pyrolysisoilisa good substitute of conventional fuel and in various test run by Dr. Rao and team it is found that the oil when blended with conventional fuel like petrol & diesel, shows same characteristics as pure fuel dose. It is worth mention to notify that not only pure plastics but also plastics in which additives were used can be treated to form equally good oil . Thermal and catalytic pyrolysis has their own yield aspects for different products. It has been found that can be opted thermal pyrolysis for Liquid products and to catalytic pyrolysis can be preferred for Gaseous products.

5.CONCLUSION:

In the light of addressing solution for energy and environmental issues. Pyrolysis has been found the most effective technique of conversion of waste plastic to fuels. It is noticeable that the fuel obtained by Pyrolysis is cleaner than conventional fuels.

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