PYROLYSIS OF LOW DENSITY PLASTIC WASTE INTO BIO DIESEL

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ABSTRACT

Plastics have become an integral part of human life, and during the past 50 years, the commercial use of plastics has increased dramatically. A very large part of plastics ends up in municipal waste and poses problems with waste management. Pyrolysis of plastics is one of the efficient ways to recover plastic waste. Pyrolysis refers to a thermal degradation of long-chain organic molecules into smaller hydrocarbons. Many ongoing research studies are trying to gain a better understanding of the pyrolysis technology with the aim of establishing new industrial processes for plastic recycling. The pyrolysis process can thermally degrade plastics or a mixture of biomass and plastics in the absence of oxygen. Temperature has the most impact on pyrolysis. Other processes to use in the conversion of plastic wastes into valuable products are steam cracking and gasification. The objective of this work is to find the best operation conditions for conversion of plastic wastes. In this work, plastic wastes were used for the pyrolysis to get fuel oil that has the same physical properties as the fuel bio-diesel. In conclusion, the study offers a comprehensive overview of plastic pyrolysis progress, which will remain a major area of research for chemists and engineers in the coming decade and a powerful tool for environmental management.

Key words: Pyrolysis, municipal, waste, degradation and recycling.

1. INTRODUCTION

Plastics are polymeric materials, a material built up from long repeating chains of molecules. Polymers such as rubber occur naturally, but it wasn’t until the development of synthetic polymers around 1910 that the polymers tailored to the needs of the engineer first started to appear. One of the first commercial plastics developed was Bakelite and was used for the casting of early radios. Because the early plastics were not completely chemically stable, they gained a reputation for being cheap and unreliable. However, advances in plastic technology since then, mean that plastics are a very important and reliable class of materials for product design. Plastic is a marvel of polymer chemistry, plastics have become an indispensable part of our daily life. Different technologies are available for plastic waste recovery. Gasification, Incineration and torrefaction serve the purpose of waste to energy principle of waste management. However, the utility of energy recovered from those processes is limited. The products from pyrolysis are oil and monomers, which can substitute diesel fuel and monomers for plastic production. In addition to higher recovery value, the primary driving factor at present is the global warming issues and stricter emission rules which are forcing forward mechanisms to recover valuable plastic wastes that are usually incinerated or sent to landfills. However, the primary concern in pyrolysis processes has been the wide range of pyrolytic products arising based on the feed mixture and the pyrolytic process condition. As pyrolysis is a thermal degradation process, efficient heat transfer increases the efficiency of the process. But repeated reprocessing of plastic waste and its disposal causes environmental problems, pose health hazards, in addition to being a public annoyance. The biggest current threat to the conventional plastics industry is likely to be environmental concerns, including the release of toxic pollutants, greenhouse gas and non-bio degradable landfill impact as a result of the production and disposal of petroleum-based plastics.

Pyrolysis is one of the most important thermo chemical energy conversion methods for renewable energy sources. In this paper the conversion of waste Plastic/Polythene into pyrolytic oil by air tight reactor has been taken into consideration. The raw and crack plastic particle was pyrolized in an electrically heated 7.5 cm diameter and 18 cm high air tight reactor with nitrogen as a carrier gas. The reactor was heated by using electric heater. The parameters varied were running time and feed particle size. The different temperatures were found to influence the product significantly. The maximum liquid yield was 66 wt% at 350°C for a feed size of 3 cm^2 at a Nitrogen gas flow rate of 2 liter/min with a running time of 40 minutes. The pyrolysis oil obtained at these optimum process conditions was analyzed for some of its properties as an alternative liquid fuel.

A Plastic material is any of a wide range of synthetic or semi-synthetic organic solids used in the manufacture of industrial products. Plastic are typically polymers of high molecular mass, and may contain other substances to improve performance and reduce production cost. Monomers of plastic are either natural of synthetic organic compounds [4]. The word plastic is derived from the Greek word “Plastikos” meanings capable of being shaped or molded. There are mainly two types of plastics: Thermoplastic and Thermosetting polymers. Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be molded again and again. Examples include poly propylene, polystyrene, polyvinyl chloride and poly tetra Fluroethylene (PTFE) [5]. Thermosets can melt and take shape once after they have solidified, they stay solid. In the thermosetting process, a chemical reaction occurs that is irreversible. Polyethylene is classified into several different categories based mostly on its density and branching. The mechanical properties of PE depend significantly on variables such as the extent and type of branching, the crystal structure and the molecular weight [6]. Such as- Ultra high molecular weight polyethylene (UHMWPE), High density polyethylene (HDPE), Linear low-density polyethylene (LLDPE), Medium density polyethylene (MDPE), Low density polyethylene (LDPE) etc.

Environmental impact of plastic waste Due to their insolubility in water and relative chemical inertness, pure plastics generally have low toxicity. Some plastic products contain a variety of additives, some of which can be toxic. For example, plasticizers like adipates and phthalates are often added to brittle plastics like polyvinyl chloride to make them pliable enough for use in food packaging, toys, and many other items. Traces of these compounds can leach out of the product. Owing to concerns over the effects of such lactates, the European Union has restricted the use of DEHP (di-2- ethylhexyl phthalate) and other phthalates in some applications. Some compounds leaching from polystyrene food containers have been proposed to interfere with hormone functions and are suspected human carcinogens. Whereas the finished plastic may be non-toxic, the monomers used in the manufacture of the parent polymers may be toxic. In some cases, small amounts of those chemicals can remain trapped in the product unless suitable processing is employed. For example, the World Health Organization's International Agency for Research on Cancer (IARC) has recognized that vinyl chloride, the precursor to PVC, as a human carcinogen [7].

Waste plastics are one of the most promising resources for fuel production because of its high heat of combustion and due to the increasing availability in local communities. Unlike paper and wood, plastics do not absorb much moisture and the water content of plastics is far lower than the water content of biomass such as crops and kitchen wastes. The conversion methods of waste plastics into fuel depend on the types of plastics to be targeted and the properties of other wastes that might be used in the process. Additionally, the effective conversion requires appropriate technologies to be selected according to local economic, environmental, social and technical characteristics. In general, the conversion of waste plastic into fuel requires feed stocks which are non-hazardous and combustible. In particular each type of waste plastic conversion method has its own suitable feed stock. The composition of the plastics used as feed stock may be very different and some plastic articles might contain undesirable substances which pose potential risks to humans and to the environment. The types of plastics and their composition will condition the conversion process and will determine the pre-treatment requirements, the combustion temperature for the conversion and therefore the energy consumption required, the fuel quality output, the flue gas composition (e.g. formation of hazardous flue gases such as NOx and HCl), the fly ash and bottom ash composition, and the potential of chemical corrosion of the equipment.

The problems of waste plastics can‘t be solved by land filling or incineration, because the safety deposits are expensive and incineration stimulates the growing emission of harmful greenhouse gases like COx, NOx, SOx and etc. These types of disposal of the waste plastics release toxic gas which has negative impact on environment. Plastic wastes can also classified as industrial and municipal plastic wastes according to their origins, these groups have different qualities and properties and are subjected to different management strategies. Plastic wastes represent a considerable part of municipal wastes furthermore huge amounts of plastic waste arise as a by-product or faulty product in industry and agriculture. The total plastic waste, over 78% weight of this total corresponds to thermoplastics and the remaining to thermosets. Thermoplastics are composed of polyole fins such as polyethylene, polypropylene, polystyrene and polyvinyl chloride and can be recycled.

Municipal plastic wastes (MPW) normally remain a part of municipal solid wastes as they are discarded and collected a household waste. The various sources of MPW plastics includes domestic items like food containers, milk covers, water bottles, packaging foam, disposable cups, plates, cutlery, CD and cassette boxes. Fridge liners, vending cups, electronic equipment cases, drainage pipe, carbonated drinks bottles, plumbing pipes and guttering, flooring. Cushioning foams, thermal insulation foams, surface coatings, etc. Agricultural waste like mulch films, feed bags, fertilizer bags, and in temporary tarpaulin-like uses such as covers for hay, silage, etc. Thus, the MPW collected plastics waste is mixed one with major components of polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate, etc. The percentage of plastics in MPW has increased significantly.

Industrial plastic wastes are those arising from the large plastics manufacturing, processing and packaging industry. The industrial waste plastic mainly constitutes plastics from construction and demolition companies examples like polyvinylchloride pipes and fittings, tiles and sheets. Electrical and electronics industries wastes like switch boxes, cable sheaths, cassette boxes, TV screens, etc. and the automotive industries spare-parts for cars, such as fan blades, seat coverings, battery containers and front grills. Most of the industrial plastic waste has relatively well physical characteristics i.e. they are sufficiently clean and free of contamination and are available in fairly large quantities.

PLASTIC PYROLYSIS OIL

Pyrolysis is a thermo chemical decomposition of organic material at elevated temperatures in the absence of oxygen (or any halogen). It involves the simultaneous change of chemical composition and physical phase, and is irreversible. The word is coined from the Greek-derived elements pyro "fire" and lysis "separating".

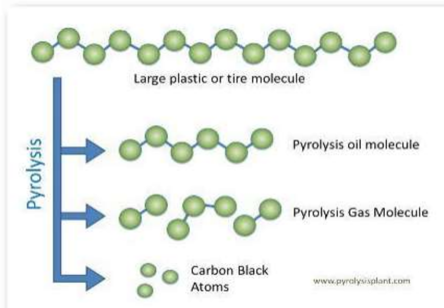

Figure1 Breaking of Hydrocarbon chain in Pyrolysis Process

Pyrolysis differs from other high-temperature processes like combustion and hydrolysis in that it usually does not involve reactions with oxygen, water, or any other reagents. In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs. Bio-oil is produced via pyrolysis, a process in which biomass is rapidly heated to 450–500°C in an oxygen-free environment and then quenched, yielding a mix of liquid fuel (pyrolysis oil), gases, and solid char. Variations in the pyrolysis method, biomass characteristics, and reaction specifications will produce varying percentages of these three products. Several technologies and methodologies can be used for pyrolysis, including circulating fluid beds, entertained flow reactors, multiple hearth reactors, or vortex reactors. The process can be performed with or without a catalyst or redundant.

PYROLYSIS PROCESS-WORKING PRINCIPLE

In this work, commercialized available shredded plastics were procured and washed before pyrolysis. One of the most favorable and effective disposing method is pyrolysis, which is environmentally friendly and efficient way. Pyrolysis is the thermal degradation of solid wastes at high temperatures (300-900nC) in the absence of air (and oxygen). As the structure of products and their yields can be considerably modified by catalysts, results of pyrolysis in the absence of catalyst were presented in this article Pyrolysis of waste plastics was carried out in an indigenously designed and fabricated reactor. Figure 2 shows the scheme of the process involved in the experiments. Waste plastics had been procured form the commercial source and stored in a raw material storage unit. Raw material was then fed in the reactor and heated by means of electrical energy. The yield commenced at a temperature of 350^0C. The gaseous products resulting from the pyrolysis of the plastic wastes is supplied through the copper tube. Then the burned plastic gas condensed in a water-cooled condenser to liquid fuel and collected for experiments.

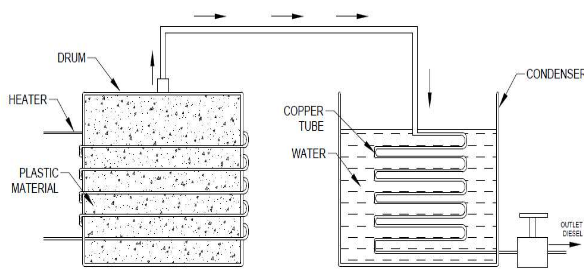

Figure 2. Simple schematic layout of a pyrolysis plant

Feeding- Feed the feedstock‘s to reactor through feeder and closes the feeder inlet.

Heating- To increase the temperature of reactor, heat the product of reactor inside by using heating source.

Condensing- The plastic gets evaporated at high temperature this vapor is condensed to atmospheric temperature by using straight and spiral tube condensers.

Liquid collection-Out coming product from the condenser is collected at liquid collector. At the end of condenser provide a cyclone separator to separate the plastic liquid fuel and non-condensable gases. These non-condensable gases are reuses to heat the pyrolysis unit.

Water wash, Purification and pH test- This involves many purification processes. In this method equal proportion of plastic fuel and water in a container taken and shake well, allow it for 5-7 hours to settle down. Now water along with some crystals is collected at bottom and pure plastic fuel is collected at the top container.

MAIN DEVICES USED IN THE PROCESS:

HEATING COIL:

Electric heating is a process in which electrical energy is converted to heat. Common applications include space heating, cooking, water heating and industrial processes. An electric heater is an electrical device that converts electric current to heat. The heating element inside every electric heater is an electrical resistor, and works on the principle of Joule heating, an electric current passing through a resistor will convert that electrical energy into heat energy. Most modern electric heating devices use nichrome wire as the active element the heating element, depicted in figure 3, uses nichrome wire supported by ceramic insulators.

Figure 3. Heating coil

NiCrome (nichrome) Wire can be obtained by purchasing a "heating spiral" from an electrical contractor; the one illustrated above is rated at 1 KW (on a 230v supply) and cost £3.99 in 2001. It is in the form of a tightly wound spiral shown in the inset at left heating Spiral Close Up

Before its use, it requires to be straightened. It is tough stuff, but this can be achieved by placing one end in a vice and by pulling and curling using a round hardwood dowel and industrial gloves. This removes the waviness from the original spiral and the curved shape that results will not hinder the rest of the process. The NiCrome wire needs about 4 amps flowing to get red hot, but the voltage will only be in the one volt region for a single turn coil, multiple turn coils of thinner wire can be heated from a 12 volt battery, or a battery charger, or battery under charge. The form of the coil affects the shape of the finished tip. The number of turns, the overall diameter, arrangement of turns all have an effect. In addition, tubular shields can be positioned coaxially between glass tube and coil so as to mask some of the heat from the glass. Single turn coil with brass tube support wires that are arranged at the same spacing as the pitch of the electrical connectors. The coil illustrated is about 8 mm ID. Additional electrical connectors fitted to extended brass tubes can also be used as a 'plug and socket' arrangement for interchanging the coils, with the added rigidity helping to preserve the coils which tend to become brittle with use. Electrical Connector Block Melamine Connector Block. The connections to the coil can be made via a "chocolate block" connector (the white one). This is so called as they are usually supplied as a strip of twelve and can be cut to length simply with a knife. The near right version is made of hard thermosetting plastic that can be parted using a hacksaw and this type is more resistant to the high temperatures that we will encounter.

CONDENSER:

In systems involving heat transfer, a condenser is a device or unit used to condense a substance from its gaseous to its liquid state, by cooling it. In doing so, the latent heat is given up by the substance and transferred to the surrounding environment. Condensers can be made according to numerous designs, and come in many sizes ranging from rather small (hand-held) to very large (industrial-scale units used in plant processes). For example, a refrigerator uses a condenser to get rid of heat extracted from the interior of the unit to the outside air. Condensers are used in air conditioning, industrial chemical processes such as distillation, steam power plants and other heat-exchange systems. Use of cooling water or surrounding air as the coolant is common in many condensers.

Heat exchangers are devices that transfer heat in order to achieve desired heating or cooling. An important design aspect of heat exchanger technology is the selection of appropriate materials to conduct and transfer heat fast and efficiently. Copper has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity allows heat to pass through it quickly. Other desirable properties of copper in heat exchangers include its corrosion resistance, bio fouling resistance, maximum allowable stress and internal pressure, creep rupture strength, fatigue strength, hardness, thermal expansion, specific heat, antimicrobial properties, tensile strength, yield strength, high melting point, alloy ability, ease of fabrication, and ease of joining. The combination of these properties enable copper to be specified for heat exchangers in industrial facilities, HVAC systems, vehicular coolers and radiators, and as heat sinks to cool computers, disk drives, televisions, computer monitors, and other electronic equipment. Copper is also incorporated into the bottoms of high-quality cookware because the metal conducts heat quickly and distributes it evenly. Non-copper heat exchangers are also available. Some alternative materials include aluminium, carbon steel, stainless steel, nickel alloys, and titanium. It cools the entire heated vapor coming out of the reactor. It has an inlet and an outlet for cold water to run through its outer area. This is used for cooling of the vapor. The gaseous hydrocarbons at a temperature of about 350°C are condensed to about 30 – 35°C

 It is the part of machine which condenses the vapors coming out from the catalytic cracker.

The condenser must condense the very hot vapors in an efficient manner to give the condensate.

- clogging in the condenser must be prevented.
- This can be achieved by increasing the diameter of the pipe.
- In this machine, spiral condenser is used to increase the efficiency of condensation.

Experimental Setup

Fig 4. Experimental Setup

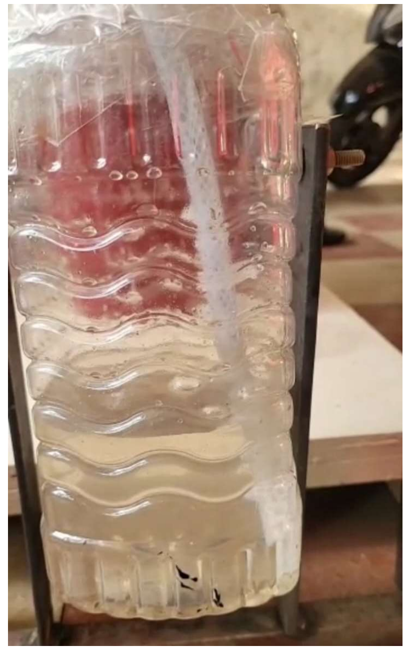

Fig 5. Pyrolysis Gas getting accumulated

PYROLYSIS/THERMAL DEGRADATION:

Pyrolysis is a process of thermal degradation of a material in the absence of oxygen. Plastic is fed into a cylindrical chamber. The pyrolytic gases are condensed in a specially designed condenser system, to yield a hydrocarbon distillate comprising straight and branched chain aliphatic, cyclic aliphatic, and aromatic hydrocarbons, and liquid is separated using fractional distillation to produce the liquid fuel products.

The plastic is pyrolysed at 370°C–420°C. (1) Evenly heating the plastic to a narrow temperature range without excessive temperature variations, (2) Purging oxygen from pyrolysis chamber, (3) Managing the carbonaceous char by-product before it acts as a thermal insulator and lowers the heat transfer to the plastic, (4) Careful condensation and fractionation of the pyrolysis vapours' to produce distillate of good quality and consistency.

5. RESULT

1. Thermolysis of waste plastics to liquid fuel, a suitable method for plastic waste management and conversion of waste plastic into liquid hydrocarbon by using new technology can convert all types of waste plastic into hydrocarbon fuel at the temperature profile 350ºc to 500ºc.
2. Lesser emission of unburnt HYDROCARBONS in waste plastic pyrolysis oil compared to that of diesel.
3. The diesel or oil thus obtained has a higher efficiency with around 30 to 40% low production cost compared to that available in the market.

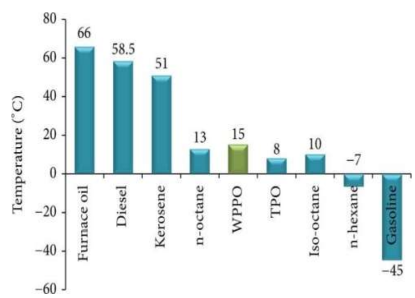

Figure 6 - Graphical presentation of flash point of different oil.

PHYSICAL PROPERTIES OF DIESEL GRADE OF WASTE PLASTIC [10]

Sl no.	Characteristics	Diesel Grade Fuel
1	Flash point in °C	87
2	Fire point °C	92
3	Viscosity @40 °C	3.8
4	Density kg/m3	800
5	Calorific value kj/kg	46988

Figure 7 .Test Conducted in Laboratory

CONCLUSION

It is very difficult to find out alternative of plastic. Even plastic´s demand is increasing every day as well as their waste. In this work it is observed that the use of waste plastics, a factory planning and its feasibility in Metropolitan City. It is easily assumed that, when the use of waste plastic will increase then the solid waste management will search more ways to find out to collect them. The implementation of this work can develop so many opportunities in the city. It can be a solution to control waste plastic, develop a new technique or idea, and detect the source of diesel for the country. Though the plastic pyrolysis oil offers lower engine performance, the plastic waste amount is enormous and it needed to be process to reduce the environmental problems. Usage of catalyst will create a huge impact on reducing of anaerobic combustion temperature. As zeolite catalyst was banned in India recently due to its harmful impact on human FCC is used as substitute. Moreover, the engine can be modified to follow the combustion condition of plastic pyrolysis oil. The waste plastic used in the process must be PE or PP or LDPE in order to protect the contamination of chlorine in the oil. Physico chemical properties of obtained fuel oil can be exploited to make highly efficient fuel or furnace oil after blending with other petroleum products. However, further studies are necessary to utilize this oil as fuel or feed stock.

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