

# PRODUCTION OF FUEL FROM MUNICIPAL WASTE PLASTIC BY PYROLYSIS PROCESS

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**Abstract:** Waste plastic in this modern era is abundant in nature and its disposal creates large problems for the environment in our country and also in the world. Global population of plastics, being one of the main contributors of global warming and other natural calamities. The high demand and high price for energy sources are driving efforts to convert wasted organic compounds into useful hydrocarbon fuels which is more convenient and enhanced. Plastic generally doesn't decompose in landfills due to which it is not easily recycled and degrades in quality during the recycling process and thus can lead to production of waste ash, heavy metals which are in the form of carbonous chains, and potentially very harmful gas emissions and intoxicating inhaling gas source if incinerated at high temperatures. To reduce the number of plastics, process of pyrolysis, i.e., thermal degradation in the absence of oxygen can be used. It breaks "Cracks" polymer chains into smaller chains under heat and pressure. Using pyrolysis to extract fuel (crude oil or diesel) from end-of-life plastic is one of the best options after recycling.

**Key words:** Pyrolysis, Society of Plastic Industry (SPI), Hydrocarbon, Thermoplastics and Thermosetting Polymers

## I. INTRODUCTION

Plastics are also called polymers which was invented by Alexander Parkes in the year 1862; the term polymer means a molecule made up by repetition of simple unit that are synthetic organic materials produced by polymerization. They are typically of high molecular mass, and may contain other substances besides polymers to improve performance or reduce costs.

These polymers are made of a series of repeating units known as monomers; therefore polymers can be moulded or extruded into desired shapes. Basically we can classify plastics in two broad categories: thermoplastics and thermosetting polymers.

Plastic is one of the most commonly used materials in day to day life; which can be classified in many ways such as based on its physical and chemical properties like the chemical structure such as shape and size, synthesis process, density, and other properties. In order to assist recycling of the waste plastic, Society of Plastic Industry (SPI) has defined a new resin identification code system that divides plastics into the following seven groups based on the chemical and physical structures which outlooks on the shape and size and applications:

Table1: Seven groups of Plastic on the basis of SPI code, chemical structure and examples

Sl. No	SPI Code	Plastic Types	Examples
1		PET (Poly Ethylene Terephthalate)	Soft drink bottle, Water bottle and Cooking oil
2		HDPE (High Density Polyethylene)	Cleaning agents, Shampoo bottles washing and Showering soaps
3		PVC (Polyvinyl Chloride)	Trays for sweets and Fruits, Food wrapping foils
4		LDPE (Low Density Polyethylene)	Crushed bottles, Shopping bags
5		PP (Polypropylene)	Furniture, Luggage and Toys
6		PS (Polystyrene)	Refrigerator trays, Audio cassettes and Costume jewellery
7		Others: Plastics including acrylic	Polyactic fibres, Nylon, Fibre glass and Baby feeding bottles

## II. SELECTION OF WASTE PLASTICS

Plastic Wastes are one of the most promising resources for fuel production in our daily outlook for humans sphere because of its high heat of combustion and due to the increasing availability in local commodities such as in industrial hub sites, stoke markets, etc. Unlike paper and wood, plastics do not absorb much moisture from the atmosphere and the water content of plastics is far lower than the water content of any biomass such as crops, kitchen wastes, etc.

The types of plastics and their composition will affect the conversion process and will determine the pre-treatment requirements and also the combustion temperature for the conversion and therefore the energy consumption required needs the fuel quality output as well as the fuel gas composition (e.g. formation of hazardous flue gases such as NO<sub>x</sub> and HO), the fly ash and bottom ash composition, and the potentiality of the chemical corrosion of the equipment.

As shown in Table 2, PE, PP and PS thermoplastics are preferable as feedstock in the production of liquid hydrocarbons. The addition of thermosetting plastics, wood, and paper to the feedstock leads to the formation of carbonous substances and lowers the rate and yield of liquid products.

The municipal plastic waste comprises of 80% thermoplastics and 20% thermosetting plastic. Since thermoplastics are can be further processed, basic types of thermoplastics can be used. Simple and common thermoplastics are polyethylene and polypropylene.

Table 2- Product types of some plastics pyrolysis

Main products	Type of plastics	Feedstock of liquid fuel
Liquid hydrocarbons	Polyethylene (PE)	Allowed.
	Polypropylene (PP)	Allowed.
	Polystyrene (PS)	Allowed.
	Polymethyl metacrylate (PMMA)	Allowed.
Liquid hydrocarbons	Acrylonitrile-Butadiene-Styrene copolymer (ABS)	Allowed. But not suitable. Nitrogen-containing fuel is obtained. Special attention required to cyanide in oil
	Polyvinyl alcohol (PVA)	Not suitable, formation of water and alcohol
No hydrocarbons suitable for fuel	Polyoxymethylene (POM)	Not suitable. Formation of formaldehyde.
	Polyethylene terephthalate (PET)	Not suitable. Formation of terephthalic acid and benzoic acid.
Solid products	Polyurethane (PUR)	Not suitable.
	Phenol resin (PF)	Not suitable.
Hydrogen chloride & Carbonous products	Polyvinyl chloride (PVC)	Not allowed.
	Polyvinylidene chloride (PVDC)	Not allowed.

For our experiment, we took Polypropylene as the raw material for the following reasons and factors.

- PP (Polypropylene) fuel has more calorific value than all fuels.
- PP (Polypropylene) is abundantly used in Plastic bags, plastic bottles so raw material is easy to get.
- The crystallinity of PP (Polypropylene) is less than PE (Polyethylene).

### III.METHODOLOGY

Decomposition of plastic inside an inert environment into a liquid medium is called pyrolysis. There are four stages of reactions during the plastic pyrolysis process: initiation, propagation, hydrogen transfer, and termination reactions. In the plastic pyrolysis, the research as well as the industrial plastic type and operation differ in large scales. In the field of research, the pyrolysis rate of feedstock plastics is measured by using thermo gravimetric analysis (TGA) in fix-bed batch pyrolysis reactor with some precautions being handled simultaneously.

The overall percentage of gaseous products is measured simultaneously with the occurrence of the simultaneous reactions which takes place in fluidized bed reactor or continuous reactor. Operation temperature is normally monitored by using thermocouples along the process line, which is used for estimating thermal reactions including heating-up, decomposition, cracking, and condensation. With these monitoring devices, the processes can be controlled by adjusting the operating factors such as heating power, feeding rate, pressure and carrier gas flow rate when needed.

**Design Criteria.** The modified pyrolysis apparatus were directed towards its effectiveness to convert plastics into crude oil (diesel fuel) that helped find alternative source of crude oil which is one of the most commonly used fuels amongst the farmers; hence, it increases their income. It also directed towards the decreasing number of plastics in the environment.

**Design Requirements.** The factors considered in the development of the pyrolysis apparatus were; (a) materials are locally available and affordable, (b) easily fabricated by small scale farmers, (c) easy to transport.

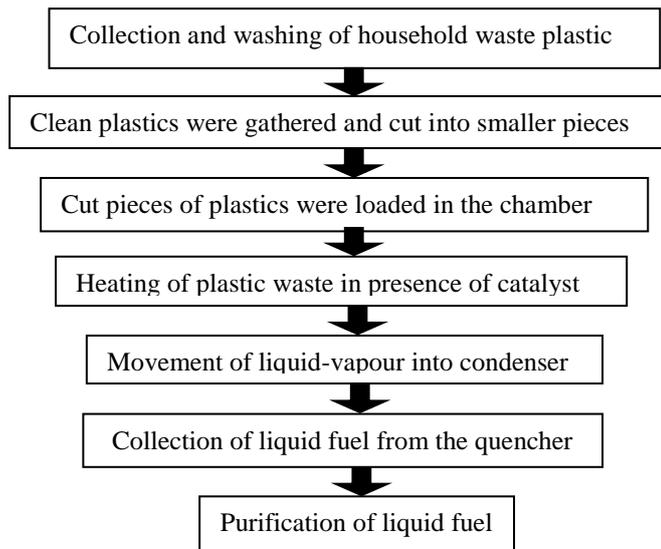
### IV. PRODUCTION PROCEDURE:

The materials used in the fabrication of the modified pyrolysis including the tools needed were bought and prepared. Having prepared all the materials and tools needed, fabrication activities were then scheduled as follows:

Measuring dimensions to parts → Cutting to dimensions of part → Joining parts through welding machine & oxyacetylene → Assembling of parts into a single unit → Finishing

## V. TESTING PROCEDURE:

The following steps were followed in testing the performance of the pyrolysis:



**Figure1: Flow diagram of Conversion of Plastics waste into Liquid Fuel**

## VI. PRODUCT SEPARATION AND COLLECTION

The products from the plastic pyrolysis are mainly combustible gases and liquids; liquids can be either combusted for power generation or for further refining to produce high quality fuels such as Diesel range products so that they can be distilled out as in an oil refinery process. The non-condensable gases are mainly made of hydrocarbons, and a minor amount of hydrogen and carbon monoxide; the gases can be liquefied as fuels, or used as fuels to ignite the pyrolysis reactor.

**Data Gathered:** The weight of plastic used was set two kg for all the trials and residence time was used as the treatment.

**Weight of Wood Used:** The kilograms of wood used in furnace to heat the plastics inside the chamber.

**Weight of the Residue ( $W_r$ ):** The weight of unconverted plastic inside the chamber after each treatment.

**Volume of oil:** The volume (ml) of oil produced in each treatment.

**Conversion Efficiency:** The ability of the apparatus to convert waste plastic into oil in terms of weight. This is computed by dividing the weight of oil recovered by the original weight of plastic and is multiplied by 100.

**Oil recovery:** The measure of how much oil the apparatus can recover per kg of waste plastic. This was computed using the formula:  
 $RO = V_r / W_s$

Where: RO = Recovery of oil (ml/kg)

$V_r$  = Volume of oil recovered (ml)

$W_s$  = Weight of sample (kg)

## VII. RESULT

In the Pyrolysis reaction different type of oil will be extracted from different type of waste plastic. Such oil acts as petrol, diesel and kerosene depending upon the heat treatment. It also produce 6% gas which acts as LPG. Smooth feeding for equipment, effective conversion, well-controlled combustion are the factors to be considered for better result.

## VIII. PRODUCT ANALYSIS METHOD

The pyrolysis products of plastics are mainly hydrocarbons presenting in gaseous, liquids and solid wax phases under standard conditions of temperature and pressure. Hydrogen gas and char are generally found in the products in very minor amounts.

Hydrocarbon products from industrial pyrolysis of waste plastics are used as a substitute for commercial fuels as they are readily available. Heavy hydrocarbon wax can be processed into gases or light liquid by further igniting them to high temperature treatments or catalytic cracking so that it yields of non-condensable gases and wax vary largely in different studies done by experts.

The properties of plastic pyrolysis fuels are analyzed by some experts in some studies and it was found that the pyrolysis products from PE, PP, and PS are mainly hydrocarbons with molecular weights very similar to the petrol and diesel range. A certain limited quantity of non-condensable gases such as carbon dioxide, propene, etc and insignificant amount of heavy wax such as paraffin were also found in the pyrolysis products.

## IX.ADVANTAGES

1. Desirable process as energy is obtained from renewable sources like municipal solid waste.
2. Disposal of waste plastic can be solved.
3. No pollutants during cracking of plastic.
4. Waste plastic is converted into the high value of fuels.
5. The crude oil can be used for generation of electricity.
6. Industrial and automobile fuel requirement may be fulfilled at lower price.
7. Volume of waste is significantly reduced.
8. Reduce environment effects.
9. Echo friendly.

## X.CONCLUSION

Pyrolysis of hydrocarbon polymers is a very complex process, consisting of various types of reactions and products. Several factors have significant effects on the reaction and the products like temperature, pressure, etc. With increasing temperature, plastic will undergo through different states such as the glassy state, rubbery state, liquid state, and decomposition. This method is superior in all respects (ecological and economical).By adopting this technology, efficiently convert weight of waste plastics into 70% of useful liquid hydrocarbon fuels without emitting any pollutants. It would also take care of hazardous plastic waste and reduce the import of crude oil. Depletion of non-renewable source of energy such as fossil fuels at this stage demands the improvements of this technique.

## XI.FUTURE SCOPE

This paper shows the possibility of manufacturing liquid fuels for further modification or commercial use. By using this technology we could solve the waste plastic problem and also significantly reduce the landfills-which are the cause of infertility of Agriculture land. Waste plastics can also become a very good source of energy and an alternative to fossil fuel which have caused an environment imbalance.

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