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Conversion of Plastic Waste into Hydrocarbonat Low Temperature

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***Abstract*:**

Plastic isone of the most widely used materials in human daily life. Due to its specific properties, it plays important role in domestic as well as in industrial applications but on other hand, its unbound use has raised an environmental concern. Mostly used plastic,i.e. polyethylene which takes around 1000 years of time to decompose. This article presents advanced methodologies used to treat plastic waste for low temperatures.The traditional treatments for the plastic waste management were recycled, incinerated or landfilling. However, these treatments have limitations where gasification and bioconversion are mainly used for organic matter. The Chemical treatment via pyrolysis process is a promising technique for the treatment of plastic waste. Pyrolysis is environment friendly process of thermal degradation of plastic waste in absence of oxygento produce pyrolytic gases and oils which tackles both problems of management plastic waste as well as fuel shortage, economically. Zeolite & silica-alumina is the most common catalyst used for this process. This process providing an alternative source of energy. Thus, the pyrolysis process has now turned into the opportunity to make the best from waste.

Key Words:Plastic waste, Pyrolysis, Thermal Degradation,Zeolite

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1.INTRODUCTION

In this today's world,life is impossible without plastic.Plastics has some specific properties like lightweight, easy handling, transparency, strong and cheap production.Thus,theProduction of plastic has increased rapidly over the last few decades. The universal production of plasticincreased by 4% in 2012 and it was around 299 million tons in 2013 and 380 million tons in 2018. Around 8.8 million tons of plastic enters in the ocean from coastal areas per year.It is also predicted by some researchers that there will be more plastic than fish in the ocean by 2050. According to the Central Pollution Control Board (CPCB) production of plastic waste in India in 2020 was around 33 million tons. Around 25940 tonsper day of plastic waste generation taking place in India.India ranksat the 12thpositionthe list of top20 countries for engendering plastic waste. Plastic wastes are one-third part of municipal corporations. The generation of plastic waste is now a major problem in urban areas.Used plastic we discharge directly into the environment. Particularly polyethylene bags of below 50 microns which takes more than a thousand years to get decompose and proving hazard to nature. So,that it needs to be properly managed in order to prevent any damage to the environment.Plastic waste generated from Teflon, nylon, polyethylene, polypropylene, plastic bottles. Producing oil will be the best option to obtain energy. There is increasing diesel and petrol consumption in developing countries like

India. These countries addressing issues of fuel prices and energy. Also, diesel engines most widely preferred in developing countriesbecause of their excellent performance and high efficiency. But the problem with diesel engine is that they release high amount of nitrogen peroxide which affect human health. Still, there is rapid increase in the number of automobiles vehicles. Eventually increase in fuel demand. So effective utilization of Plastic waste oil and finding an alternative for diesel engine has become a good opportunity.

For the decomposition of plastic waste, there are several methods but degradation in nature is occurs into three categories i.e. physically, chemically, and biological processes. Biological degradation happens due to bacteria and enzymes but it is very difficult and it takes so much time too. Physical degradation occurs due to humidity, heat from the sun, and pressure but due to the very strong bond between the hydrocarbon monomer and strong structure degradation at normal Temperature pressure is difficult. Hence, we have been developed efficientprocesses to conduct the recycling of plastic waste. Generally, physical process works on the principle "three R" i.e. reduction, reuse, recycling. We can reduce the use of the plastic but reuse and recyclingthese two methods are inappropriate because at end of the day plastic waste returns to the environment. Also, there are some chemical methodologies for degradation like hydrogenation and gasification. However, the chemical recycling process via pyrolysis method is a more efficient and economical method of recycling.

1.1 DIFFERENT TYPE OF PLASTIC:

Table No: 1Different Types of Plastic; Properties &Applications

TYPE OF PLASTICS	PROPERTIES	APPLICATIONS
Low Density Polyethylene (LDPE)	➢ High Transparency ➢ Hard and Rigid ➢ Chemical & Electrical resistivity	➢ Pipes & Bottles ➢ Films ➢ Fertilizer Bags
High Density Polyethylene (HDPE)	➢ High Chemical Resistivity ➢ Hard & Strong ➢ High Melting Point	➢ Acid Storage Tanks ➢ Detergent Bottles ➢ Water & Soft Drink Bottles
Polyvinyl Chloride (PVC)	➢ Hard & Rigid ➢ Long term stability ➢ Moisture barrier properties	➢ Credit Cards ➢ Window & Door Frames ➢ Wire & Cable Product
Polystyrene (PS)	➢ Clear to opaque ➢ Glassy Surface ➢ Brittle & Hard	➢ Clear to opaque ➢ Glassy Surface ➢ Brittle & Hard
Polypropylene (PP)	➢ Chemical Resistance ➢ Hard but Brittle ➢ Waxy Surface	➢ Ketchup & syrup Bottles ➢ Potato Crisp Bags ➢ Refrigerator Containers

Chemically plastics are mainly composed of carbon and hydrogen. Some plastic may contain other elements like polyvinyl chloride (PVC) contains chlorine and nylon contains nitrogen and oxygen. Due to this higher carbon contain in plastic it has high a calorific value. The calorific value of plastic is approximately same as common fuel. But the direct combustion of plastic causes emission of carbon dioxide and carbon monoxide. So, by using pyrolysis we can convert plastic waste into suitable hydrocarbons. Pyrolysis is one of the advance technique of thermal degradation of plastics in absence of reactive gases like oxygen. The chemical bond between two monomers will get break due to temperature. It resulted in production of light weight hydrocarbons.

2. METHOS FOR CONVERSION OF PLASTIC WASTE INTO HYDROCARBON:

Chemical degradation is a versatile process for the conversion of plastic waste into light hydrocarbon. There are several methods but the thermal cracking and catalytical pyrolysis are the most suitable method for the degradation.

2.1HYDROCRACKING:

Hydro cracking was first invented by Germany in early 1915 for the purpose of obtaining a liquid fuel from coal. The first plant started in 1927 as a commercial hydro cracking unit. Then in 1960 hydro cracking is used for the conversion of low value distillates such as heavy gas and cycled oil into the high value gasoline product. Hydro cracking is a process for conversion of heavy components into lighter components at high temperature and pressure. In this process high weightcomplex hydrocarbon molecules of petroleum component are broken into simple hydrocarbon, such as kerosene. For the conversion of plastic waste into light hydrocarbon, it requires temperature and pressure is about 250-450 degree celsius and 35-200 kg/cm^2.This process release energy. Several catalystscan be used in hydro cracking process such as Pt, Ni, Mo and support acids such as Zeolite, Silica-Alumina. These catalysts incorporate both cracking and hydrogenation and obtained gasoline product.
The advantage of this process is that, it is applicable for wide range of feeds as polypropylene, polyester, polyvinylchloride, or a mixture of all polymers. It gives products having high octane numbers.

2.2 THERMAL CRACKING:

In the early 20^{th} century, thermal cracking is invented by William Merriam, a chemist who worked in Amoco Corporation. Thermal cracking is used to break the polymers. Crude oil from the earthcrust is a mixture of the different molecular weight hydrocarbons. Separation of them according to their physical and chemical properties such as relative volatility and their market demand. This processof splitting of large hydrocarbon into light hydrocarbon involvesa chemical process of thermal cracking. By using this process, we can convert raw material into useful product. In 1913 first time this process was used for the conversion of plastic waste into fuels. It was successful process of cracking the plastic. Thermal cracking for polymeric material required high temperature in between range 350-900 degree celsius and it conducted in absence of oxygenwhich results in formation of volatile fraction and char. In further process involves condensation and fractionation of liquid product.

2.3 PYROLYSIS:

Pyrolysis is the word derived from two greek wordsi.e.pyro and lysis where pyro means “fire” and lysis means “separation”. From the ancient time, we are using the pyrolysis process for conversion of wood into charcoal. First time in ancient Egypt people used pyrolysis process for production of methanol from the wood.

Pyrolysis is the thermal degradation of Polymeric materials at high temperaturein the absence of oxygen. It is a chemical process which breaks larger molecules into smallermolecules. Generally, pyrolysis starts in the range of 200-300 degree celsius[3].

Mainly pyrolysis process used for organic substances, it produces volatile substances as product and leaves carbon as a residue. Pyrolysis process hasapplications in chemical industries as well as in energy industries.Also, it is used to obtain ethylene from the trunk of trees and different chemicals from the organic matter.

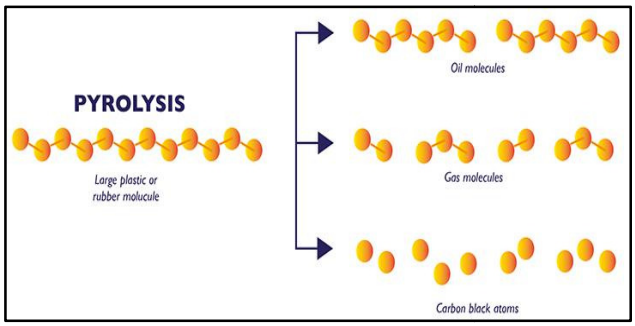

Fig: Breaking of Hydrocarbon Chain in Pyrolysis

Sajid Shah et al. has studied Pyrolysis of theplastic waste at low temperature for this purpose he carried out pyrolysis reaction in 1 lit volume reactorfor both catalytical and non-catalytical processes. 1 gm of zeolite catalyst for 50 gm of polyethylene feed was used, and repetition of the same processfordifferent temperature and he concluded as a catalytical process has high potential to produce more pyro-gas & pyro-oil than non-catalytical process for the same temperature[3].Dan KicaOmol et al. has studied pyrolysis reaction in three phases as without catalyst, using acid activated clay mineral as catalyst and aluminum chloride on activated carbon as catalyst at 600 degree celsius they observed that reaction start after 350 degree celsius for non-catalytical process whether it starts at 280 degree celsius for catalytical process. It is observed that reaction with aluminum chloride catalyst has more volatile product with less residue[4]. Around 90 wt% yield has obtained for the process of Pyrolysis at the condition of -3 mm of Hg pressure and about 550 degree celsius temperature when experiment conducted in four tray packed bed column by R.Thahir et al. and the product obtained was kerosene and gasoline[5]. The product obtained from pyrolysis of plastic waste is depends on type of plastic, type of feeding, residence time, temperature employed, reactor type, and efficiency of the condensation process.

***Effect of Temperature& Pressure on pyrolysis*:**

1. As temperature of pyrolysis process increasesyield of the reaction increases. Plastic waste melts above 150 degree celsius and vaporization starts above 220 degree celsius. As temperature increases vapor formation increases gradually. At low temperature wt% of volatile component is less than the wt% of wax and char. Wax obtained at low temperature is brown in color, whether color of wax obtained at high temperature is greenish-yellow. Yield of pyro-gas and pyro-oil increases at high temperature[7]. Yield of reaction with temperature is different for different types of Plastic.

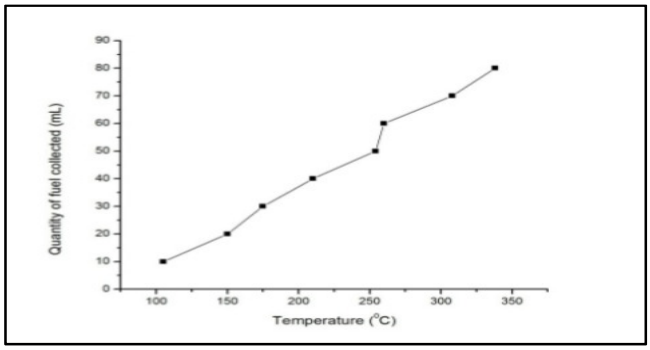

Fig 2: Quantity of oil produced (ml) Vs Temperature (C)

2. Heat requirement for the pyrolysis process reduces when pressure of the system increases. Heat of pyrolysis process may shift from endothermic process to exothermic

process at high temperature. As heat of reaction is function ofpressure. pressure affects the rate of reaction and yield as well. As pressure increases yield of reaction also increases.

***Effect of catalyst on pyrolysis*:**

Catalyst we can define as, a substance that increases the rate of reaction by reducing the activation energy of reaction. As like any other reaction catalysts plays an important role in pyrolysis reaction as well. For the catalytical pyrolysis vapor formation starts early as over non-catalytical pyrolysis process. Also in catalytic pyrolysis,wt% of gas and oil production is high where production of char & wax obtained is less.

Wide range of catalysts has been used for pyrolysis process of plastic waste, like ZSM-5, Zeolite, Y-Zeolite, FCC, and MCM-41.

***Effect of reaction time*:**

According to the literature, 30 min or 60 min time is not sufficient for the completion of the reaction. The gas formation will start after 30 min at 1atm & 300 degree celsius. More than 2 hours is required for maximum conversion for pyrolysis of plastic waste. Plastics of higher strength takes more time than soft plastics i.e Conversion of LDPE occurs earlier than HDPE.

CONCLUSION:

Chemical degradation is a versatile process for the conversion of plastic waste into light hydrocarbon. There are several methods for recycling of plastic but Pyrolysis has high potential to convert Plastic waste into fuel. More purity& maximum yield can be obtained in pyrolysis process by adding catalysts into the process. An increase in temperature and pressure affects positively on pyrolysis process. At high pressure reaction changes from exothermic reaction to endothermic reaction. The products obtained at high temperature reaction have more calorific values and less viscosity. Also, the reaction time and type of plastic affects the reaction.Packed bed column& trey column are more efficient than the simple batch reactor or mixed flow reactor for the pyrolysis process. The only disadvantage of pyrolysis process is separation of product stream is more difficult.

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