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Synthesis of the Fuel from Waste plastic

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ABSTRACT

The present work involves the synthesis of a petroleum-based fuel by the catalytic pyrolysis of waste plastics. Catalytic pyrolysis involves the degradation of the polymeric materials by heating them in the absence of oxygen and in the presence of a catalyst. In the present study different oil samples are produced using different catalysts under different reaction conditions from waste plastics. The synthesized oil samples are subjected to a parametric study based on the oil yield, selectivity of the oil, fuel properties, and reaction temperature. Depending on the results from the above study, an optimization of the catalyst and reaction conditions was done. Gas chromatography-mass spectrometry of the selected optimized sample was done to find out its chemical composition. Finally, performance analysis of the selected oil sample was carried out on a compression ignition (CI) engine. Polythene bags are selected as the source of waste plastics. The catalysts used for the study include silica, alumina, Y zeolite, barium carbonate, zeolite, and their combinations. The pyrolysis reaction was carried at polymer to catalyst ratio of 10 : 1. The reaction temperature ranges between 400°C and 550°C. The inert atmosphere for the pyrolysis was provided by using nitrogen as a carrier gas.

***Key Words**: Synthesis Of Fuel from Waste Plastic, Pyrolysis, Targed product, Polypropylene Oil AndDiselComparioson, RECOUP Recycling of Used Plastic Web Page.*

INTRODUCTION

In the recent years it is quite common to find in newspapers and publications that plastics are turning out to be a menace. Days are not so far when earth will be completely covered with plastics and humans will be living over it. All the reasoning and arguments for and against plastics finally land up on the fact that plastics are non-biodegradablein nature. The disposaland decomposition of plastics has been an issue which has caused a number of research works to be carried out in this regard. Currently the disposal methods employed are land filling, mechanical recycling, biological recycling, thermal recycling, and chemical recycling. Of these methods, chemical recycling is a research field which is gaining much interest recently, as it turns out to be that the products formed in this method are highly advantageous.

Kong spends about US$ 14 million a year on the exercise [1]. The majority of the plastic waste ends up in landfills, and becomes a carbon sink where it may take up to 1000 years to decompose and potentially leak pollutants into the soil and water.and metals. On the other words, more than half of the municipal solid waste components are organic species mainly thermoplastics, Also the plastic wastes are dumped in the oceans threatening the health and safety of marine life. The uncontrolled incineration of plastic produces polychlorinated dibenzo-p-dioxins, a carcinogen. So, converting the waste plastic into crude oil will have two benefits. First of all, the hazards caused due to plastic waste can be reduced and secondly, we will be able to obtain some amount of oil from it, which can be further purified to be used as a fuel in different areas such as domestic fuel, fuel for automobiles and industries etc. Thereby, our dependency on fossil fuels will reduce to a certain extent.

A. Plastics

1) plastic, polymeric material that has the capability of being molded or shaped, usually by the application of heat and pressure. This property of plasticity, often found in combination with other special properties such as low density, low electrical conductivity, transparency, and toughness, allows

plastics to be made into a great variety of products. These include tough and lightweight beverage bottles made of polyethylene terephthalate (PET), flexible garden hoses made of polyvinyl chloride (PVC), insulating food containers made of foamed polystyrene, and shatterproof windows made of methacrylate And thermosetting polymers. Thermoplastics can Repeatedly soften and melt if enough heat is applied Hardened on cooling, so that they can be made into Plastics products. Examples are polyethylene, Polystyrene and polyvinyl chloride, among others.

2) Thermosets or thermosetting can melt and take Shape only once. They are not suitable for repeated heat Treatments; therefore, after they have solidified, they Stay solid.

B. Target Waste Plastics

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 feedstock which arenon-hazardous and Combustible. In particular each type of waste plastic Conversion method has its own suitable feedstock. The Composition of the plastics used as feedstock may b Very different and some plastic articles might contain Undesirable substances (e.g. additives such as flame-Retardants containing bromine and antimony Compounds or plastics containing nitrogen, halogens Sulphur or any other hazardous 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, Therefore the major quality concerns When converting waste plastics into fuel resources are

As follows:

1) Smooth feeding to conversion equipment: Prior to Their conversion into fuel resources, waste plastics are Subject to various methods of pre-treatment to facilitate The smooth and efficient treatment during the Subsequent conversion process. Depending on their Structures (e.g. rigid, films, sheets or expanded (foamed) material) the pre-treatment equipment used

For each type of plastic (crushing or shredding) is often the high viscosity of plastics is not a problem for the flow in screw kiln reactor because the flow is driven by the external motor. Melted plastic or even plastic solid particles can be fed into this reactor. The small diameter of the extruder and good mixing of the materials make the radial temperature gradient negligible. The process is relatively stable and does not use bed material as in the fluidized bed reactor. The feeding rate can be controlled by adjusting the rotation speed of the extruder, which also determines the residence time of plastics

2) Effective conversion into fuel products: In solid fuel production, thermoplastics act as binders which form pellets or briquettes by melting and adhering to other non-melting substances such as paper, wood and thermosetting plastics. Although wooden materials are formed into pellets using a pelletize, mixing plastics with wood or paper complicates the pellet preparation process. Suitable heating is required to produce pellets from thermoplastics and other combustible waste.

In liquid fuel production, thermoplastics containing liquid hydrocarbon can be used as feedstock. The type of plastic being used determines the processing rate as well as the product yield. Contamination by undesirable substances and the presence of moisture increases energy consumption and promotes the formation of by-

3) Well-controlled combustion molecular weight hydrocarbons, non-condensable petroleum gases. In a slow pyrolysis, long residence time encourages the carbonization process and produces more tar and char in the products.

4. Fuel Demand

The present rate of economic growth is unsustainable without saving of fossil energy like crude oil, natural gas or coal. International Energy Outlook 2010 reports the world consumption of liquid and petroleum products grows from 86.1 million barrels per day in2007 to 92.1 million barrels per day in 2020 and 110.6 million barrels per day in 2035 and natural gas consumption increases from 108 trillion cubic feet in 2007 to 156 trillion cubic feet in 2035. This way, the oil and gas reserve available can meet only 43 and 167 years further. Thus mankind has to rely on the alternate/renewable energy sources like biomass, hydropower, geothermal energy, wind energy, solar

CLASSIFICATION OF PLASTICS

Plastics are classified into two types, they are

1) High-density polyethylene

2) Low-density polyethylene

1) High-density polyethylene

Polypropylene and polystyrene. Also, plastics are classified by their chemical structure of the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, poly addition, and cross-linking.

2) Low-density polyethylene

Low-density polyethylene (LDPE) is used for its toughness, flexibility, and relative transparency. LDPE is used to make bottles that require extra flexibility. To take advantage of its strength and toughness, it is used to produce grocery bags and garbage bags, squeezable bottles, shrink wrap, stretch films, and coating for milk cartons. It can also be found in toys, container lids, and packaging. Polypropylene (PP) is known for its highmelting point, which makes it ideal for holding hotliquids that cool in the bottles (for example, ketchup and syrup). It can be manufactured to be flexible or rigid. PP is used to make containers for yogurt, margarine, takeout meals, and deli foods. It is also use for medicine bottles, bottle caps, and some household

LITERATURE SURVEY

In order to have a proper background study on technologies available for conversion of waste plastics to fuel, literature survey is carried out to know its various applied method throughout the globe, they are summarized below. From this crude oil various products petrol, diesel and kerosene etc. can be obtained by distillation. This process can convert all HDPE waste plastic to different grade fuels and specially jet grade fuel. After reviewing these various literatures, we can see those different forms of Pyrolysis processes have been employed for the conversion of plastic wastes to efficient fuels and also successfully tested as well.

A. Production of Plastics

The production of plastic begins with a distillation process in an oil refinery. The distillation process involves the separation of heavy crude oil into lighter groups called fractions. Each fraction is a mixture of hydrocarbon chains (chemical compounds made up of carbon and hydrogen), which differ in terms of the size and structure of their molecules. One of these fractions naphtha, is the crucial element for the production of plastics. Plastics are also produced from natural gas.

B. Production of Naphtha

Naphtha is an intermediate hydrocarbon liquid stream derived from the refining of crude oil. It is the lightest liquid distillate product of crude distillation consisting of C5 to C10 hydrocarbons boiling in the 100 to 310°F range. It is produced from the atmospheric distillation of crude oil and from many secondary processing units in the refinery. Unlike other petroleum fuels such as kerosene, diesel, or fuel oil, naphtha is not a direct petroleum fuel but is used as a feedstock for the manufacture of plastics. The first unit process in a petroleum refinery is the crude oil distillation unit. The overhead liquid distillate from that unit is called virgin or straight-run naphtha and that distillate is the largest source of naphtha in most petroleum refineries. The naphtha is a mixture of very many different hydrocarbon compounds. It has an initial boiling point of about 35 °C and a final boiling point of about 200 °C, and it contains paraffin, naphthenic (cyclic paraffin's) and aromatic hydrocarbons ranging from those containing 4 carbon atoms to those containing about 10 or 11 carbon atoms.

The virgin naphtha is often further distilled into two streams: a virgin light naphtha with an IFP of about 30 °C and a FBP of about 145 °C containing most (but not all) of the hydrocarbons with 6 or less carbon atoms. A virgin heavy naphtha containing most (but not all) of the hydrocarbons with more than 6 carbon atoms. The heavy naphtha has an IFP of about 140 °C and a FBP of about 205 °C [2]. It is the virgin heavy naphtha that is usually processed in a catalytic reformer because the light naphtha has molecules with 6 or less carbon atoms which, when reformed, tend to crack into butane and lower molecular weight hydrocarbons which are not useful as high-octane gasoline blending components. Also, the virgin light naphtha molecules with 6 carbon atoms tend to form aromatics which are high-octane components but which are undesirable because they are carcinogens (most particularly benzene) and governmental environmental regulations in a many countries limit the amount of aromatics that gasoline may contain.

METHODOLOGY

A. Pyrolysis

Pyrolysis is generally defined as the controlled heating of a material in the absence of oxygen. In plastics Pyrolysis, the macromolecular structures of polymers are broken down into smaller molecules or oligomers and sometimes monomer units. Further degradation of these subsequent molecules depends on a number of different conditions including (and not limited to) temperature, residence time, presence of catalysts and other process conditions. The Pyrolysis reaction can be carried out with or without the presence of catalyst. Accordingly, the reaction will be thermal and catalytic Pyrolysis. Since majority of plastic used are polyolefin, so extensive research has been done on this polymer which is summarized as below.

B. Thermal Pyrolysis of Polyolefin

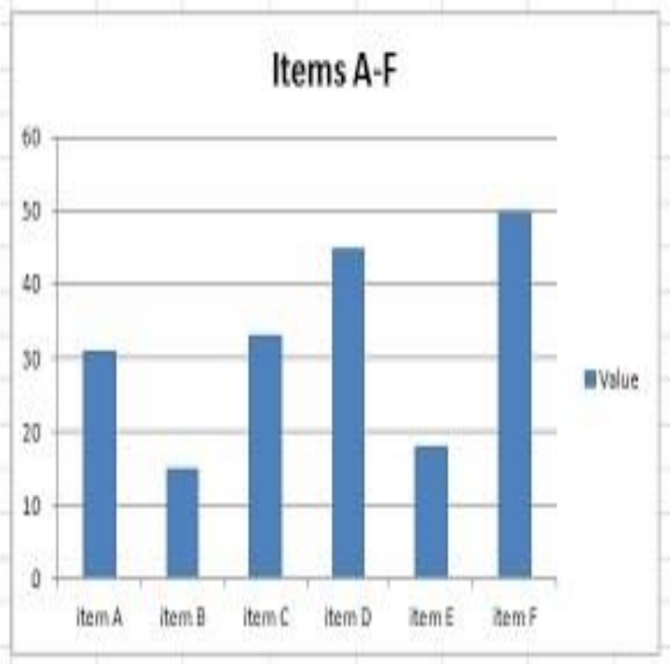
The non-catalytic or thermal Pyrolysis of polyolefin is a high energy, endothermic process requiring temperatures of at least 350–500 °C.research, the hydrocarbon products can be firstly separated though gas chromatography (GC) and then identified by either comparing with hydrocarbon standards or passing through mass spectrometry (MS). Hydrocarbon products from industrial pyrolysis of waste plastics are used as a substitute for commercial fuels. Instead of investigation on individual components, the commercial fuel regulation requirements focus on the physical and chemical properties of fuels relate to engine performance. The New Zealand regulation requirements on the properties of petroleum fuels such as LPG, petrol and diesel adapted standard test methods from the American Society for Testing and Materials (ASTM) and institute of petroleum (IP) testing methods. The properties of plastic pyrolysis fuels are analyzed in some studies. It was found that the pyrolysis products from PE, PP, and PS are mainly hydrocarbons with molecular weights similar to the petrol and diesel range. A certain amount of non-condensable gases and insignificant amount of heavy wax were also found in the pyrolysis products

Heavy hydrocarbon wax can be processed into gases or light liquid by further high temperature treatments or catalytic cracking so that the yields of non-condensable gases and wax vary largely in different studies. The plastic derived fuels were also found to have higher unsaturated hydrocarbon content and lower stability than those of commercial fuels.

PYROLYSIS

The description and classification of pyrolysis reactors are given in Section 2.1 of this thesis and the existing commercial pyrolysis plants use various types of the reactors. Continuous pyrolysis process is applied on most commercial plants with capability to use catalysts in which the plastic retention time is relatively short. Very few of the commercial plants use high pressure operation condition and most of the plants operate at or slightly above atmospheric pressure. The operating temperature in the reactors varies largely from 250 ºC (Mazda fixed- bed catalytic process in Japan) up to 800

ºC (Compact Power fixed-bed pyrolysis in United Kingdom) but most of the pyrolysis reactors operate between 400 ºC and 550 ºC. It must be noted that if the operation temperature is above 800 ºC, the process becomes gasification and the products are mainly short chain hydrocarbons which remains as gases under room temperature and atmospheric pressure. All of the commercial plants are fast or flash pyrolysis. Three types of reactors including fixed-bed, fluidized-bed, and rotary kiln can be found in the literature review.



RAW MATERIAL

The Raw material used for extracting oil by the process of Pyrolysis is Polypropylene (PP). The Material Safety Data Sheet taken from Indian Oil Corporation gives detailed information about various safety aspects of the material used. Chemical Family : Polyolefin

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CONCLUSIONS

Pyrolysis of hydrocarbon polymers is a very complex for this project. We are thankful to our principal Prof. V. R. Rathi Sir for their inspiration. process, which consists of hundreds of reactions and This work is also products. Several factors have significant effects on the the outcome of the blessing guidance and support of reactions and the products. Based on previous research, my parents and family members and friends. Lastly, this chapter investigated the fundamental plastic our cordial thanks to all who have contributed indirectly processes and reactions. With temperature increasing, and materially in words and deeds for completion of plastic will go through glassy state, rubbery state, liquid this work. state, and decomposition. Decomposition of plastic in an

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2. Material Safety Data Sheet Polypropylene(PP) India products through a secondary cracking process. This Oil Corporation Ltd.. secondary cracking process has significantly influence on the distribution of the product. This process converts heavy hydrocarbons into gas or light liquid product.

FUTURE SCOPE

The project shows some light on the possibility of manufacturing liquid fuels which could be used as feed stock refinery for further modification or commercial use. By using this technology we could solve the waste plastic problem and also significantly reduce the landfills-which