

Synthesis of the Fuel from Waste plastic

Kote Siddanth , Tapkir Nikhil , Bhawar Sejal, Jadhav Suraj and Porf. Ashwini Kharde

1. Student of Department of chemical Engineering and Porf. .Department of Chemical Engineering.

P. Dr. V. V. Patil Poly. College, Loni. Pravaranagar, Ahmednagar-413736.

ABSTRACT.....

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 principal of the production / process will be discussed.

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

INTRODUCTION

Plastic waste is regarded as a potentially cheap source of chemicals and energy. Lots of us have encountered a variety of products that use plastic materials today. As a result of the increasing level of private consumption of these plastic materials huge amount of wastes are discharged to the environment. Plastic materials are a type of material that cannot be decomposed easily in a short period of time. Substantial quantities of plastic have accumulated in the natural environment and in landfills. Those wastes can be classified according to their origins. They are

Industrial • Municipal

These groups have different qualities and properties and are subjected to different management strategies. Huge amounts of plastic wastes arise as a by- product or defective product in industry and agriculture. The main components of municipal solid waste (MSW) are food waste, wood, paper, cardboard, plastics, rubbers, fabrics, and metals. On the other words, more than half of the municipal solid waste components are organic species mainly thermoplastics, which can be used as energy sources. The traditional MSW disposal method is landfill. Because of the longevity of plastics, disposal to landfill may simply be storing problems for the future. For example, plasticizers and other additive chemicals have been shown to leach from landfills. The extent of varies accordingly, particularly pH and organic content. Synthesis of fuel from waste plastic

Thermoplastics can repeatedly soften and melt if enough heat is applied and hardened on cooling, so that they can be made into new plastics products. • Thermosets or thermosetting plastics can melt and take shape only once. They are not suitable for repeated heat treatments; therefore after they have solidified, they stay solid. Recently, the conception of energy recovery from MSW has been a very hot topic. It is also undesirable to dispose of waste plastics by landfill due to poor biodegradability. An alternative strategy is that of chemical recycling, known as feedstock recycling or tertiary recycling, which has attracted much interest recently with the aim of converting waste plastics into basic petrochemicals to be used as chemical feedstock or fuels for a variety of downstream processes.

PLASTICS

As a brief introduction to plastics, it can be said that plastics are synthetic organic materials produced by polymerization. They are typically of high molecular mass, and may contain other substances besides polymers to improve performance and/or reduce costs. These polymers are made of a series of repeating units known as monomers. Therefore polymers can be molded

or extruded into desired shapes. There are two main types of plastics: thermoplastics and thermosetting polymers. Examples are polyethylene, polystyrene and PVC. Examples are phenol formaldehyde and urea formaldehyde.

1.3 TYPE OF REACTOR

The reactor type for the plastic pyrolysis significantly influences on the heat transfer rate, mixing of plastics with pyrolysis products, residence time and the reflux level of the primary products. Reactors can be classified into batch, semi-batch and continuous or classified based on types of reactor bed.

BATCH, SEMI-BATCH AND CONTINUOUS REACTORS

According to the feeding and product removal processes, the pyrolysis reactor is categorized into batch, semi-batch and continuous reactors. In the batch reactor, the materials are fed into the reactor in batches for pyrolysis either at the start of the process or after all of the fed materials are processed. In the continuous reactor, the feed materials are input from one part and the products are led out from the other part of the reactor. A semi-batch reactor removes the pyrolysis products continuously once they are generated but the feed materials are added initially before the pyrolysis process starts. Some semi-batch process uses inert carrier gas to help remove the pyrolysis products. Batch and semi-batch reactors are mainly applied on research, and continuous reactor is mainly for industrial production. Particular reactions and phenomenon such as secondary pyrolysis may occur in semi-batch reactors and does not occur in batch reactors.

FIXED BED, FLUIDIZED BED AND SCREW KILN REACTORS

Based on the heat transfer methods and flow patterns of the feedstock and products, the pyrolysis reactors can be classified into fixed bed reactor, fluidized bed reactor and screw kiln reactor. In the fixed bed reactor, the pyrolysis occurs on a stationary bed which is easy to design and operate. However, the irregular sizes and shape of the feedstock plastics may cause feeding problems in continuous process and the low thermal conductivity of the plastics results in large temperature gradient in batch process devices. In some systems, the fixed bed reactors are only used as the secondary pyrolysis reactor because the products from the primary pyrolysis are mainly in liquid and gaseous phase which

can be easily fed into the fixed bed. The fluidized bed reactor has been used in most commercial plants in which gaseous products or inert gas flow through an expanded bed of feedstock and other bed materials, forming bubbles or eddies. The advantages of fluidized bed reactor are the homogeneity of both temperature and composition. Heat and mass transfer rates are much higher than the fixed bed thus the low thermal conductivity in fluidized bed reactors is no longer a problem. In the fluidized bed reactor, the dimensions and the material of the bed material are the key parameters affecting the pyrolysis and products. Bed materials loss and separation from the gases are other issues which need consideration. In recent years, a new reaction system named screw kiln reactor has been widely applied for plastic processing. In this type of reactor, here is an extruder to screw the feedstock from a feeder in an oxygen free environment. The extruder is heated by external heat sources. Solid residues and pyrolysis products are separated and collected from the other end of the extruder. 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.

RESIDENCE TIME

The definition of residence time differs in various studies. The table 2.2 shows the various target products. In fast pyrolysis or continuous pyrolysis process, it refers to the contact time of the plastic on the hot surface throughout the reactor. However in slow pyrolysis and batch process, the residence time means the duration from the time when feedstock plastic start to be heated to the time when the products are removed. Longer residence time favors a further conversion of the primary products thus yielding more thermal stable products such as light 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.

USE OF CATALYST

ADVANTAGES OF USING CATALYST

In order to optimize plastic pyrolysis reactions and modify the distribution of pyrolysis products, catalysts are widely used in research and industrial pyrolysis processes. Petroleum fuels, such as LPG, petrol, kerosene, and diesel, are hydrocarbons from C1 to C24. The PE pyrolysis products are mainly straight hydrocarbons from C1 up to C80, which contain much heavier molecular weight components. One of the main purposes of using catalysts is to shorten the carbon chain length of the pyrolysis products and thus to decrease the boiling point of the products. Catalysts are found to be mainly applied to PE pyrolysis because the primary product from other plastics, such as PP and PS, are mainly light hydrocarbons, with similar carbon chain length to the range of commercial fuels. The products from non-catalytic PE pyrolysis contain high proportion of 1-alkenes and dialkenes. Some catalysts are applied specifically to reduce the unsaturated hydrocarbons and promote the yield of aromatics and naphthenes. This can significantly increase the stability and cetane number of the oil products. Moreover, it is reported that activation energies (E_a) measured in the PE pyrolysis with catalysts (such as HZSM-5, HY, and MCM-41) were much lower than those when no catalyst was added.

PRESSURE

pressure has significantly effect on both the pyrolysis process and the products. The boiling points of the pyrolysis products are increased under higher pressure, therefore, under pressurized environment heavy hydrocarbons are further pyrolyzed instead of vaporized at given operation temperature. Figure 2.4 shows Effect of pressure on the distribution of PE pyrolysis products. In effect, under pressurized pyrolysis, more energy is required for further hydrocarbon cracking. It was also found that high pressure increases the yield of non-condensable gases and decreases the yield of liquid products. (Figure 2.5) The average molecular weight of gas product also decreases with the increase of pressure. The influence of pressure on the concentration of double bond, C=C, of the liquid product was not significant. In summary, pressure has major effects on the pyrolysis reaction and the distribution of PE pyrolysis products, but has minor effect on the double bond components.

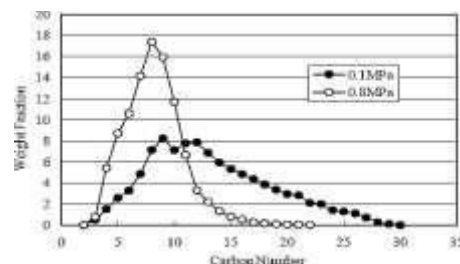


Figure 2.4 Effect of pressure on the distribution of PE pyrolysis products

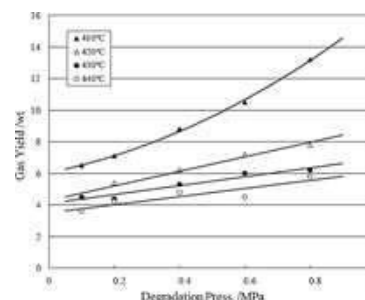


Figure Effect of pressure on the yield of gas at different temperature.

The catalyst are classified into two. They are Homogeneous catalysts used for polyolefin pyrolysis have mostly been classical Lewis acids such as $AlCl_3$. Generally, heterogeneous catalysts are preferred due to their easy separation and recovery from the reacting medium. Heterogeneous catalysts can be summarized as nanocrystalline zeolites, aluminium pillared clays, conventional acid solids, mesostructured catalysts, superacid solids, gallosilicates, metals supported on carbon, and basic oxides. Among the mentioned catalysts, nanocrystalline zeolites have been extensively studied for polyolefin pyrolysis and this type of catalysts will be discussed in more details as follows. A zeolite is a crystalline aluminosilicate with a three-dimensional framework structure that forms uniform pores of molecular dimensions. Zeolites act as sieves on a molecular scale and exclude molecules that are too large to pass through the pores. The three-dimensional frame structure significantly increases the area of the sieves and absorbs molecules that have similar sizes as the pores. According to the structure of zeolites, 176 zeolite framework types have been confirmed. A three-letter code, such as MFI, is assigned to framework types by the Structure Commission of the International Zeolite Association. The codes are derived from the name of the zeolite, for example, MFI from ZSM-5. The pore openings and sizes are key parameters for the catalytic

effect in the plastic pyrolysis, which are determined by the size of single ring and the structure features

PRODUCT ANALYSIS METHOD

The pyrolysis products of plastics are mainly hydrocarbons presenting in gaseous, liquids and solid wax phases under standard conditions of temperature of 25 °C and pressure of 100 kPa. Minor amounts of char and hydrogen gas may be found in the products. The char product can be analyzed by elemental analyzer or electron- microscope dispersive X-ray analyzer. In 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 °C (Mazda fixed- bed catalytic process in Japan) up to 800



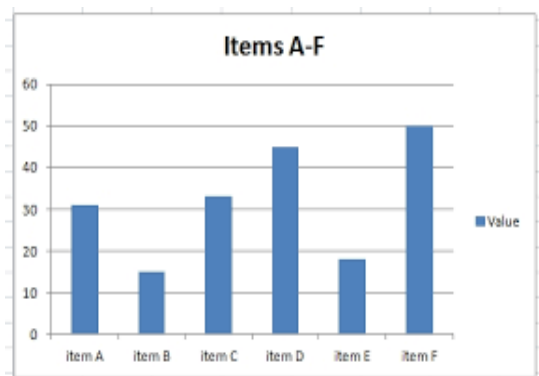
°C (Compact Power fixed-bed pyrolysis in United Kingdom) but most of the pyrolysis reactors operate between 400 °C and 550 °C. It must be noted that if the operation temperature is above 800 °C, the process becomes gasification and the products are mainly short chain hydrocarbons which remains as gases 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 C.A.S. No. : 9003-07-0 Manufacturer's Name : Indian Oil Corporation Limited Address : Product Application and Development Centre (PADC), Panipat Petrochemical Marketing Complex (PPMC), Panipat Refinery, Baholi, Panipat – 132 140

Telephone No : +91 180-2578091

Fax No. : +91 180-2578098



Solid Fuel Production

CONCLUSIONS

Pyrolysis of hydrocarbon polymers is a very complex process, which consists of hundreds of reactions and products. Several factors have significant effects on the reactions and the products. Based on previous research, this chapter investigated the fundamental plastic processes and reactions. With temperature increasing, plastic will go through glassy state, rubbery state, liquid state, and decomposition. Decomposition of plastic in an inert environment into liquid is called pyrolysis. There are four stages of reactions during the plastic pyrolysis process: initiation, propagation, hydrogen transfer, and termination reactions. It was found that heavy molecular weight hydrocarbons produced from primary cracking can be further cracked into light molecular weight products through a secondary cracking process. This 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 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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