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STUDY ON PLASTIC RECYLING USING PYROLYSIS AND CATALYST CRACKING

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Abstract - ***Waste plastic disposal and excessive use of fossil fuels have caused environment concerns in the world. Both plastics and petroleum derived fuels are hydrocarbons that contain the elements of carbon and hydrogen. The difference between them is that plastic molecules have longer carbon chains than those in LPG, petrol, and diesel fuels. Therefore, it is possible to convert waste plastic into fuels.***

The main objectives of this study were to understand and optimize the processes of plastic pyrolysis for maximizing the diesel range products, and to design a continuous pyrolysis apparatus as a semi-scale commercial plant. Pyrolysis of polyethylene (PE), polypropylene (PP), and polystyrene (PS) has been investigated both theoretically and experimentally in a lab-scale pyrolysis reactor. The key factors have been investigated and identified. The cracking temperature for PE and PP in the pyrolysis is at 450 ºC, but that of PS is lower, at 320 ºC. High reaction temperature and heating rate can significantly promote the production of light hydrocarbons. Long residence time also favours the yield of the light hydrocarbon products. The effects of other factors like type of reactor, catalyst, and pressure and reflux rate have also been investigated in the literature review.

From the literature review, the pyrolysis reaction consists of three progressive steps: initiation, propagation, and termination. The activation energy and the energy requirement for the pyrolysis are dependent on the reaction process and the distribution of the final products. Following the equations from other literatures, the theoretical energy requirement for pyrolyze 1kg PE is 1.047 MJ. The estimated calorific value of the products is about 43.3 MJ/kg. Therefore, the energy profit is very high for this process.

Key Words: *Pyrolysis,Plastics,catalytic cracking etc*

1 Introduction

According to a nationwide survey, conducted in the year 2004, approximately 10,000 tones (ten thousand tones) of plastic waste were generated every day in our country, and only 60% of it was recycled, balance 40% was not possible to dispose off. So gradually it

goes on accumulating, thereby leading to serious disposal problems. Plastic is derived from petrochemical resources. In fact these plastics are essentially solidified oil. They therefore have inherently high calorific value.

Theoretically energy of various plastic materials can be captured and transformed into other useful forms. It is a well known fact that energy can neither be created nor destroyed but merely transformed. One of the most common methods of transforming energy from for example, a solid to another form is thermal treatment. Through the various methods of thermal treatment one may obtain heat, electricity or chemicals suitable for other applications

Waste Plastics are mostly land filled or incinerated; however, these methods are facing great social resistance because of environmental problems such as air pollution and soil contamination, as well as economical resistance due to the increase of space and disposal costs. In a long term neither the land filling nor the incineration solve the problem of wastes, because the suitable and safe depots are expensive, and the incineration stimulates the growing emission of harmful and greenhouse gases e.g. NOx, SOx, COx etc. Accordingly, recycling has become an important issue worldwide. This method can be classified as energy recovery, material recycling and chemical recycling. Among them one of the prevalent alternative methods is the production of converted fuel and chemicals by means of the thermal or catalytic degradation of polymers.

2. PLASTIC WASTE

Plastics are macromolecules, formed by polymerization and have the ability to be shaped by the application of reasonable amount of heat and pressure or some other form of force. Polymerization is the process by which individual units of similar or different molecules ("mers") combine together by chemical reactions to form large or macromolecules in the form of long chain structures, having altogether different properties than those of starting molecules ("mers"). Several hundreds and thousands of "mers" combine together to form the macromolecules, that we call polymers. Depending upon their nature and properties, the polymers are classified as Plastics, Rubbers or Elastomers and Fibers.

2.1 Plastic identification and recycling code:

Symbol	Plastic Name	Used for	Does it Leach?	Recycles?	Notes	
1 PETE	**PET or PETE** *Polyethylene Terephthalate*	Bottling beverages	No	Yes	Easy to recycle. Recycled PET is has many uses.	**Good**
2 HDPE	**HDPE** *High Density Polyethylene*	Milk jugs, cosmetics	No	Yes	Easy to recycle. Recycled HDPE is in high demand and is used to make plastic lumber.	**OK**
5 PP	**PP** *Polypropylene*	Baby bottles, yogurt, deli containers, reusable plastics	No	Yes	Generally recyclable.	**OK**
4 LDPE	**LDPE** *Low Density Polyethylene*	Shopping bags, plastic wraps, baby bottles, reusable plastics.	No	Yes	Generally not recyclable – some stores will accept, but most pick-ups do not.	**Bad**
6 PS	**PS** *Polystyrene*	Plastic cutlery, egg containers.	Yes	No	Banned in some major cities (Portland, San Francisco). Leaches styrene, a neurotoxin and suspected carcinogen.	**Very Bad**
3 PVC	**PVC** Vinyl or Polyvinyl Chloride	Plastic wrap, toys, spray bottles	Yes	No	Considered one of the worst plastics. Leaches toxic phthalates, off-gas chemicals.	**Very Bad**
7 OTHER	Everything Else	Food packaging	Maybe	No	Difficult to determine which items have BPA and which do not. Check package because this also includes some bio-plastics. Items with polycarbonate (PC) leach BPA.	**Very Bad**

2.2 Recycling techniques of waste plastics:

Basically there are 4 different ways of recycling of plastics:

1. Primary Recycling – Conversion of waste plastics into products having performance level comparable to that of original products made from virgin plastics. These methods are undergone in to material recycling methods.
2. Secondary Recycling – Conversion of waste plastics into products having less demanding performance requirements than the original material. These are also a part of material recycling methods.
3. Tertiary Recycling – The process of producing chemicals / fuels / similar products from waste plastics. These methods are known as chemical recycling or feedstock recycling methods.
4. Quaternary Recycling – The process of recovering energy from waste plastics by incineration.

2.3 Study of various catalysts :

Zeolites are Zeolites occur in nature and have been known for almost 250 years as aluminosilicates minerals. Examples: faujasite, mordenite, offretite, ferrierite, erionite and chabazite. Elementary building blocks are ALO4 & SiO4 tetrahedra. The adjacent tetrahedra are linked at their corners via a common oxygen atom and this result in an organic macro molecule with a structurally distinct 3D framework. Chemical composition of a zeolite can be hence represented by Am+Y/M[(SiO2)X, (AlO2-)Y]. zH 20.

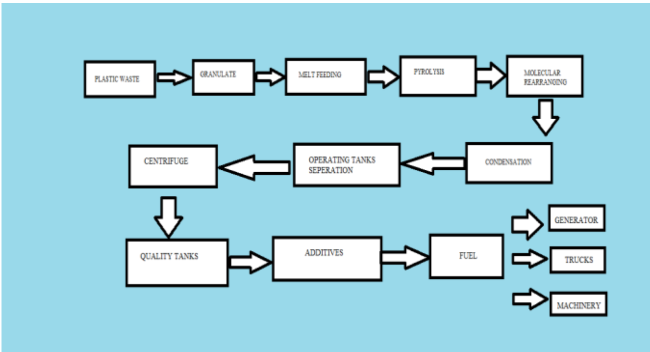
The major limitations of natural zeolites are

1. Chemical composition various from one deposited to another
2. Also one stratum to another of same deposit etc

Bentonite is also used as catalyst in catalysis process. It is an absorbent composed of aluminium phyllosilicate, essentially impure clay consisting mostly of montmorillonite. There are different types of bentonite, each named after the respective dominant element, such as potassium (K), sodium (Na), calcium (Ca),and aluminium (Al).

clays are used for the preparation of commercial cracking catalyst. Two types of clays are mainly used they are montmorillonite and halloysite.There is no known chemical or physical test which will enable one to predict whether or not a particular montmorillonite clay will respond to acid treatment and produce a catalyst of high activity. Very few montmorillonite clays are known which yield satisfactory catalysts. Halloysites as previously stated, may be activated by acid treatment followed by calcination. These materials so treated ordinarily give catalysts of considerably lower activity, which produce 20 to 30 percent gasoline when tested by CAT-A, compared with the best montmorillonites, which produce 40 to 45 percent.

2.4 Pyrolysis and catalytic cracking processes:



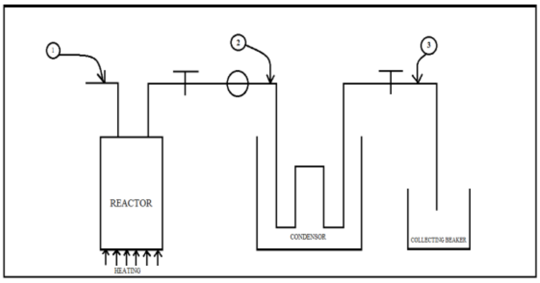
The main events in the working of the pyrolysis unit are

1. Purging oxygen from chamber.
2. Evenly heating the plastic to a narrow temperature range without excessive temperature variations.
3. Pyrolising the plastics.
4. Catalytic conversion of the gases to specific carbon chain lengths.

5. Managing the carbonaceous char by-product before it acts as a thermal insulator and lowers the heat transfer to the plastic.
6. Careful condensation and fractionation of the pyrolysis vapours to produce fuels of excellent quality and consistency.

2.5 EXPERIMENTAL SETUP OF PYROLYSIS UNIT

The heart of the process is a reactor where the cracking reaction occurs. The reactor is loaded with feed mixed with catalyst in the desired ratio and sealed off from the external environment by tightly screwing the head with an asbestos gasket in between the reactor and head. The reactor is uniformly heated across its surface by using a heater. The temperature within the reactor is measured with the help of a thermocouple which is connected to a PID controller and contactor. As the temperature within the reactor rises the feed present in the reactor melts. Vapors are generated rapidly as cracking temperature is attained. The generated vapors are removed from top of the reactor through opening provided on the head of the reactor. The vapors then pass through a series of GI pipes interconnected to form two 900 bends. The open end of the pipe connections is immersed in a quenching jar with ice cold water. The vapors pass through the GI pipes into the quenching jar where they are met by ice cold water and are condensed to form an oil layer which separates above the water layer due to density difference. Oil is separated from water by using a separating funnel to obtain the oil.



1. WASTE PLASTIC WITH CATALYST IN TO THE REACTOR
2. EVAPORATED PRODUCT FROM REACTOR TO THE CONDENSER
3. CONDESED FUEL RANGE HYDROCARBONS TO THE COLLECTING BEAKER

3. CONCLUSIONS

Studies on plastics, recyclability of various plastics, pyrolysis process and various types of catalysts used for catalysis (pyrolysis with a help of a catalyst) were conducted. In the study on various reactors such as fluid bed reactors, fixed bed reactors and moving bed reactors, we found that fixed bed reactors are more suitable for fabrication. In the study on various catalyst such as zeolites, bentonite, silicates, allumino silicate etc, we concentrated on zeolites and bentonites because of their greater efficiency compared to others. It is also seen that the catalyst can be mixed with the feed plastics in two phases such as gaseous or liquid. It is found that the liquid phase addition is simpler than gaseous phase.

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