



Catalytic Pyrolysis of Polystyrene Waste using Bentonite as a Catalyst

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Abstract

The recycling of waste plastics by thermal and catalytic degradation processes can be an important source of producing alternative fuel oil from the view point of an economical aspect and contributing to the environmental protection from the view point of an environmental aspect. In this work pyrolysis of Polystyrene (PS) was carried out with bentonite as a catalyst at temperature between 380 to 420 °C to explore its effect on pyrolysis product distribution. Three fractions of products were obtained: Pyrolysis oil (55 wt %), pyro gas (10 wt %) and char (34 wt %). The presences of catalyst produces light oil as well as increase in yields of liquid and gas fractions as the temperature increases were reported.

Keywords : *Catalyst; Oil; Plastic; and Pyrolysis*

1. INTRODUCTION

Our modern society is unimaginable without plastics. Both the consumption and production of polymers are increasing day by day, but the increasing amount of polymer waste from them generates further environmental degradation(1) on the other hand the capacity of landfill sites and incinerates is limited. Due to the limitations, chemical (e.g., thermal and thermo catalytic waste) recycling is growing importance and it is in the focus of the solution to the problem

Since plastics are non-biodegradable, they cannot be easily returned to the natural carbon cycle; hence the life cycle of plastic materials ends at waste disposal facilities. In most developed society's domestic organic waste, including plastics packaging, indisposed of insanitary land filled or by incineration. There are several methods for disposal of municipal and industrial plastic waste, i.e., landfill, incineration (energy recovery), true

material recycling (similar recycled product or monomer recovery), and chemical recovery. The suitable treatment of plastic wastes is one of the key questions of waste management and is important from energetic, environments, economical and political aspects represent the different routes for plastic waste management being followed.

The main components of the house hold plastic waste streams include the following five families of plastics. Polyethylene, low density polyethylene (LDPE), Linear low density polyethylene (LLDPE), high density polyethylene (HDPE), Polypropylene (PP), Polyvinylchloride (PVC), Polystyrene (PS) and Polyethylene terephthalate (PET) which account entirely for 74% of all plastic waste.

Polystyrene is an important plastic with the rapid increase of production and consumption of PS, the amount of waste PS discarded constantly increasing every year and is causing serious pollution problem. The situation for recycling recently has improved evolving the society in to a

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recycling oriented one. By imposing various government laws, the cooperation of civil society and the increasing new technological development has opened up new ways of plastic recycling. The poor biodegradability of PS creates serious environmental problem. So the recycling of PS gain momentum in recent years.

Generally the recycling methods are classified as the material recycling and chemical recycling. The chemical recycle which is an advanced technology in which the plastic waste is converted into smaller molecules corresponding to the chemical intermediate through the use of heat and chemical treatment such as liquids, gases and wastes (Kumar et.al, 2011).

The chemical recycling are classified as heterogeneous and homogeneous process. The chemolysis methods a homogeneous process utilize chemical agents such as chemical agents as catalyst. The heterogeneous processes are greatly described by gasification and pyrolysis. In pyrolysis technique the polymeric materials are heated in the absence of oxygen and it leads to degradation. The method has the routers as the thermal cracking catalytic cracking and hydro cracking. The recycling of waste plastics by thermal and catalytic degradation processes can be an important source producing alternate fuel oil in economical aspect and contributing to the environmental protection (Demirbar 2004).

In pyrolysis, thermal degradation is a simple method for upgrading plastic waste into liquid product at medium temperature (400 - 600p C) in the absence of oxygen. Due to low thermal conductivity of waste plastics this process requires relatively high energy consumption (Marcilla et.al, 2009).

The catalytic degradation process based on the addition of catalyst can be conducted at low temperature and high quality products are obtained in a comparison with thermal degradation process (Miskolczi et al., 2004). The most commonly used catalyst as (1) solid acid catalyst such as Zcolits,

silica-alumina, FLL catalyst and MCM-41, etc., [Miskolczi et al., 2004; Lec et al., 2002; Garcia et al., 2005; Seddegi et al., 2002; Lin&yang 2007] and (2) Bifunctional catalysts[Buckens & Huang 1998].

This chapter presents the pyrolysis of polystyrene with different physiochemical properties and also the up grading of low grade oil product obtained by catalytic degradations.

2. BASIC PYROLYSIS

2.1 Reaction mechanism of polystyrene

The pyrolysis is basically degradation for large hydrocarbon into smaller once. Due to the process the polymer is converted into paraffin and olefin etc., with low molecular weight (Scheirs & Kaminsky, 2006). Pyrolysis of polyrene with cyclic structure is occurred by end chain and random chain scissions. This polymer is broken yielding the corresponding monomer as well as its breaking randomly into smaller molecules of one (or) more benzene-ring like structure.

3. EXPERIMENTAL

3.1 Raw Materials

In our experiment polystyrene (PS) from the industrial waste were crushed to pieces of 4 to 7 mm and used as raw material. The melt flow index (MFI) (at 190p with 2160 g load) was 0.519 g/10min for polystyrene. The used raw material had sulphur and nitrogen content from additives.

3.2 Catalysts and their characterization

Three different cracking catalysts were used in thermo catalytic cracking an equilibrium fluid catalytic cracking catalyst (FCC) a commercial 2SM-5 catalyst. First the catalysts were degassed under vacuum at 160p C for 5h and then the surface area of catalyst was calculated by the application of BET procedure.

Addition of catalyst enhances the conversion and fuel quality. As compared to the thermal pyrolysis the addition of catalyst creates the following significance.

- (1) It lowers pyrolysis temperature and time. Due to reduction in temperature and reaction time results in an increase in the conversion rates for a wide range of polymers at much lower temperature than with thermal pyrolysis.
- (2) Narrows and provides better control over the hydrocarbon products distribution in polystyrene pyrolysis.

3.3 Pyrolysis reaction of PS

The catalytic cracking reactions were performed in a reactor at given temperature and pressure. The mixture of catalyst and PS was added into the reactor and heated. The heating rate will be 20p /min. The products like liquid and gas coming out from the reactor were separated in a condenser and accumulate to determine their composition by a gas chromatograph. FID was used as a detector. The conversion of PS and the yield of liquid product were calculated according to the following formula.

$$\text{Conversion of PS} = \frac{\text{Weight of PS and catalyst} - \text{Weight of residu}}{\text{Weight of PS} \times 100} \% \quad (1)$$

$$\text{Yield of liquid product} = \frac{\text{Weight of liquid products}}{\text{Weight of PS} \times 100} \% \quad (2)$$

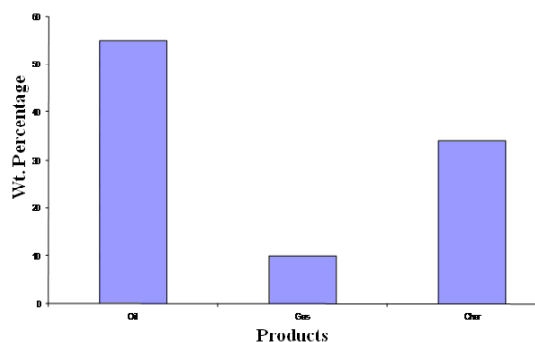


Fig. 1: Plastic pyrolysis yield graph

4. RESULT AND DISCUSSION

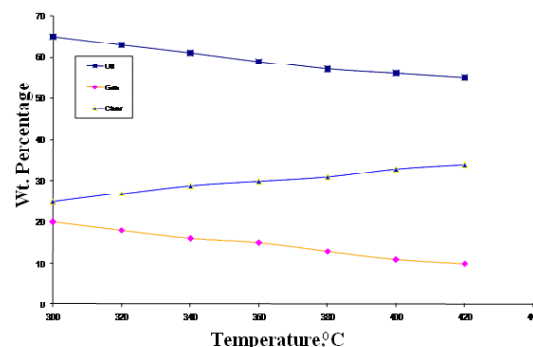


Fig. 2. Effect of temperature in product yield

The increase of temperature from 380 °C to 420 °C the wt.% of char decreased to 34 wt.% almost equivalent but some what higher then the theoretical yield. Therefore one might think that not all the volatile mater of tire has been decomposed to liquid and gases. The oil yield maximum value 55 Wt.% at 420 °C probably owing to strong cracking of waste plastic at this temperature and than decreasing oil yield with increasing temperature because of the decomposition of some oil vapour s in to permanent gas and secondary reactions of the oil hydrocarbons in char.

Plastic pyrolysis oils from tire pyrolysis with out catalyst have been shown to be highly aromatic, which are limited to be used as a alternate liquid fuel. So, catalysts are used to produce more single ring aromatic compounds during tire pyrolysis. Since the derived oils contain concentrations of valuable chemicals such as Benzene, Toluene, Xylene, etc., So they can be extracted from the derived oils and used as chemical feedstock's in the chemical industry. Catalysis leads to substantial increase in amount of gases and consequent decrease in the amount of liquid.

5. CONCLUSION

Catalytic pyrolysis of waste plastic has several advantages over other alternative plastic

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Catalytic pyrolysis of waste plastic has several advantages over other alternative plastic recycling methods. It has been shown that the conversion at lower temperature in the presence of catalytic for waste plastic in to liquid is a feasible process. An important difference is that the liquid obtained relatively with greater volume and low boiling range in the presence of catalyst as compared to pyrolysis in the absence of catalyst. recycling methods. It has been shown that the conversion at lower temperature in the presence of catalytic for waste plastic in to liquid is a feasible process. An important difference is that the liquid obtained relatively with greater volume and low boiling range in the presence of catalyst as compared to pyrolysis in the absence of catalyst.

The total pyrolytic liquid can be blended with the gasoline diesel fuel. Consequently, evaluation of waste plastic by catalytic pyrolysis is very important from economical and environmental point of view. However, further studies are necessary to utilize pyrolysis liquid as liquid fuel or feed back.

REFERENCES

- Aguadi J, Serrano DP and Escola JM. Fuels from waste plastics by thermal and catalytic processes. *Ind. Engg. Chem. Res* 2008, 47, 7982-7992.
- Bagri R, Williams PT. Fluidised – bed catalytic pyrolysis of polystyrene. *Journal of the institute of energy* 2002: 75 (505): 117-23
- Ding Wb, Liang J, Anderson LL Thermal and catalytic degradation of high density polyethylene and commingled post – consumer plastic waste. *Fuel processing technology* 1997:51 (1-2): 47-62
- Donald S. Scott, Piotr Majerski, Jan Piskorz, Demond Radlein and Michael Barnickel. Production of Liquid fuels from waste plastics. *The Canadian journal of chemical engineering*, vol.77, October 1999.
- Kim JR, Yoon JH, Park DW. Catalytic recycling of the mixture of polypropylene and polystyrene. *Polymer degradation and stability* 2002:76 (1): 61-7
- Lee SY. Catalytic degradation of polystyrene over natural clinoptilolite zeolite. *Polymer degradation and stability* 2001: 19(4): 658-62
- Li Jianfeng, Liu Fusheng, Yu Shitao, Ge Xiaoping, Zhai Xin. Pyrolysis of waste Polystyrene to recover styrene over alkaline mesoporous molecular sieve K_2O -BaO/MCM-41. 2010 International Conference on Digital Manufacturing & Automation.
- Miskolczi N, Bartha L, Deak Gy. Thermal degradation of polyethylene and polystyrene from the packaging industry over different catalysts into fuel-like feed stocks. *Polymer degradation and stability* 2006:91:517-526
- Ohlita H, Nishiyama R, Tochiyama Y, Mizushima T, Kakuta N, Morioka Y, Acid properties of silica – alumina catalyst and catalytic degradation of polyethylene. *Industrial and Engineering chemistry Research* 1993: 32(12): 3112-6
- Park DW, Hwang EY, Kim JR, Choi JK, Kim YA, Woo HC, Catalytic degradation of polyethylene over solid acid catalyst. *Polymer degradation and stability* 1999-65 (2): 193-8