iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 Issue: XI Month of publication: November 2016

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

www.ijraset.com Volume 4 Issue XI, November 2016
IC Value: 13.98 ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Review of Plastic Waste Management by Pyrolysis Process with Indian perspective

Dr. M. Eswaramoorthi[1], T.Venkateshan[2], M. Bala kumaran[3], S. Gejendhiran[4]
[1]Professor, [2,3,4]Asst. Professor
Nandha Engineering College, Erode, Tamilnadu, India.

Abstract: The plastics have found its important role in the day-to-day life of human being and industries. The increasing demands and inefficient disposal methods have resulted in the accumulation of these wastes in the landfills. But these landfills require a lot of spaces and further pollute the lands. India generates 5.6 million metric ton of plastic wastes yearly, as reported by Central Pollution Control Board (CPCB).

The increased plastic production led to the depletion of non-renewable fossil fuels indirectly. In order to counter these problems, one way is to recycle plastic wastes and convert plastic wastes into fuel. Unfortunately, the recycling of plastics is a costlier method and demands a huge water source which can't be reused. Meanwhile, the process of extraction of fuel from plastic waste has got the attention of scientists for optimization. The recovery of plastic waste to fuel oil has a great potential as the fuel oil produced had good calorific value. Among all the processes, the pyrolysis process has been reported to be the most efficient method for converting plastic wastes into fuel oil. An attempt has been made to review the pyrolysis process and different plastics. Further, the key process parameters like temperature, pressure and residence time were reviewed along with various end products.

I. INTRODUCTION

Plastic products occupies very important role in the fields of construction, healthcare, electronic, automotive and packaging. The global plastic production had been approximated to 299 million tons by 2012 due to increasing population. Further this demand had increased by 4% in the year of 2013. This increasing demand of plastic had resulted in the growth of waste accumulation every year. This huge percentage of plastic waste ended up in the landfill not only requires a huge space but also pose to be a threatening problem in terms of pollution. The landfill would not be the proper solution for these plastics as it would cause severe environment issues. In order to resolve these issues, the best solution could be finding a method to reduce these wastes either by recycling or by converting them into useful fuel.

Plastics may take up to billions of years to degrade naturally. They degrade gradually since the molecular bonds containing hydrogen, carbon and few other elements such as nitrogen, chlorine and others that make plastic very durable. The continuous disposal of plastic in the landfill would definitely cause serious environmental problem. In order to reduce plastic disposal to the landfill, recycling method is considered as another alternative to manage plastic waste. Back to the statistic mentioned above, the percentage of recycling still at the lowest. Recycling plastic has proven difficult and it can be costly because of the constraints on water contamination and inadequate separation prior to recycle that is labour intensive. Separation is needed since plastics are made of different resin compound, transparency and colour. Normally, pigmented or dyed plastics have lower market value. Clearly transparent plastics are often desirable by the manufacturers since they can be dyed to transform into new products, thus have greater flexibility. With the stringent requirement to get high value product, recycling plastic becomes quite challenging nowadays.

Recently, the energy conversion from waste has been an intelligent way to fully utilize the waste to meet the increased energy demand. The conversion of plastics to valuable energy is possible as they are derived from petrochemical source, essentially having high calorific value. Hence, pyrolysis is one of the routes to waste minimization that has been gaining interest recently. Pyrolysis is the process of thermally degrading long chain polymer molecules into smaller, less complex molecules through heat and pressure. The process requires intense heat with shorter duration and in absence of oxygen. The three major products that are produced during pyrolysis are oil, gas and char which are valuable for industries especially production and refineries. Pyrolysis was chosen by many researchers. It should be noted that the product yield and quality heavily depends on the set up parameters. Therefore, this review focused on different type of plastic pyrolysis that has been explored together with the main affecting parameters in plastic pyrolysis process that need an attention in order to maximize liquid oil production and enhance the oil quality. The main parameters include temperature, type of reactors, residence time, pressure, different catalysts usage and type of fluidizing gas with its flow rate. Additionally, some relevant discussion regarding the optimization of liquid oil yield was also presented in this paper. The fuel

©IJRASET: All Rights are Reserved

obtained depends 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.

II. PYROLYSIS OF PLASTICS

Fundamentally, different types of plastics have different compositions that normally reported in terms of their proximate analysis. Proximate analysis can be defined as a technique to measure the chemical properties of the plastic compound based on four particular elements which are moisture content, fixed carbon, volatile matter and ash content. Volatile matter and ash content are the major factors that influence the liquid oil yield in pyrolysis process. High volatile matter favoured the liquid oil production while high ash content decreased the amount of liquid oil, consequently increased the gaseous yield and char formation.

These characteristics indicate that plastics have high potential to produce large amount of liquid oil through pyrolysis process. Since the results of plastics proximate analysis are very convincing, the following discussion would focus more on the process parameters involved during the pyrolysis process that would have major influence in the liquid production.

III. TYPES OF PLASTICS

PET has become the great choice for plastic packaging for various food products, mainly beverages such as mineral water, soft drink bottle and fruit juice containers.

To ease the recycling process, the PET waste needs to be sorted into different grades and colors that make its recovery inefficient and uneconomical.

HDPE is characterized as a long linear polymer chain with high degree of crystalline and low branching which leads to high strength properties. Due to its high strength properties, HDPE is widely used in manufacturing of milk bottles, detergent bottles, oil containers, toys and more.

Polyvinyl chloride (PVC) Unlike other thermoplastics such as polyethylene (PE), polystyrene (PS) and polypropylene (PP) which can be softened by heating and solely derived from oil, PVC is exceptional since it is manufactured from the mixture of 57% chlorine (derived from industrial grade salt) and 43% carbon (derived from hydrocarbon feedstock such as ethylene from oil or natural gas

Polypropylene (PP) is a saturated polymer with linear hydrocarbon chain that has a good chemical and heat resistance. It has a lower density than HDPE but has higher hardness and rigidity that makes it preferable in plastic industry.

Polystyrene (PS) is made of styrene monomers obtained from the liquid petrochemical. The structure consists of a long hydrocarbon chain with phenyl group attached to every other carbon atom.

IV. PROCESS PARAMETERS CONDITION

Parameters play major role in optimizing the product yield and composition in any processes. In plastic pyrolysis, the key process parameters may influence the production of final end products such as liquid oil, gaseous and char. Those important parameters may be summarized as temperature, type of reactors, pressure, residence time, catalysts, type of fluidizing gas and its rate.

A. Temperature

It is one of the most significant operating parameters in pyrolysis since it controls the cracking reaction of the polymer chain. Molecules are attracted together by Vander Waals force and this prevents the molecules from collapsed.

B. Type of catalysts

There are two types of catalyst which are homogeneous (only one phase involve) and heterogeneous (involves more than one phase). Zeolite catalyst. Zeolites are described as crystalline aluminosilicate sieves having open pores and ion exchange capabilities. The structure is formed by three-dimensional framework where oxygen atoms link the tetrahedral sides. It is built by different ratio of $SiO_2/Al_2\ O_3$ depends on its type. The ratio of $SiO_2/Al_2\ O_3$ determines the zeolite reactivity which affects the final end product of pyrolysis.

Silica–alumina catalyst. Silica–alumina catalyst is an amorphous acid catalyst that contains Bronsted acid sites with an ionisable hydrogen atom and Lewis acid site, an electron accepting sites.

V. CHARACTERISTICS OF PLASTIC PYROLYSIS OIL

A. Physical properties

The experimental calorific value of HDPE, PP and LDPE are all above 40 MJ/kg and were considered high for energy utilization. The calorific value of PS was commonly lower than the polyolefin plastic due to the existence of the aromatic ring in the chemical structure

©IJRASET: All Rights are Reserved

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

which had lesser combustion energy than the aliphatic hydrocarbon. Overall, PET and PVC had the lowest calorific value below 30 MJ/kg due to the presence of benzoic acid in PET and chlorine compound in PVC that deteriorated the fuel quality

B. Chemical properties

The liquid oil composition was usually characterized using the FTIR and GC–MS equipment for detailed analysis. The corrosiveness of the acid made it unfavorable to be used in thermochemical conversion system. As the reaction proceeded during pyrolysis, PET tended to lose more aliphatic compound than the aromatic compound and this resulted in higher liquid yield than PVC.

C. By-products of the plastic pyrolysis

Pyrolysis of plastics also produces char and gas as by-products. The proportion of by-product in pyrolysis strongly depends on several parameters such as temperature, heating rate, pressure and residence time. Some information about the by-products generated is discussed below.

1) *Char:* It is long residence time maximizes the char formation in pyrolysis process. Even though the char formation in fast pyrolysis process is commonly low, it is worth noting the properties and usage of the charto fully maximize the potential of plastic pyrolysis
2) *Gas:* It is high temperature and long residence time were the best condition to maximize gas production in pyrolysis process. However, these conditions are opposite with the parameters to maximize oil production. Generally, gas production in pyrolysis process of polyolefins and PS plastics were quite low in the range of 5–20 wt% and it is strongly depends on the temperature and type of plastics used in pyrolysis.

VI. DISCUSSION ON PLASTIC PYROLYSIS SCENARIOS

This review showed that many researchers have been done to study the potential of plastic pyrolysis process in order to produce valuable products such as liquid oil and the results were convincing. This technique offers several advantages such as enhancing the waste management system, reducing the reliability to fossil fuels, increasing energy sources and also prevents the contamination to the environment. The technique can be executed at different parameters that resulted in different liquid oil yield and quality. Besides that, this technique offers great versatility and better economic feasibility in terms of the process handling and the variability of the product obtained.

VII. CONCLUSION

This review has provided concise summary of plastic pyrolysis for each type and a discussion of the main affecting parameters to optimize liquid oil yield. Based on the studies on literatures, pyrolysis process was chosen by most researchers because of its potential to convert the most energy from plastic waste to valuable liquid oil, gaseous and char. Therefore, it is the best alternative for plastic waste conversion and also economical in terms of operation. The flexibility that it provides in terms of product preference could be achieved by adjusting the parameters accordingly. The pyrolysis could be done in both thermal and catalytic process. However, the catalytic process provided lower operating temperature with greater yield of liquid oil for most plastics with the right catalyst selection. The sustainability of the process is unquestionable since the amount of plastic wastes available in every country is reaching millions of tons. With the pyrolysis method, the waste management becomes more efficient, less capacity of landfill needed, less pollution and also cost effective. Moreover, with the existence of pyrolysis method to decompose plastic into valuable energy fuel, the dependence on fossil fuel as the non-renewable energy can be reduced and this solves the rise in energy demand.

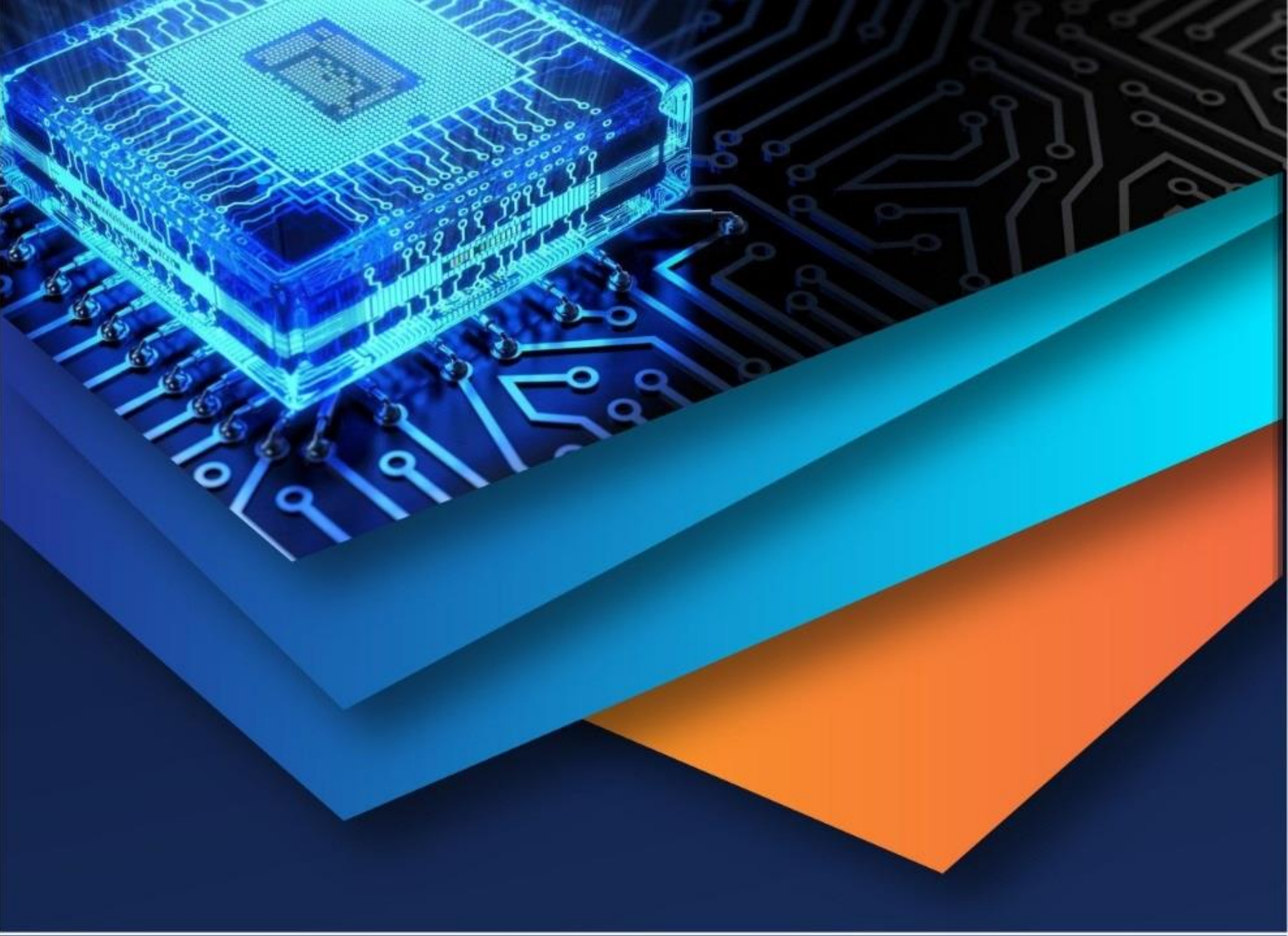
REFERENCES

[1] Association of Plastic Manufacturers Europe. An analysis of European plastics production, demand and waste data. Belgium: European Association of Plastics Recycling and Recovery Organisations; 2015. p. 1–32.
[2] U.S. Environmental Protection Agency. Common wastes and materials. US; 2014.
[3] Kukreja R. Advantages and disadvantages of recycling. Conserve Energy Future; 2009.
[4] Masanet E, Auer R, Tsuda D, Barillot T, Baynes A. An assessment and prioritization of ‘‘design for recycling” guidelines for plastic components. In:Electronics and the environment, IEEE international symposium; 2002. p. 5–10.
[5] Fakhrhoseini SM, Dastanian M. Predicting pyrolysis products of PE, PP, and PET using NRTL activity coefficient model. Hindawi Publishing Corporation; 2013. p. 1–5.
[6] Bridgwater AV. Review of fast pyrolysis of biomass and product upgrading. Biomass Bioenergy 2012;38:68–94.
[7] Abnisa F, Wan Daud WMA. A review on co-pyrolysis of biomass: an optional technique to obtain a high-grade pyrolysis oil. Energy Convers Manage 2014;87:71–85.

©IJRASET: All Rights are Reserved

[8] Kreith F. The CRC handbook of mechanical engineering. 2nd ed. CRC Press, Inc; 1998.
[9] Zannikos F, Kalligeros S, Anastopoulos G, Lois E. Converting biomass and waste plastic to solid fuel briquettes. J Renew Energy 2013;2013:9.
[10] Heikkinen JM, Hordijk JC, de Jong W, Spliethoff H. Thermogravimetry as a tool to classify waste components to be used for energy generation. J Anal Appl Pyrol 2004;71:883–900.
[11] Ahmad I, Ismail Khan M, Ishaq M, Khan H, Gul K, Ahmad W. Catalytic efficiency of some novel nanostructured heterogeneous solid catalysts in pyrolysis of HDPE. Polym Degrad Stab 2013;98:2512–9.
[12] Hong S-J, Oh SC, Lee H-P, Kim HT, Yoo K-O. A study on the pyrolysis characteristics of poly(vinyl chloride). J Korean Inst Chem Eng 1999;37:515–21.
[13] Park SS, Seo DK, Lee SH, Yu T-U, Hwang J. Study on pyrolysis characteristics of refuse plastic fuel using lab-scale tube furnace and thermogravimetric analysis reactor. J Anal Appl Pyrol 2012;97:29–38.
[14] Nino EF, Nino TG. Fuels and combustion. Manila: Rex Bookstore, Inc.; 1997
[15] Kim S. Pyrolysis of PVC waste pipe. Waste Manage 2001;21:609–16.
[16] Jamradloedluk J, Lertsatitthanakorn C. Characterization and utilization of char derived from fast pyrolysis of plastic wastes. Proc Eng 2014;69:1437–42.
[17] Bernando M. Physico-chemical characterization of chars produced in the copyrolysis of wastes and possible routes of valorisation. Portugal: Chemical Engineering. Universidade Nova de Lisboa; 2011. p. 27–36.
[18] Prabir B. Biomass gasification and pyrolysis. Practical design and theory. USA: Elsevier Inc.; 2010.
[19] Williams PT, Williams EA. Interaction of plastics in mixed-plastics pyrolysis. Energy Fuel 1998;13:188–96.

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)