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A REVIEW ON: COMPARISON OF VARIOUS CATALYST FOR THE CATALYTIC DEPOLYMERISATION OF WASTE POLYSTYRENE

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ABSTRACT

The aim of this research is to carry out a comparison study of the liquid hydrocarbons produced due to the use of various catalyst in the pyrolysis of waste polystyrene. Zeolite and Non-Zeolite catalyst such as, HUSY, HMOR, HZSM-5, SAHA, Modernite and Silicalite are to be used for the catalytic depolymerisation of polystyrene. Polystyrene (PS) being one of the high commodity plastics, is used widely for several purposes with the scale of its production being a few several million tonnes a year. Polystyrene is infamous for its slow rate of degradation among environmentalist. Pyrolysis of PS is a Green technology available for the recycling of waste materials into liquid hydrocarbon. This research mainly focuses on the production of liquid hydrocarbon by the catalytic cracking of polystyrene and the comparison of this fuel oil generated by their respective catalyst against commercially available fuel.

Keywords: Catalytic depolymerisation, Pyrolysis of plastic, Polystyrene waste, Liquid Hydrocarbon, polystyrene depolymerisation.

I. INTRODUCTION

The growth in the consumption of plastics has been occurring rapidly in the past 60 years due to their favorable physical properties such as the ability to be simply formed, light weight and non-corrosive properties [1]. The rapid increase in production and demand is subsequently increasing the amount of waste plastic disposed off into landfills and the marine environment. It has been estimated that almost 60% of plastic solid waste is discarded in open space or land filled worldwide [2]. Mismanaged polystyrene waste also finds its way into the marine environment and causes impressionable environmental hazards. Expanded polystyrene (EPS) due to its large volume and light weight can be easily scattered by wind in open landfills further littering the vicinity and floats on the surface of the marine environment. When EPS breaks apart the small components of polystyrene can be consumed by animals or aquatic life in the oceans. Even though provisions and policies are available for recycling, plastics such as polystyrene find their way into disposal bins and the surrounding areas. Polystyrene waste is not bio-degradable and it can remain in the landfill for a long period of time creating gas emissions and for this reason is also a major concern for climatic change [2]. Hence, recycling of waste plastic is the best solution for eliminating the environmental concerns regarding the plastic industry.

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The destruction of polymers by incinerations is available at present however this method is not cost effective and often creates several problems with unacceptable emissions [3]. An alternate approach for recycling of plastics is the chemical feedstock or chemical recycling method, that is used to describe a diverse range of techniques that include pyrolysis, hydrolysis, hydrogenation, methanolysis and gasification, however the most attractive technique of recycling is *pyrolysis* [4]. The pyrolysis of waste plastic is a propitious method for the conversion of waste into liquid hydrocarbons [5]. Pyrolysis represents a process of thermal degradation of the waste in the total absence of oxygen at temperature range of 300 °C to 850°C [6]. The by-products of pyrolysis are oil, gas and char. Pyrolysis has several advantages such as the volume of the plastic waste is reduced significantly by around 50% to 90%, the solid, liquid and gaseous fuel care the by-products of the process, storable/transportable fuel or chemical feedstock is obtained, the nuisance of plastic mismanagement is reduced, it is a relatively beneficial process as fuel is generated from waste material and the capital cost is low [7].

II. MATERIALS AND METHODS

2.1 Materials

2.1.1 Polymer Sample

Kowley Polymers Pvt Ltd, uses powdered polystyrene waste as fillers for polymer coating of various appliances. The waste polystyrene is procured from this factory located in Pune.

2.1.2 Catalyst

Catalysts assist in increasing the reaction time of a chemical reaction, but remain unchanged towards the end of the reaction. When a catalyst is used it helps in reducing the activation energy and thus increases the speed of the reaction this in turn helps in reducing the optimum temperature required for the process. Many researchers have also used catalyst for product upgrading to improve the hydrocarbon distribution in order to obtain pyrolysis liquid that has similar properties to the conventional fuel such as gasoline or diesel [8]. Pyrolysis has a wide temperature range and it can be performed with or without a catalyst. The catalysts used for this study are:

• HZSM-5
• HUSY
• HMOR
• Modernite
• Silicalite
• SAHA

2.1.3 Specifications of Batch Reactor

2.1.3.1 Materials of reactor, Dimensions and Capacity: Mild Steel scrap material purchased from Nafees Ahmed Dealers and Suppliers, Pimpri, Pune.

• Bottom round plate, diameter = 13 inches; thickness = 5 mm.
• Circular pipe, diameter = 11 inches; thickness = 2.5 mm.
• Top plate, diameter = 13 inches; thickness = 3mm.
• Outlet pipe, diameter = 1 inch.
• Designed to sustain production of 1 kilogram plastic waste.

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2.1.3.2 Miscellaneous parts

• Stainless steel bolts, diameter = 8 mm.

• Metallic reinforced gasket, diameter = 6 inches.

• Glass wool insulation, thickness = 50 mm.

2.1.3.3 Welding

Industrial Arc welding using cromoten-C electrodes carried out by Jishan steel traders.

2.1.3.4 Condensation

The gaseous by-products travel from the reactor to a collection pipe that is placed in a tub filled with cold water for the purpose of condensation.

2.1.3.5 Collection

A 5 litre plastic container with a tap arrangement is used for the collection of the liquid hydrocarbon, with a sufficient hydroseal for the purpose of creating a vacuum.

2.2 Methodology

2.2.1 Pyrolysis Process

The Pyrolysis process is an advanced conversion technology that has the ability to produce liquid hydrocarbons from polymers. It is the thermodecomposition of these polymers at elevated temperatures in the absence of oxygen. When subjected to pressure and heat the long chain polymers containing hydrogen, oxygen and carbon decompose into short chain petroleum hydrocarbons. The hydrocarbon molecules from the primary polymer split under the impact of the catalyst and converts inside the reactor. The important steps in the pyrolysis of waste polystyrene are:

• Uniformly heating the polystyrene to a narrow temperature range without frequent temperature variations,

• Creating a vacuum in the pyrolysis chamber

• Managing the carbonaceous char by-product before it acts as a thermal insulator and lowers the heat transfer to the plastic,

• Careful condensation and distillation to obtain good quality liquid hydrocarbons.

2.2.1.1 Sample Analysis

Analysis of the samples is being carried out by the following method:

2.2.1.1.1 Physical analysis of liquid products:

In this method we physically observe the yield of oil obtained from the process as well as the percentage of residue left.

2.2.1.1.2 Solid Residue:

The study of the solid residue left behind is important. The coloration of the residue itself is an in-situ test.

2.2.1.1.3 Physical properties of liquid fuels:

The samples collected will be tested for their physical properties. The properties that are going to be tested are:

• Specific gravity

• Pour point

• Flash Point

• Fire Point

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III. DISCUSSIONS

In this research a comparison of liquid hydrocarbons obtained under the action of various catalyst in the pyrolysis of polystyrene is being studied. The comparison study will be conducted to determine the following:

• The yield of liquid hydrocarbon from each respective catalyst.

• The optimum temperatures attained for each catalyst.

• The total processing/retention time.

• Quality of liquid hydrocarbon produced.

3.1 Source of Data

The sources from which the data for this study are obtained are classified into the following:

3.1.1 Primary source:

The comparison of the yield and quality of liquid hydrocarbon produced for the respective catalyst will be inferred by carrying out the experiment with the help of the batch reactor designed.

3.1.2 Secondary source:

The selection of the type of catalyst to be used for the experiment is determined with reference to different international and national journals.

3.1.3 Empirical methods:

The design of the reactor is determined by the practical knowledge gained while interning with Trident Renewable Energy Enterprise.

IV. CONCLUSIONS

The maximum yield of liquid hydrocarbon is expected from the use of zeolite catalyst (HMOR, HUSY and HZSM-5) as compared to the non-zeolite catalyst (Modernite, SAHA, Silicalite). The nanocrystalline size of the zeolites helps in maximizing the production of volatile hydrocarbon [8].

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REFERENCES

[1] Mochamad Syamsiroa, d*, Harwin Saptoadib, Tinton Norsujiantob, Putri Noviasria,b,Shuo Chenga, Zainal Alimuddinc, Kunio Yoshikawaa (2014), Fuel Oil Production from Municipal Plastic Wastes in Sequential Pyrolysis and Catalytic Reforming Reactors, Energy procedia 47(2014)180-188.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

[2] Moinuddin Sarker*, Mohammad Mamunor Rashid, Muhammad Sadikur Rahman, Mohammed Molla (july 20,2012), A New Kind of Renewable Energy: Production of Aromatic Hydrocarbons Naphtha Chemical by Thermal Degradation of Polystyrene (PS) Waste, American Journal of Climate Change, 2012,1, 145-153.

[3] Y.-H. Lin , M.-H. Yang, T.-F. Yeh[b], M.-D. Ger (Feb 20 2004) Catalytic degradation of high density polyethylene over mesoporous and microporous catalysts in a fluidised-bed reactor, Polymer degradation and stability 86 (2004) 121-128.

[4] Sachin Kumar and R. K. Singh (October - December, 2011) Recovery of Hydrocarbon Liquid From Waste High Density Polyethylene By Thermal Pyrolysis, Brazilian Journal of Chemical Engineering, Vol. 28, No. 04, pp. 659 - 667.

[5] P. Senthil Kumar, M. Bharathikumar, C. Prabhakaran, S. Vijayan, K. Ramakrishnan (feb 12 2015), Conversion of waste plastics into low-emissive hydrocarbon fuels through catalytic depolymerization in a new laboratory scale batch reactor",DOI 10.1007/s40095-015-0167-z.

[6] V. Chhabraa, Y. Shastria, S. Bhattacharya, (2016), Kinetics of Pyrolysis of Mixed Municipal Solid Waste- A Review, Published by Elsevier, Procedia Environmental Sciences 35 (2016) 513 – 527 1878-0296 © 2016 Published by Elsevier B.V. Available online at www.sciencedirect.com ScienceDirect International Conference on Solid Waste Management,5IconSWM201.

[7] Neha Patni, Pallav Shah, Shruti Agarwal, and Piyush Singhal (april 2013) Alternate Strategies for Conversion of Waste Plastic to Fuels, Hindawi Publishing Corporation, ISRN Renewable Energy,Volume 2013, Article ID 902053.

[8] Shafferina Dayana, Anuar Sharuddin, Faisal Abnisa *, Wan Mohd Ashri Wan Daud, Mohamed Kheireddine Aroua (feb 12 2016), A review on pyrolysis of plastic wastes, Elsevier, Energy conservation and management 115(2016)308-326.

[9] Deepak Pant, A New Role of Alumina in Polyethylene Degradation: A Step towards Commercial Polyethylene Recycling Journal of Scientific & Industrial Research Vol. 64, December 2005, pp.967-972.

[10] Prof. T. Z. Quazi Prof. M. D. Jagtap (aug-2015), Sustainable plastic waste management- a case study of thane Municipal corporation novateur Publications International journal of innovations in engineering research and technology [ijiert] Issn: 2394-3696 volume 2, issue 8.

[11] Mr.Mandar Dnyaneshwar Jagtap Mr. Sagar Suryakant Khatavkar Prof.T.Z.Quazi Methods for Waste Plastic Recycling, International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE) ISSN: 2349-7947 Volume: 2 Issue: 6 120 – 122.

[12] Mr.Mandar Dnyaneshwar Jagtap Mr. Sagar Suryakant Khatavkar Prof.T.Z.Quazi Methods for Waste Plastic Recycling, International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE) ISSN: 2349-7947 Volume: 2 Issue: 6 120 – 122

[13] Feng Gao, "Pyrolysis of Waste Plastics into Fuels" Ph.D Dissertation, Department of Chemical and Process Engineering,University of Canterbury, New Zealand, 2010.