iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 Issue: VIII Month of publication: August 2019

DOI: http://doi.org/10.22214/ijraset.2019.8127

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

Recent Methods Available for Recycling of Plastic Waste: A Review

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Abstract*: Plastics have been one of the materials with the fastest growth because of their wide range of applications due to versatility and relatively low cost. Since the life duration of plastic products is hundred years, there is a vast plastics waste stream that reaches each year to the final recipients creating a serious environmental problem. Again, because disposal of postconsumer plastics is increasingly being constrained by legislation and escalating costs, there is considerable demand for alternatives to disposal or land filling. Recycling of plastics is the method for production of vital resource of liquid and gaseous fuels. Pyrolysis/thermal degradation, catalytic degradation and gasification are the alternative methods for recycling of plastic waste to produce fuel having similar properties to commercial fuels. This processes done in order to overcome with shortage of commercial fuel and problem of plastic waste.
Key words: Catalyst, Commercial, Density, Diesel, Fuel, Plastic, Pyrolysis, Viscosity, Waste

I. INTRODUCTION

Plastic is the polymeric material that has the capacity of being moulded or shaped, usually by the application of heat and pressure. They are typically of high molecular mass, and may contain other substances besides polymers to improve performance and to reduce cost. The plastics are mostly non-biodegradable and remain in the environment for hundreds of years [3]. Plastics in general are lightweight with significant degree of strength. Plastics can be extruded, cast and blown into seemingly limitless shapes and films or foams or even drawn into fibers for textiles. Many types of coatings, sealants and glues are actually plastics, too. Plastic is one of the most commonly used material in daily life which can be classified in many ways such as based on its chemical structure, synthesis process, density and other properties. Society of Plastic Industry (SPI) defined a resin identification code system that divides plastic into seven groups based on the chemical structure and applications-

A. PET (polyethylene terephthalate)
B. HDPE (high density polyethylene)
C. PVC (polyvinyl chloride)
D. LDPE (low density polyethylene)
E. PP (polypropylene)
F. PS (polystyrene)
G. others

Because of such wide range of applications and properties demand and manufacturing of plastics increases year by year. The demand for plastics has increased by 5% every year since 1990 [8]. The increase in plastics use correspondingly increases the amount of plastic wastes being produced. The total global production of plastics has grown from around 1.3 million tonnes (MT) in 1950 to 245 MT in 2006. Plastics continue to be a global success story with Europe and Switzerland remaining a major manufacturing region, producing about 25% of the total estimated worldwide plastics production of 245 million tonnes during 2006. An analysis of plastics consumption on a per capita basis shows that this has now grown to over 100 kg/year in North America and Western Europe, with the potential to grow to up to 130 kg/year per capita by 2010 [14]. The highest consumption of plastics among different countries is found in USA which is equal to 27.3 MT against 170 MT world consumption in 2000 and is expected to reach to 39 MT by 2010 [7]. The highest potential for growth can be found in the rapidly developing parts of Asia (excluding Japan), where currently the per capita consumption is only around 20 kg/year. The average Indian consumption of virgin plastics per capita reached 3.2 kg in 2000/2001 (5 kg if recycled material is included) from a mere 0.8 kg in1990/1991 and 1.8 kg in 1998/1999. However, this is only one fourth of the consumption in China (12 kg/capita, 1998) and one sixth of the world average (18 kg/capita) [6].

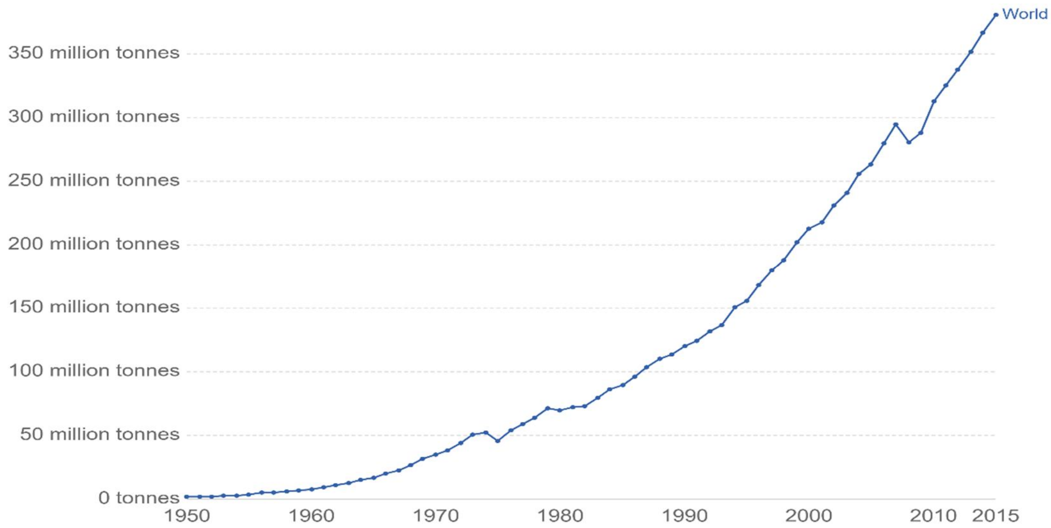

Fig-1 Annual global plastic production (per 10 years) [12]

II. EFFECT OF IMPROPER DISPOSED PLASTIC

Incorrect disposal of plastic waste is harmful to the environment. Most petrol based plastics have negative in the ozone layer, contributing to global warming. Also burning of plastic emits toxic gases in atmosphere. Plastic when old or left in the sun for too long will break in tiny little pieces. It will then be eaten by fishes, birds and other animals. The plastic pieces will of course not be digested by animals and the blockage of intestinal track take place remains in its stomach which will make the animal difficult to digest food and then die due to digestion problem. On an average plastic waste kill one animal per every three months due to unintentional digestion or inhalation. Plastic is one of the cause of death for, most marine and other animals. It is estimated that 300 million plastic bags end up in the Atlantic Ocean alone. As one of the species being to die off at an abnormal rate, every other living organism in the universe is impacted. Toxic chemicals leach out of plastic and are found in the blood and tissue of nearly all living beings. Exposure to them to cancers, birth defects, impaired, endocrine disruption and other ailments. The bellow fig shows the quantity of plastic waste floating at the ocean surface within each of the world's ocean

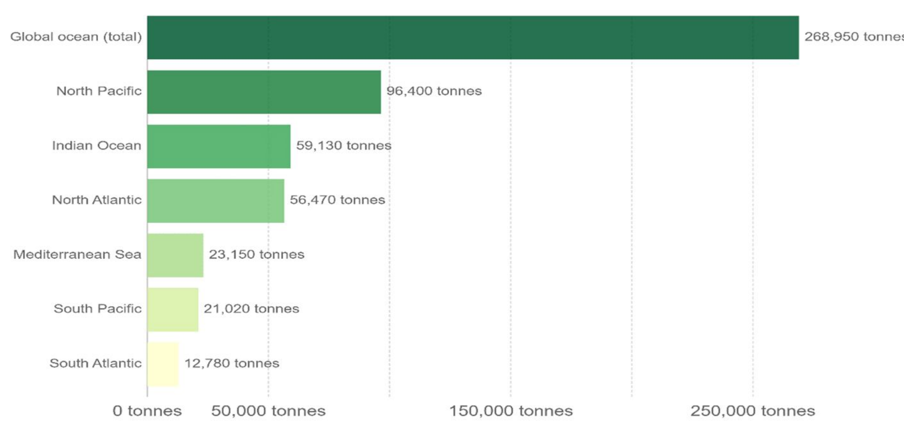

Fig-2 Plastic waste floating at different ocean [12]

III. SOURCE OF PLASTIC WASTE

Huge amounts of plastic waste arise as a by-product or faulty product or waste product in industry agriculture and house hold [10]. The main source of plastic waste are municipal waste and industry waste, classified on the basis of their origin. Both types have different properties, qualities and management strategies. Municipal plastic waste- Municipal plastic waste (MPW) is a mixture of HDPE and LDPE, PP, PS and PET. It comprises of residential market waste, hotels and hospitals waste. The rate of MPW generation has increased steadily at 5% per year whereas that of MPW recycling is only at 3% per year. Municipal plastic wastes are heterogeneous. Of the total plastic waste, over 78 wt% of this total corresponds to thermoplastics and the remaining to thermosets [1]. Thermoplastics are composed of polyolefins such as polyethylene, polypropylene, polystyrene and polyvinyl chloride [4] and

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can be recycled. On the other hand thermosets mainly include epoxy resins and polyurethanes and cannot be recycled [1]. They are unsuitable for reclamation. In this case thermal cracking into hydrocarbons may provide a suitable means of recycling, which is termed chemical recycling [5]

Industrial plastic waste- Industrial plastic wastes also called primary waste are those rejected from the plastics manufacturing, processing and packaging industry. The industrial waste plastic mainly comprises of plastics from construction and demolition companies, electrical and electronics industries and the automotive industries. Most of the industrial plastic waste have relatively good physical characteristics i.e. they are sufficiently clean and free of contamination and are available in fairly large quantities. It has been exposed to high temperatures during the manufacturing process which may have decreased its characteristics, but it has not been used in any product applications. Repelletization and remolding seem to be a simple and effective means of recycling.

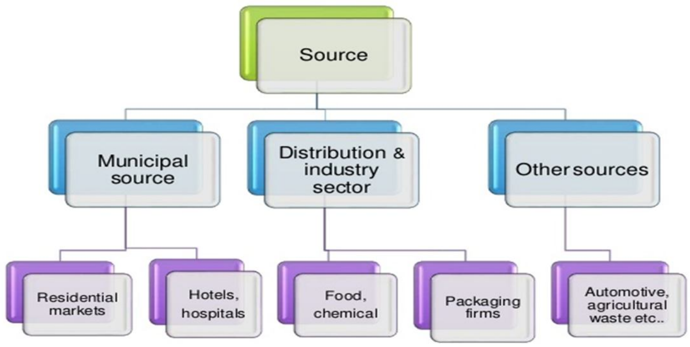

Fig-3 Source of plastic waste

IV. RECYCLING METHODS FOR PLASTIC WASTE

A. Pyrolysis/Thermal Degradation

Pyrolysis or thermal degradation is the process of controlled heating of material in the absence of oxygen. The process is carried out at the temperature 350-900 ^{o}C and results in the formation of the carbonized char (solid residues) and a volatile fraction that may be separated into condensable hydrocarbon oil consisting of paraffins, isoparaffins, olefins, naphthenes and aromatics and non-condensable high calorific value gas. The process of pyrolysis is completed in following manner. The step is the pretreatment of the selected plastic waste. The efficiency and the nature of the product depends on the particle size and moisture content of the peace talks the high moisture waste stream required wine and fill dog has to be sliced reduced before being used for pyrolysis. After that pre heated biomass is introduced into the pyrolysis reactor which contains the airlock to keep oxygen and unwanted air out of the reactor. The combustor pre heat the process reactor and the charged waste indirectly. In general pyrolysis of organic substance produce the gas, char and sometimes liquid products and leave the solid residue richer in carbon content at the bottom of the reactor. This process is differ from other high temperature process like compulsion and hydrolysis in that it usually does not involve reaction with oxygen, water or any other reagents. The next step is char collection. In this the gas and char are introduced to the cyclone separator to remove char. Then the purified gases are condense with water and the liquid product is deposited at the bottom and the non-condensable gases are used as gas fuel or recycled to the combustor. It produces the crude liquid fuel. And finally desired products are separated with the help of fractionating tower.

B. Catalyst Degradation

The process of thermal degradation and catalyst degradation is same. Only difference is- in catalyst degradation, catalysts are added to pyrolysis reactions to improve conversion, fuel quality, increase selectivity, and lower the pyrolysis temperature and residence time[11]. The acidic nature of most of the catalysts used enhances conversion by protonating the defective sites of polymers forming on-chain carbonium ions [5]. Selectivity and fuel quality vary with the strength of the catalyst's acidity. The use of a strong catalyst results in the production of lower hydrocarbons ranging between C3 and C5. A polymer to catalyst ratio of 10:1 yields 100% conversion within an hour of contact time [2]. The catalysts used for plastic upgrading are grouped into a few main categories: fluid cracking catalysts (FCC), reforming catalysts, and activated carbon. FCC catalysts include zeolite [9, 13], silica-alumina [11], and clay [11, 13]. Reforming catalysts include transition metals loaded in silica–alumina [5]. Activated carbon is also widely used and can be loaded with or without transition metals [2, 13]. The life of a catalyst can be increased by using a two-step process that involves thermal cracking followed by catalytic cracking [2]

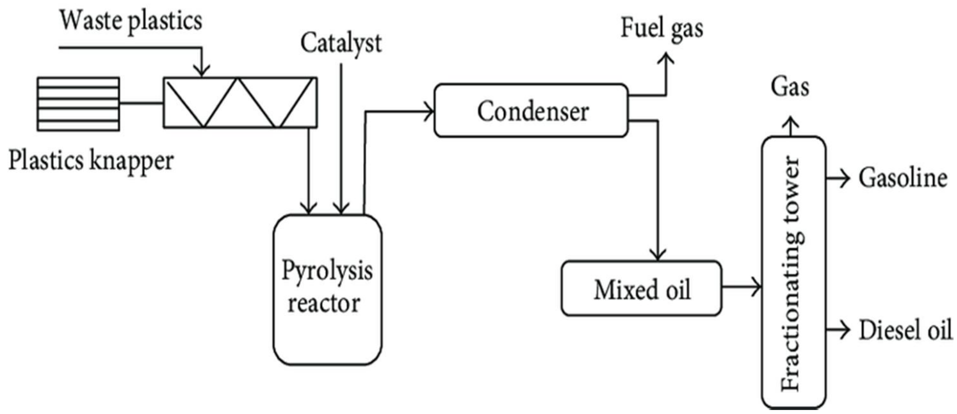

Fig-4 Catalyst degradation flow diagram

C. Gasification

The gasification is the process of conversion of plastic waste to gaseous fuel. It requires high temperature (>900-1200 ^{o}C). The gasification system consists of mainly gasifier, gas cooling and clean up system and the energy recovery system. The proper feed is introduced to gasifier in the presence of gasification agent. At the high temperature of gasifier the feed is converted into the gases form. This hot gases cooled down and send to gas clean up system where char and other unwanted substances are removed. The gasification process produces the solid phase (char), the liquid phase (tar) and the gas phase. The gas phase is a gaseous mixture of carbon monoxide and hydrogen and the few amount of gaseous hydrocarbons and can be used as substitute of natural gas or in chemical industry. Gasification process represents a future alternative to the waste incinerator for the thermal treatment of homogeneous carbon based waste and for pretreated heterogeneous waste.

V. RELATED WORK CARRIED OUT FOR RECYCLING PROCESS

Mochamad Syamsiro et al. conducted the study, with municipal plastic waste in sequential pyrolysis and and catalyst reforming reactors. Three kinds of municipal plastic wastes were used for their experiments, i.e. polyethylene bag with (PE bag II) and without(PE bag I) crushing and washing, and high density polyethylene (HDPE) waste after crushing and washing and in their experiments, Y zeolite and natural zeolite catalysts were used. The use of catalyst reduces the liquid fraction and increases the gaseous fraction. Followed by these processes we can obtain the liquid and gaseous fuels similar to commercial fuels. The process gave the desired volume of liquid and gaseous fuel with density 0.8544 g/cm^3 for PE bag I, 0.824 g/cm^3 for PE bag II and 0.7991 g/cm^3 for HDPE at 15 ^{o}C respectively. Kinematic viscosity values are 1.739 cSt for PE bag I, 1.838 cSt for PE bag II and 2.319 cSt for HDPE at 40 ^{o}C whereas heating values are 41.45 MJ/kg, 46.67 MK/kg and 42.82 MK/kg respectively.

Brajendra K. Sharma et al. made study on production of alternative diesel fuel from pyrolysis of waste plastic grocery bags. Pyrolysis of HDPE waste grocery bags followed by distillation resulted in a liquid hydrocarbon mixture with average structure consisting of saturated aliphatic paraffinic hydrogen (96.8%), aliphatic olefinic hydrogen (2.6%) and aromatic hydrogen (0.6%) that corresponded to the boiling range of conventional petroleum diesel fuel. They were collected plastic HDPE grocery bags from local retailers and represent the typical ones used in grocery stores. Thermochemical conversion of plastic grocery bags (HDPE) to oils were conducted using a pyrolysis batch reactor in triplicate. 420-440 ^{o}C temperature were maintain and the reaction time was 2 hours. 74% of plastic crude oil, 17% solid residue and 9% of gases were produced after pyrolysis. After successive gas chromatography-mass spectroscopy, simulate distillation, size exclusion chromatography and nuclear magnetic resonance with Fourier-Transform infrared spectroscopy final diesel produced having similar properties to commercial diesel with kinematic viscosity 4.6 mm^2/s at 40 ^{o}C.

Stella Bezergianni et al. carried out the experiment on the waste plastic to get alternative diesel via a two-step thermochemical process based on pyrolysis and hydrotreatment. The experiment components of plastic feed stock are 60-70 wt% PE+PP and 30-40 wt% PET. They worked on the temperature of 170-370^{o}C. The oil yield over the dry feedstock mass was estimated to be 49%, with an energy recovery in oil of about 54%. The diesel shows the density of 790.6 kg/m^3 at 15^{o}C and viscosity value is 2.377 mm^2/s at 40^{o}C.

Chika Muhammad et al. carried out the experiment on thermal degradation of real-world waste plastics (MP) and simulated mixed plastics (SMP) in a two-stage pyrolysis-catalytic reactor for fuel production. They worked with flaked and air separated PE, PP and PET samples size of ~5mm. First process is thermal degradation involved heating ~15 mg of the plastic sample (in N_2) at 10 °C/min to a final temperature of 500 °C and kept constant at that temperature for 30 minutes. The evolved pyrolysis volatiles were passed directly to the second stage reactor containing 2 g of the Zeolite catalyst mixed with 2 g of quartz sand previously heated to 500 °C. They maintained the 1:1 ratio of plastic to catalyst. The final result showed, yield of 39% of liquid, 53% gas and >4% char for MP and 37% liquid, 56% gas and >2% char.

VI. CONCLUSION

This paper has given a review that recycling of plastic waste is must to prevent environment pollution. The above study discuss different methods of recycling process. The pyrolysis, catalyst degradation and gasification methods helpful for the recycling of plastic and to produce fuels having similar properties to commercial fuel. It has been noted that the gasification method is more capable than other methods as gasification is self-sufficient in terms of energy balance. Thus for future progress in gasification method, more work will needed to be done with advance technology.

REFERENCES

[1] Achilias DS, Roupakias C, Megalokonomosa P, Lappas AA, Antonakou EV. Chemical recycling of plastic wastes made from polyethylene (LDPE and HDPE) and polypropylene (PP). Journal of Hazardous Materials 2007;149:536–42.

[2] Aguado J, Serrano DP, Escola JM. Fuels from waste plastics by thermal and catalytic processes: a review. Ind Eng Chem Res 2008;47(21):7982–92.

[3] Ashworth, A.J., Sadaka, S.S., Allen, F.L., Sharara, M.A. and Keyser, P.D., 2014. Influence of pyrolysis temperature and production conditions on switch grass biochar for use as a soil amendment. *BioResources*, *9*(4), pp.7622-7635.

[4] Balakrishnan RK, Guria C. Thermal degradation of polystyrene in the presence of hydrogen by catalyst in solution. Polymer Degradation and Stability 2007;92:1583–91.

[5] Buekens AG, Huang H. Catalytic plastics cracking for recovery of gasoline range hydrocarbons from municipal plastic wastes. Resources Conservation and Recycling 1998;23:163–81.

[6] Gupta S, Mohan K, Prasad R, Gupta S, Kansal A. Solid waste management in India: options and opportunities. Resources Conservation and Recycling 1998;24:137–54.

[7] Indian Plastic Industry Review & Outlook, plastindia foundation report [http://www.cipad.org/files/files/india_2006.pdf]

[8] Lettieri P, Al-Salem, S. Thermochemical treatment of plastic solid waste. In: Letcher TM, Vallero D, editors. Waste: A hand book for management;2011,p. 233–42.

[9] Miskolczi N, Angyal A, Bartha L, Valkai I. Fuels by pyrolysis of waste plastics from agricultural and packaging sectors in a pilot scale reactor. Fuel Process Technol2009;90(7–8):1032–40.

[10] Miskolczia N, Barthaa L, Deak G, Jover B. Thermal degradation of municipal plastic waste for production of fuel-like hydrocarbons. Polymer Degradation and Stability 2004;86:357–66.

[11] Panda AK, Singh RK, Mishra DK. Thermolysis of waste plastics to liquid fuel: A suitable method for plastic waste management and manufacture of value added products Aworldprospective.RenewSustainEnergyRev2010;14 (1):233–48.

[12] Ritchie, H. and Roser, M., 2018. Plastic Pollution. *Our World in Data*.

[13] Scott DS, Czernik SR, Piskorz J, Radlein DSAG. Fast pyrolysis of plastic wastes. Energy Fuels1990;4(4):407–11.

[14] The compelling facts about plastics. Analysis of plastics production, demand and recovery for 2005 in Europe published in 2007 [http://www.kunststofflandnrw.de/modules/kln_infomaterial/files/623f1d611b6ae2b.pdf] and the compelling facts about plastics, Analysis of plastics production, demand and recovery for 2006 in Europe published in 2008[http://www.pvc.org/PVC.org/Media-Centre/Documents-Library/The-Compelling-Facts-about-Plastics].