International Journal of Trend in Scientific Research and Development (IJTSRD)
International Open Access Journal
ISSN No: 2456 - 6470 | www.ijtsrd.com | Volume - 2 | Issue – 5

Converting Plastic to Useful Energy Resources

Dhaval M Prajapati
Student, Department of Civil Engineering,
Vadodara Institute of Engineering, Waghodia, Vadodara, India

ABSTRACT
In India the grown of population and industries are very rapid in urban area and therefore plastic waste problem is generated. The characteristics of plastic waste depend on factors such as lifestyle, climate, tradition, food, habits etc. The problem of plastic is that it cannot be disposed which is harmful for environment .The other problem of plastic is that when it is being manufactured toxic gases are released which then create problem such as global warming &pollution. Present study aims at some sort of new technology which can control toxic gases and convert plastic waste into useful energy resource. This technology will bring employment opportunities and it may generate big amount of income.

Keywords: *Plastic waste, Energy, pyrolysis*

I. INTRODUCTION

Plastics have become an indispensable part in now present-day is living world , due to their insignificant, durability, and energy efficiency, coupled with an accelerated of production and design flexibility; these plastics are industrious in entire scope of industrialized and domestic areas; hence, plastics have become essential substantial and their applications in the industrial zone are continually increasing. In the regular day, waste plastics have more generated a very serious environmental challenge because of their vast quantities and their disposal problems. Waste plastic pyrolysis in liquid fuel (gasoline, diesel oil, etc.) or synthetical raw materials not only can completely solve the problem of white pollution, but also can alleviate the energy shortage to a certain extent. Recycling of waste plastics is expected to become the most effective way. Waste plastics' reprocess, reproduce, recycling, regenerating and utilizing have become a hot spot of research at home and abroad and gradually formed a new industry [1–6].

The degeneration of polymorphic materials is also significant and of interest to industries since plastic is used in many of present's commodities [7, 8]. The extensive use of polymorphic materials or plastics resulted in the accumulations of untraditional wastes not native to the mother earth life cycle [9, 10]. Therefore, wastes of modernized materials are incorporated without effective decomposition and recycling routes in the landfills. The increase of petroleum and petrochemical demand opened the approach for industries to invest in decomposition of plastic wastes to petrochemicals [11, 12]. Today, plastic landfills are as valuable as petroleum mines. Models for represents kinetics for optimum pyrolysis conditions of waste plastic mix have been proposed by researchers. Research infest in the recycling of these conventional wastes to petrochemicals [13,15] and many industries are sustained and developed based on decomposition of natural and synthetic polymers [14, 15]. From a scientific-engineering point of view, no deg radability of plastics is no longer an environmental issue in landfills since the plastics can be recycled. However, run-away plastic wastes are continuing to be a huge hazard on the surface and surface water such as waterways, seas, and oceans, hazard safe life for both animals and humans [15].

The plastics include polystyrene [16, 17], poly (vinyl chloride) [17, 18], polypropylene [17–19], polystyrene terephthalate [18], acrylonitrile-butadiene-styrene [18], and polystyrene [16–18]. In some cases, plastics were copyright with other substantial such as wastage diesel oil [18]. With regard to fast pyrolysis of polystyrene, pyrolysis of low density polythylene [16], high density polythylene [20, 21], and various mixtures [17] was reported. In all polystyrene studies, the properties of the resulting bio-oil were not reported, nor were the upgrading to fuel-grade hydrocarbons and subsequent fuel property determination.

The purposeof this study was the creation, model, and evaluation of alternative fuel from pyrolysis of high density polythylene waste plastics. Comparison of our pyrolysis oil with conventional petroleum-derived diesel fuel was a further objective, along with a comparison to petrol, diesel standards such as ASTM D 975 and EN 590. Mixture of waste plastic pyrolysis Soil (WPPO) with oil was prepared and the outcome fuel properties were measured. It is predictable that these outcome will further the understanding of the applicability and limitations of high density polyethylene as a feedstock for the production of alternative fuel.

II. Material & Methodology

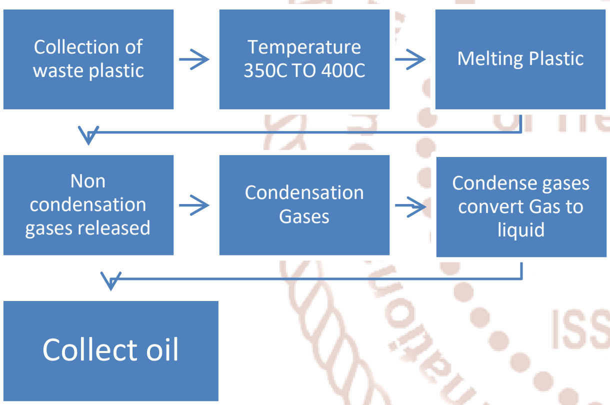

Figure1. Flowchart of experimental procedure

A. Material and Process description

The plastic used in this study was used waste plastic polythene (LDPE) for domestic purposes. Waste plastics were cleaned with solvent and clean water to remove contained foreign matter such as mud and oil. Wash out waste plastics were dry and cut into small slice.

B. Experimental Setup

A laboratory scale externally heated fixed bed pyrolysis batch reactor was used for production of oil from plastic. The schematic diagram of plastic pyrolysis setup is shown in figure. Basic instruments of the pyrolysis chamber are temperature controller, condenser, a heating coil, storage tank, valve, and gas exit line. The effective length and diameter of the glass made reactor are 38 cm and 15 cm, respectively. The reactor with polythene was heated electrically up to 475°C with Ni-Cr wire electric heater. Then the gases produced from heating of plastic are passed toward condenser, where condensation of these gases occur and get oil from the plastic.

Figure2. Experimental setup

There was no output at low temperature range and the process was carried out between the temperature ranges of $330^{\circ}C$ to $490^{\circ}C$ in the reactor for about two hours and forty minutes. The vapour products of pyrolysis were carried out through condenser. The condenser was cooled with ice water and condensed bio oil was collected into collector .The non-condensed gas was flared to the atmosphere and the char was collected from the reactor after completion of pyrolysis cycle.

This figure 3 shows the outcome of Experiment, after the condensation process is done gases will be converted into liquid form which is the main output of the project.

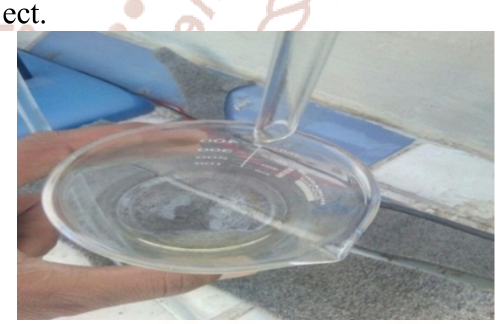

Figure3. Oil collect process

This figure 4 shows the final product after doing the experiment for approximately two hour and forty min.

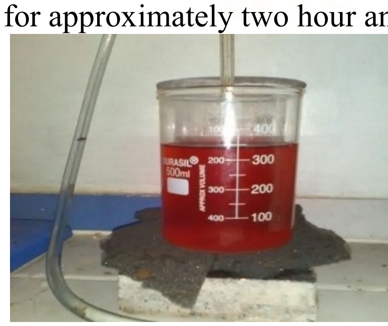

Figure4. Oil collect

Result

A. Effect of Temperature on Product Yield

The products are separated into gas, oil, and char residue by pyrolysis of waste plastic. About 38.5% of WPPO was obtained at temperature 330°C as presented in the oil percentage increased constantly to 76.0% at 425°C. The gases produced through plastic pyrolysis consist principally of hydrogen (H_2), carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), ethane (C_2H_4), and butadiene (C_4H_6), with trace amounts of propane ($CH_3CH_2CH_3$), propene ($CH_3CH{=}CH_2$), n-butane ($CH_3(CH_2)_2CH_3$), and other miscellaneous hydrocarbons.

B. Effect of Distillation Temperature on Crude WPPO

Distillation is carried out to separate the lighter and heavier fraction of hydrocarbon present in waste plastic pyrolysis oil. The distillation is operated between 116°C and 264°C; 73.5% of WPPO is distilled out. At the temperature of 116°C only about 10.0% of distilled WPPO was achieved. However, percentage of WPPO increased constantly to 73.5% at a temperature of 264°C from 10% at the temperature 116°C.

C. Analysis of Waste Plastic Pyrolysis Oil

1. Viscosity

Viscosity varies with feedstock, pyrolysis conditions, temperature, and other variables. The higher the viscosity, the higher the fuel consumption, engine temperature, and load on the engine. On the other hand, if the viscosity of oil is too high, excessive friction may take place. The viscosity was measured by the IP-50 methodology at a temperature of 40°C. It is observed that the viscosity of waste plastic pyrolysis oil obtained at 425°C pyrolysis temperature which was comparably higher than kerosene and lower than diesel. Following Table 1 represents the comparison of viscosity for various fuels.

Table 1: Comparison of viscosity with different Fuel petrol, diesel, and kerosene

Name of Fuel	viscosity (sec)
Biofuel	**58**
Diesel	0.6
Petrol	0.06
kerosene	0.06

2. Density

Density is an important property of a fuel oil. If the density of fuel is high; the fuel consumption will be less. On the other hand, the oil with low density will consume more fuel which may cause damage to the engine. Therefore, too low or too high density of fuel oil is not desirable. It is clear from Figure 15 that the densities of WPPO and WPPO50 were found to be 0.7477g/cc and 0.7943g/cc, respectively, which is close to the density of kerosene, diesel, and gas oil. So the conventional fuel such as diesel oil, kerosene oil, and gas oil may be replaced by plastic pyrolysis oil. Following Table 2 represents the comparison of density for various fuels.

Table 2:- Comparison of Density with different Fuel petrol, diesel, kerosene

Name of Fuel	Density gms/ cc
Bio Fuel	**0.77**
Diesel	0.83
Petrol	0.77
Kerosene	0.81

3. Flash Point

Flash point is the lowest temperature at which it can vaporize to form an ignitable mixture in air. Flash point is used to characterize the fire hazards of fuels. The flash point of WPPO was measured according to ASTM D 93-62 method. The flash point of WPPO was about 15°C. A low flash point indicates the presence of highly volatile materials in the fuel that is a serious safety concern in handling and transporting. The flash point of furnace oil, diesel, and kerosene is higher than WPPO which indicates that these are easy to handle. By removing lighter components (such as naphtha/gasoline) the flash point of WPPO will be increased. It has been observed that the resulted fuel contains 38^0C flash point.

4. Fire Point

The fire point of a fuel is the temperature at which it will continue to burn for at least 5 seconds after ignition by an open flame. The fire point is used to assess the risk of the materials ability to support combustion. Generally, the fire point of any liquid oil is considered to be about (5–10) °C higher than the flash point. The fire point of waste plastic pyrolysis oil was 20°C. Following Table 3 represents the comparison of fire point for various fuels.

Table 3:-Comparison of fire Point of Different oil petrol, Diesel, kerosene

Name of Fuel	Fire point(c°)
Bio Fuel	**38**
Diesel	43
Petrol	52
Kerosene	38-72

5. Pour Point

The pour point is the temperature at which the oil will just ceases to flow when cooled at a standard rate in a standard apparatus. Pour point determines the suitability of oil for low temperature installations. The pour point of WPPO was measured by using ASTM D 97-57 methodology. The pour point was <−15°C. The low pour point value of WPPO indicates that it is not suitable in cold weather country. Following Table 4 represents the comparison of pour point for various fuels.

Table 4:- Comparison of Pour Point of Different oil petrol, Diesel, kerosene

Name of Fuel	Pour point(°C)
Bio fuel	**-20**
Diesel	-40
Petrol	-40
Kerosene	-40

6. Calorific Value

One of the important properties of a fuel on which its efficiency is judged is its calorific value. The calorific value is defined as the energy given out when unit mass of fuel is burned completely in sufficient air. The calorific value of WPPO was estimated according to IP 12/58 method. The calorific value of WPPO was 9829.3515 kcal/kg.The comparison of calorific value of WPPO with other kinds of oil. Following Table 5 represents the comparison of calorific value for various fuels.

Table 5:-Comparison of calorific value of Different oil petrol, Diesel, kerosene

Name of Fuel	Calorific value (Kcal/kg)
Bio fuel	**10120**
Diesel	10470
Petrol	10840
Kerosene	10560

7. Sulphur

The presence of sulphur in vehicle fuels causes emissions that are an environmental issue. High sulphur content decreases the catalytic conversion capacity of a system, thus increasing the emissions of nitrous oxides, carbon monoxide (CO), hydrocarbons, and volatile organic compounds (VOCs). The sulphur content of WPPO was measured by using ASTM D 129-00 methodology.
The sulphur content of waste plastic pyrolysis oil was 0.246%. Sulphur content of WPPO is slightly higher than gasoline (0.014%), diesel (0.15%), and other types of fuel oil because waste plastic contains some contamination. Following Table 6 represents the comparison sulphur contents for various fuels.

Table 6:- Comparison of sulphur of Different oil petrol, Diesel, kerosene

Name of Fuel	Sulphur (PPM)
Bio fuel	**0**
Diesel	350
Petrol	150
Kerosene	200

8. Ash Content

The ash content of oil is the non-combustible residue. The ash content of distilled tire pyrolysis oil (DTPO) and DTPO50 (50% DTPO:50% diesel) was measured by using IP 04/58 test methodology. It is clear that the ash content of WPPO was 0.0036% comparatively higher than diesel, light fuel oil, and kerosene. So it can be used as an alternative of furnace oil and heavy fuel oil (HFO). The produced biofuel contains 0.03% ash contents.

9. Carbon Residue

Carbon residue indicates the tendency of oil to deposit a carbonaceous solid residue on a hot surface, such as a burner or injection nozzle, when its vaporizable constituents evaporate. The carbon residue of WPPO was measured according to ASTM D 189-65 method. Oil which deposits minimum amount of carbon is naturally preferable. The carbon residue of the plastic pyrolysis oil was 0.5%. In another study, 0.05% of carbon residue was reported [22]. The carbon residue of the diesel fuel and light fuel oil was comparatively higher than WPPO. This indicates that diesel fuels will form higher deposits. Fuels with high carbon residue content could cause increased fouling of the gas ways; more frequent cleaning is necessary, especially of the turbocharger and exhaust gas boiler. The produced biofuel contains 1.6% Carbon Residue. Following table 7represents the summary of various properties of biofuel produced through the laboratory set up.

Table 7:- Result of Oil sample

SR NO.	TEST DESCRIPTION	RESULT
1	Redwood viscosity (40^0 C)	58 Seconds
2	Density	0.77 gm/cc
3	Flash point	38°C
4	Fire point	40°C
5	Pour point	-20°C
6	Total carbon	84.33% by weight
7	Carbon residue	1.6°C% by weight
8	Sulphur	Absent
9	Ash	0.03% by weight
10	Calorific value	10120 Kcal/kg

III. Conclusion

The thermal pyrolysis of mixed plastic leads to the production of fuel oil which is a valuable resource recovery. It also reduces the problem of disposal of waste plastic. In this work, thermal pyrolysis of waste plastic is carried out because use of catalyst is costly and regeneration of catalyst is a difficult task. Mixed plastic pyrolysis yields a mixture of oil and gas and produces very small amount of char. higher pyrolysis temperature and longer reaction times increase the gas yield and decrease char production. Highly volatile products are obtained at low temperature. Liquid yield increases as the holding time increases from 1 hr to 2 hr, but as the holding time increases from 2 hr to 3 hr, the liquid yield decreases. The maximum oil yield was 77.03% at 2 hr. The liquid obtained in this process is relatively greater volume and low boiling range. Distillation of fuel-like liquids shows more light fractions at higher temperature and longer time. Physicochemical properties of obtained fuel oil can be exploited to make highly efficient fuel or furnace oil after blending with other petroleum products. However, further studies are necessary to utilize this oil as fuel or feedstock.

ACKNOWLEDGEMENT

We are extremely grateful and deeply indebted to my Research Guide, **Prof. Pranav D. Bhangaonkar** (Guide and Head of Department), **Assistance Prof. Dayanjali Thakkar** (Faculty Guide) and **Dr. Jaswant Singh**, for their excellent guidance and whole hearted involvement during our Project work without whose invaluable suggestions, meticulous efforts, versatility and untiring guidance, this project would not have been feasible. We are also indebted to them for their encouragement and moral support throughout the research work. Right from the formulation of this project, they have been a source of inspiration and help. Last but not the least; we would like to thank our family: our parents for giving birth to me at the first place and supporting us spiritually throughout our life.

REFERENCES

1. Z. Xiangxue, A. Jie, W. Yuzhong et al., "Progress of producing vehicle fuels from cracking waste plastics," Chemical Industry and Engineering Progress, vol. 31, pp. 389–401, 2012. View at Google Scholar
2. L. Guangyu, L. Jian, M. Xiaobo et al., "Pyrolysis of MSW plastics: technologies and their reactors," Environmental Engineering, vol. 27, pp. 383–388, 2009. View at Google Scholar
3. D.-M. Zheng, Q.-F. Lu, M. Liu, and Y.-X. Chen, "Study on the catalytic cracking of waste plastics and waste lubricating oil for producing fuel oil," Modern Chemical Industry, vol. 31, no. 8, pp. 47–49, 2011.View at Google Scholar · View at Scopus
4. D. Yafeng, H. Xiuling, W. Zhiwei et al., "The research and design of a new type of waste plastic cracking reactor," Machinery Design & Manufacture, no. 1, pp. 20–22, 2013. View at Google Scholar
5. W. Chao, M. Xiaobo, W. Hai et al., "Study on effective thermal conductivity coefficient of plastic wastes pyrolysis process," Materials Review, vol. 27, no. 5, pp. 108–111, 2013. View at Google Scholar
6. Y.-B. Liu, X.-B. Ma, D.-Z. Chen, L. Zhao, and G.-M. Zhou, "Copyrolysis characteristics and kinetic analysis of typical constituents of plastic wastes," Proceedings of the Chinese Society of Electrical Engineering, vol. 30, no. 23, pp. 56–61, 2010. View at Google Scholar · View at Scopus
7. D. S. Achilias, C. Roupakias, P. Megalokonomos, A. A. Lappas, and E. V. Antonakou, "Chemical recycling of plastic wastes made from polyethylene (LDPE and HDPE) and polypropylene (PP)," Journal of Hazardous Materials, vol. 149, no. 3, pp. 536–542, 2007. View at Publisher · View at Google Scholar · View at Scopus
8. M. L. Mastellone and U. Arena, "Bed defluidisation during the fluidised bed pyrolysis of plastic waste mixtures," Polymer Degradation and

Stability, vol. 85, no. 3, pp. 1051–1058, 2004. View at Publisher · View at Google Scholar · View at Scopus

9. M. Sarker, M. M. Rashid, R. Rahman, and M. Molla, "Conversion of low density polyethylene (LDPE) and polypropylene (PP) waste plastics into liquid fuel using thermal tracking process," British Journal of Environment & Climate Change, vol. 2, no. 1, pp. 1–11, 2012. View at Google Scholar
10. E. A. Williams and P. T. Williams, "Analysis of products derived from the fast pyrolysis of plastic waste," Journal of Analytical and Applied Pyrolysis, vol. 40-41, pp. 347–363, 1997. View at Publisher · View at Google Scholar · View at Scopus
11. P. T. Williams and E. A. Williams, "Fluidised bed pyrolysis of low density polyethylene to produce petrochemical feedstock," Journal of Analytical and Applied Pyrolysis, vol. 51, no. 1, pp. 107–126, 1999. View at Publisher · View at Google Scholar · View at Scopus
12. K.-H. Lee, "Thermal degradation of heavy pyrolytic oil in a batch and continuous reaction system," Journal of Analytical and Applied Pyrolysis, vol. 86, no. 2, pp. 348–353, 2009. View at Publisher · View at Google Scholar · View at Scopus
13. W. Kaminsky, M. Predel, and A. Sadiki, "Feedstock recycling of polymers by pyrolysis in a fluidised bed," Polymer Degradation and Stability, vol. 85, no. 3, pp. 1045–1050, 2004. View at Publisher · View at Google Scholar · View at Scopus
14. H. Schmidt and W. Kaminsky, "Pyrolysis of oil sludge in a fluidised bed reactor," Chemosphere, vol. 45, no. 3, pp. 285–290, 2001. View at Publisher · View at Google Scholar · View at Scopus
15. F. Pinto, P. Costa, I. Gulyurtlu, and I. Cabrita, "Pyrolysis of plastic wastes. 1. Effect of plastic waste composition on product yield," Journal of Analytical and Applied Pyrolysis, vol. 51, no. 1, pp. 39–55, 1999. View at Publisher · View at Google Scholar · View at Scopus
16. D. S. Scott, S. R. Czernik, J. Piskorz, and D. S. A. G. Radlein, "Fast pyrolysis of plastic wastes," Energy & Fuels, vol. 4, no. 4, pp. 407–411, 1990. View at Publisher · View at Google Scholar · View at Scopus
17. H.-T. Lin, M.-S. Huang, J.-W. Luo, L.-H. Lin, C.-M. Lee, and K.-L. Ou, "Hydrocarbon fuels produced by catalytic pyrolysis of hospital plastic wastes in a fluidizing cracking process," Fuel Processing Technology, vol. 91, no. 11, pp. 1355–1363, 2010. View at Publisher · View at Google Scholar · View at Scopus
18. W. L. Yoon, J. S. Park, H. Jung, H. T. Lee, and D. K. Lee, "Optimization of pyrolytic co-processing of waste plastics and waste motor oil into fuel oils using statistical pentagonal experimental design," Fuel, vol. 78, no. 7, pp. 809–813, 1999. View at Publisher · View at Google Scholar · View at Scopus
19. Y. Kodera, Y. Ishihara, and T. Kuroki, "Novel process for recycling waste plastics to fuel gas using a moving-bed reactor," Energy & Fuels, vol. 20, no. 1, pp. 155–158, 2006. View at Publisher · View at Google Scholar · View at Scopus
20. A. A. Garforth, Y.-H. Lin, P. N. Sharratt, and J. Dwyer, "Production of hydrocarbons by catalytic degradation of high density polyethylene in a laboratory fluidised-bed reactor," Applied Catalysis A: General, vol. 169, no. 2, pp. 331–342, 1998. View at Publisher · View at Google Scholar · View at Scopus
21. G. Elordi, M. Olazar, G. Lopez et al., "Catalytic pyrolysis of HDPE in continuous mode over zeolite catalysts in a conical spouted bed reactor," Journal of Analytical and Applied Pyrolysis, vol. 85, no. 1-2, pp. 345–351, 2009. View at Publisher · View at Google Scholar · View at Scopus
22. S. B. Desai, "Production and analysis of pyrolysis oil from waste plastic in Kolhapur city," International Journal of Engineering Research and General Science, vol. 3, no. 1, pp. 590–595, 2015. View at Google Scholar