

Recovery of Liquid Hydrocarbons by Catalytic Depolymerization of Waste Plastic and Blending with Automotive Fuel

Amit J. Agrawal¹, Nitikesh P. Chakole², Punit S. Arekar³

¹Asst. Professor, Department Of Petrochemical Technology, Laxminarayan Institute Of Technology, Nagpur, M.S., India

^{2,3}M. Tech Student of Petrochemical Technology, Laxminarayan Institute Of Technology, Nagpur M.S., India

Abstract - In the present condition, the use of the plastic material in the day to day life has dramatically increases. Economical growth impossible without saving of fossil fuel like crude oil, natural gas or coal they are non-renewable resources. Recovery of liquid hydrocarbon by depolymerization of waste plastic collected from local hospital i.e. saline bottles (LDPE). It was found that the LDPE yield above 65% fuel with a copper based catalyst to feed ratio 1:200 at 300-400°C in a copper batch reactor. The optimum catalytic cracking temperature up to 300 to 310°C that depend on the optimum quantity of catalyst to feed ratio. This fuel can be directly compared or blended with automotive gasoline or diesel fuel from their characterization and boiling ranges as per ASTM distillation ASTM D86 test method.

Key Words: waste plastic, depolymerization, gasoline, diesel, blending.

1. INTRODUCTION

During last few decades the tremendous population increase worldwide together with need of people to adopt improved condition of living lead to a dramatical increase of the consumption of plastic material. The plastic material had a remarkable impact on the environment and leaving standard. Due to their diverse and attractive application in household and industries, the demand is continuously increasing.

According to Plast India report India's per capita plastic consumption approximately at 9.7 kilograms in 2012-13 is far below than 109 kilogram level in United states and 45 kilograms in China, But the plastic industry poised to benefit from increasing per capita income, rising consumerism, and modernization, particularly in an urban area the plast India foundation estimated that the demand for polymers to jump to 16.5 million metric tons by 2016-17 from 11 million tons during 2012-13, Resulting in consumption rising by 10.8 percent compound annual growth rate. India is expected to among top 10 packaging consumers in the world by 2016 with demand set to reach \$24 billion according to report.

Both the landfilling and incineration processes of plastic waste management system are identified as sources of

pollutant gas emitters. [1] Reprocessing is also uneconomical in comparison to the virgin plastic products in terms of commercial values due to polymeric contamination. [2] Thermal or catalytic cracking of waste plastics is one of the possible methods of their utilization. As a result of the cracking at 400°C or higher process temperature, some quantities of hydrocarbon mixtures in the form of gas, liquid products (gasoline and diesel fuel boiling range) as well as higher boiling liquid residue or solid can be obtained. All these products can be used as fuels or fuel components. Especially liquid products of gasoline and diesel fuel boiling range can be applied to components of engine fuels. [3] The yield of liquid hydrocarbon by catalytic cracking is depending on the catalyst to feed ratio, type of plastic composition operating temperature of the reactor, the length of the condenser, flow rate and temperature of circulating water through the condenser as the cooling medium. It has been observed that on the basis of boiling ranges liquid hydrocarbon product separated into two cuts. First, cut in the boiling range of gasoline and other in the range of diesel for blending purpose.

2. EXPERIMENTAL ASSEMBLY

The reactor was made up of a copper vessel of volume 4.5 liter, diameter 17.5 cm, and height 19 cm. the upper end of reactor fabricated with stainless steel flanges with nuts and bolt for tightening purpose and centrally drilled with 2cm diameter hole for removal of vapour during cracking when reactor suggested to heating. The thermowell fabricated to lied of the reactor for measuring feed temperature during cracking. The heating mental of capacity 5-liter use as a source of heating to the reactor that controlled by the dimmer state. The reactor opening for vapour was followed by Teflon bush which specially shaped in required dimension to avoid direct contact between metal and glass joint of B24 size. This joint followed by distillation head containing thermowell for measuring product vapour temperature and series of condensers to condense oil vapour by cold water as a cooling medium.

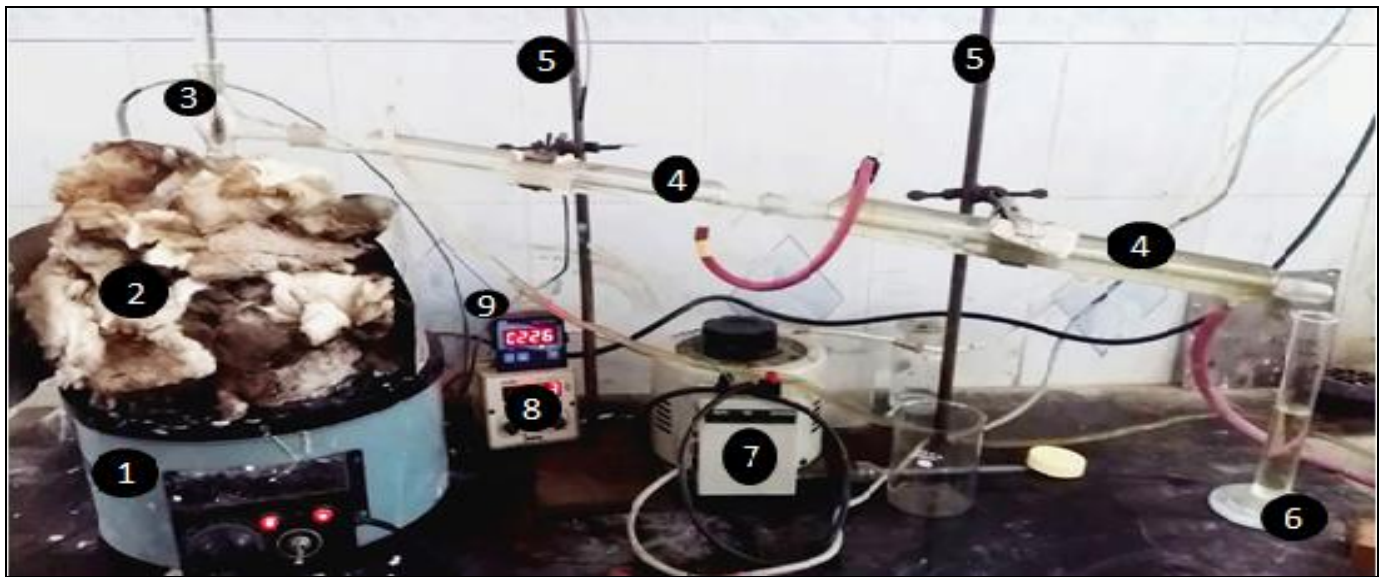


Fig -1: Experimental Setup (1.Heating mantle 2. Reactor covered with ceramic wool insulation 3. Distillation head 4. Series of condenser 5. Stands 6. Measuring cylinder for the collection of product 7. Dimmer state 8. Feed temperature indicator 9. Product vapor temperature indicator)

3.CHARACTERIZATION

Table -1: Characterization Comparison of Automotive Fuels and Recovered Liquid Hydrocarbon

Properties	Gasoline	Diesel	Recovered liquid hydrocarbon
Density (gm/ml)	0.73	0.82	0.77
Kinematic viscosity @ 40°C (Cst)	1.35	2.62	3.036
Aniline point (°C/°F)	-	72/162	59/138
Pour point (°C)		> -12°C	> -14°C
Density @ 60°F (gm/ml)	0.74	0.83	0.78
Specific gravity @ 60°F	0.75	0.83	0.78
A.P.I. Gravity	59.71	38.98	49.91
Diesel index	-	63.15	68.88
Cetane No.	-	55.15	59.59
Calorific value (Cal/gm)	-	10953.31	11122.36

3.ASTM DISTILLATION

In this test 100 ml sample distilled in a standard flask at a uniform rate of 5 cc per minute. The distillate condensed in a brass tube condenser, surrounded by a water bath kept at 0°C by the ice-water mixture. The first drop from condenser must be available in 5 to 10 minutes after heating started, at which the recorded temperature is mentioned as initial boiling point (IBP) of the sample. The vapor temperature recorded at each successive 10 cc distillate collected in a measuring cylinder the test continues in the same way till 95% of reaction is condensed. At this juncture, the heat intensity may be increased to obtain the maximum boiling point also known as end point (EP). [4] It has been observed that liquid hydrocarbon product separated into two cuts. first, cut up to 65% recovery in the boiling range of 50-210° C which is approximately in the range of gasoline fuel so it can be blend into gasoline fuel i.e. liquid hydrocarbon product (LHP) cut 1. Another cut which has a boiling range above 210°C which is in the range of diesel fuel so it can blend into diesel fuel i.e. liquid hydrocarbon product (LHP) cut 2.

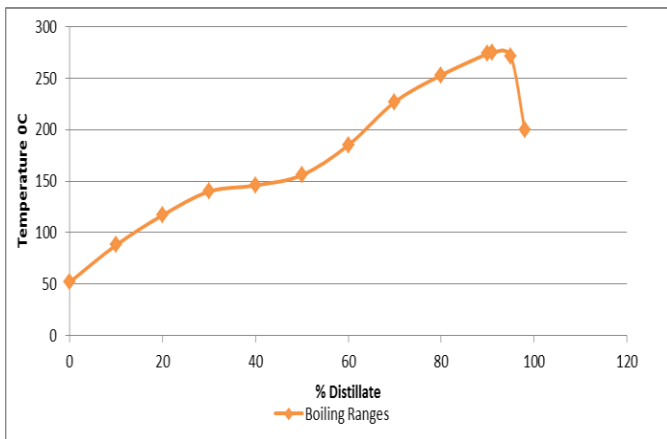


Chart -1: ASTM Graph

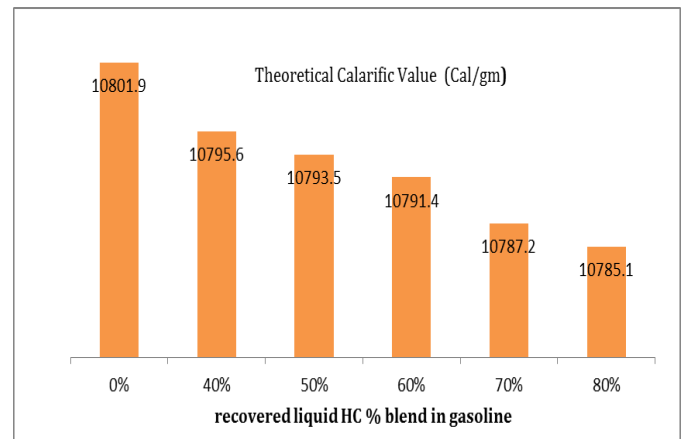


Chart -2: Theoretical Calarific Value

Table -2: Characterization of Liquid Hydrocarbon Product (LHP) Cut 1 with Gasoline

Percentage Blend		Density @ 15.6°C (gm/ml)	Specific Gravity @15.6°C	API Gravity @15.6°C	Theoretical Calorific Value (Cal/gm)
LHP	Gasoline				
0	100	0.761	0.761	54.436	10801.9
40	60	0.764	0.764	53.969	10795.6
50	50	0.765	0.765	53.467	10793.5
60	40	0.766	0.766	53.226	10791.4
70	30	0.768	0.768	52.745	10787.2
80	20	0.769	0.769	52.505	10785.1

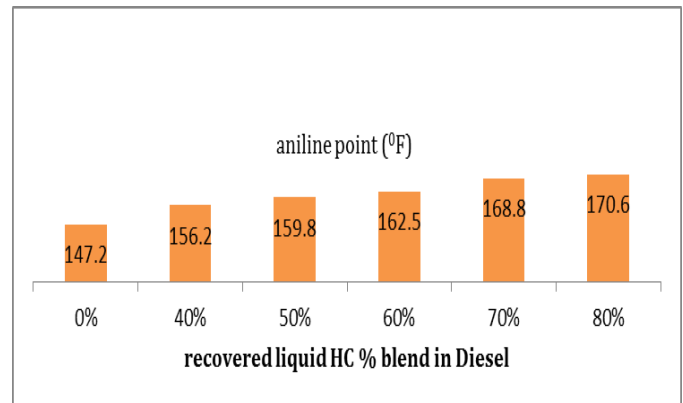


Chart -3: Aniline point

Table -3: Characterization of Liquid Hydrocarbon Product (LHP) Cut 2 with Diesel

Percentage Blend		Density @15.6°C (gm/ml)	Specific Gravity @15.6°C	API Gravity @15.6°C	Aniline point (°C)	Diesel Index
LHP	Gasoline					
0	100	0.839	0.839	37.153	147.2	54.689
40	60	0.820	0.820	41.061	156.2	64.137
50	50	0.818	0.818	41.483	159.8	66.290
60	40	0.811	0.811	42.976	162.5	69.836
70	30	0.804	0.804	44.495	168.8	75.107
80	20	0.801	0.801	45.154	170.6	77.033

4. CONCLUSION

4.1 Waste Plastic Oil Blended with Gasoline:

The lighter fraction liquid hydrocarbon product has low flash point and low density along with the boiling range which is below 210 °C (ASTM D86) which is comparable to the gasoline in the market and hence, it can be blended with gasoline fuel.

Properties of the blended fuel showed that the theoretical net calorific value of the blends was Slightly lower than the theoretical net calorific value of gasoline fuel. So, recovered liquid hydrocarbon can be a good choice as a blend with gasoline as it will not affect much of its calorific value. The results showed that we can blend up to 80% oil however if anyone does not to compromise with the calorific value then also we can easily blend up to 50%. For higher %, we can use octane boosters available in the market to maintain the octane value.

The study shows that recovered liquid hydrocarbon from plastic can be a good choice for gasoline as its demand is increasing day by day and as we are on the verge of its shortage.

4.2 Waste Plastic Oil Blended with Diesel:

Heavier fraction (Boiling range above 210 °C) of liquid hydrocarbon product has a density, viscosity and aniline point comparable to the density, viscosity and aniline point of diesel fuel in the market. Hence, it provides an option to blend it with diesel.

Aniline point is increasing with the increase of the percentage of waste plastic oil in the diesel fuel. This shows that waste plastic oil contains low aromatic content which is desirable in diesel fuel. Increase in the Diesel index with the increase of the percentage of waste plastic fuel is another good indication for using it as blending agent. As the increase in the diesel index suggests the improvement in the cetane value. This increase shows that the diesel fuel will give better ignition quality after the blending.

Considering the environmental factors, recovered liquid hydrocarbon from waste plastic oil will reduce the smoke on -start-up. It will also tend to reduce NO_x and PM emissions. NO_x will reduce in all engines while PM reduction is engine-dependent. The volatility of waste plastic oil has to be decreased in order to use it as an alternative to diesel fuel. Upto the certain extent, waste plastic oil is a good choice as a blending component for diesel fuels.

ACKNOWLEDGEMENT

The authors sincerely thank Dr. V. N. Ganvir for his Expert guidance and support throughout the work. The Authors also thank Department Of Petrochemical Technology, Laxminarayan Institute Of Technology, Nagpur for the infrastructure and Support provided.

REFERENCES

- [1] Débora Almeida, Maria de Fátima Marques, "Thermal and Catalytic Pyrolysis of Plastic Waste", *Polimeros*, Vol. 26 no. 1 Sio Carlos Jan./Mar. 2016 Epub Mar 04, 2016.
- [2] M.A.Hazrat, M.G. Rasul, M.M.K. Khan, "A Study on Thermo-catalytic Degradation for Production of Clean Transport Fuel and Reducing Plastic Wastes", *Procedia Engineering*, Volume 105, 2015, Pages 865-876.
- [3] Jerzy Walendziewski, Mieczysław Steininger, "Thermal and catalytic conversion of waste polyolefines", *Volume 65*, Issues 2-4, 20 February 2001, Pages 323-330.
- [4] B. K. Bhaskara Rao, "Modern Petroleum Refining Processes", Fifth Edition, Oxford & IBH Publishing CO. PVT. LTD.
- [5] Ram Prasad, "Petroleum Refining Technology", First Edition, Ninth Reprint 2013, Khanna Publishers.
- [6] John I. McKetta Jr. "Encyclopedia of Chemical Processing and Design". Volume 35 - Petroleum Fractions Properties to Phosphoric Acid Plants: Alloy Selection, CRC Press, 1990.