International Journal of Research in Advent Technology, Vol.4, No.4, April 2016
E-ISSN: 2321-9637
Available online at www.ijrat.org

Recycling of Waste Plastic as Fuel for DI-CI Engine

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Abstract- Hydrocarbons have been obtained from waste saline bottles, made of low density polyethylene (LDPE), by degradation using fly ash as catalyst. When cat/pol ratio was 0.1, 97% degradation was observed with 85 % of oil formation. Increase in cat/pol ratio reduced the amount oil formed and increased the amount of gaseous hydrocarbons. Increase in cat/pol ratio reduced the reaction temperature and reaction time. The oil obtained was fractionated into the following four fractions viz., fraction boiling below 100 □C, fraction boiling in the range 100 – 150 □C, fraction boiling in the range 150 – 200 □C and fraction boiling above 200 □C. In all cause the major fraction is that one boiling in the range 100 - 150 □C. The GCMS spectrum of this fractions shows that it contains large hydrocarbons with 4-9 carbons atoms. The physico-chemical properties of the three fractions boiling within 200□C suggested that they can be used as substitute for diesel.
As a part of our project work, we extracted the hydrocarbon fluid from the same type of waste plastic (medical saline bottles). Later characterization, Chromatographic and mass spectrographic analysis carried out, and to implement as fuel for DI-CI engine, the characteristics of plastic HC fluid compare with the Petroleum diesel.

Keyword- Plastic HC, Catalyst, Saline Bottles, GC-MS.

1. INTRIDUCTION

Nowadays plastic materials are widely used and this is generating huge amount of post-use plastic wastes. Management of these plastic wastes is a serious problem. Land filling, incineration and recycling are the three available methods of utilizing plastic wastes.

Since plastic wastes are voluminous land filling requires large amount of safe depots.
Hence, land filling is rather expensive. Incineration produces harmful gases like NOx, Cox and SOx. These factors make plastic recycling as the most attractive method of handling waste plastics.

One method of recycling is reuse of plastics by regranulation .However, this method requires collection of pure plastics. Plastics made of polyesters and polyamides can be converted into their monomers by chemical methods. However, polyalkenes can not be depolymerised into monomers easily. Degradation of polyalkenes into hydrocarbons has received greater attention[1-10]. Catalystic degradation has been found to be better than thermal degradation [4, 5].

Polyethylene, a widely used thermoplastic, is a polymer of ethylene and is represented as PE. The chemical formula of PE is [CH2CH2]n. Based on the value of 'n' polyethylene is classified into two types, viz. low density polyethylene [LDPE] and high density polyethylene [HDPE]. LDPE is generally used for making flexible materials like bags and geomembranes. HDPE is used for making conters .

In our project, by considering the above literature survey we developed the reactor and condenser for the extraction of plastic HC fuel, characterization and Gas Chromatography & Mass Spectrograph (GS-MS) .

2. EXPERIMENTAL SET UP FOR THE EXTRACTION OF HC FLUID:

Figure.1.1 Experimental Set Up for the Plastic Hydrocarbon fuel.

Figure.1.2 Plastic HC & Liquid HC

As shown in Fig.1.1 the experimental setup consists of heat source, reactor, condenser and fuel collection pipe. To supply the heat energy liquid petroleum gas with burner used for the experiment. Controlling of the gas and availability of the heat energy is high in this case. The energy balance calculation not included in this paper. The work mainly concentrated on extraction and characterization. Counter flow shell and tube type heat exchanger used as condenser. The center pipe carries the hot gases and annular pipe carries the cool water. Hence the condensate is formed in the central tube, and it is collected into bottles. Non condensable gases also released during the experiment. These gases are separated and burned. The reactor height is ten times more than the diameter. Hence the separation of gaseous phase and the liquid phase perfect and no liquid phase is entered into the condenser. The quality of the condensate is improved due to high length to diameter ratio for the reactor. To conduct the experimentation the chips of saline bottle placed in the reactor chamber. The chamber is filled up to 50% with the chips. The quantity of the chips weighed after that it is placed in the reactor. The reactor cap is fixed after placing the gaskets to arrest the leakage of the gases. The cap directly the condenser in let pipe is connected as shown in fig.1. Heat supplied from the bottom of the reactor. The total time of the heat supplied also considered, to calculate the heat input. In this experiment 85-90% of the hydrocarbon fluid is collected. Further the collected fluid is subjected to the fractional distillation to extract the good quality of the fuel at different temperatures.
Figure1.2 showing HC fluid obtained from saline bottle during experiment.

3. CHARACTERIZATION AND GC-MS ANALYSIS:

From the above properties, one can observe the viscosity of the Plastic HC fuel is less than the Petro From the above properties, one can observe the viscosity petro – diesel. It supports the less modification of the existed engine. The cetane number of the Plastic HC and Petro-diesel also very near. Hence the knocking tendency is also very less. The calorific value is slightly less than the petro-diesel, which causes for more fuelThe calorific value is slightly less than the petro-diesel, which causes for more fuel consumption. By observing above physical and chemical properties the extracted plastic HC is suitable for implementing as fuel for the CI engine, in the blended form as well as in neat form.

4. GC- Ms Analysis:

Gas chromatography and mass spectrographic diagrams are shown fig.3.1 & fig.3.2. Unsaturated hydrocarbons in the plastic HC fuel are 23.4%, the remaining components are Saturated hydrocarbons and aromatics which is favorable to implement as fuel for the diesel engines.

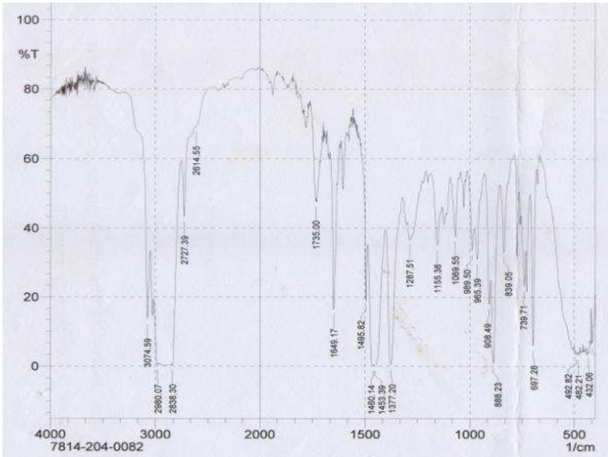

Figure.3.1 FTIR Spectrum of Plastic Hydrocarbon Fuel.

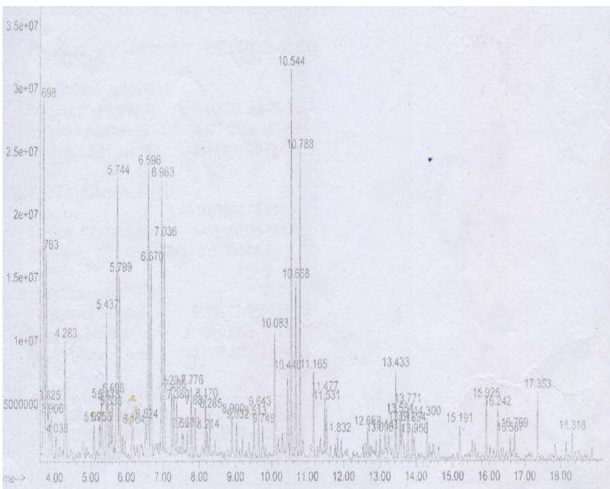

Figure.3.2 GCMS of Plastic Hydrocarbon Fuel

Table:1 Identification of Chemical Components in the Plastic HC Fluid from GC

PK#	RT	Area%	Mol. Formula
1	3.79	13.88	$C_5H_{10}O$
2	4.16	3.27	$C_{10}H_{18}$
3	5.47	19.66	C_9H_{10}
4	6.58	15.2	$C_{11}H_{22}$
5	7.47	9.41	C_9H_{18}
6	8.39	2.96	$C_{21}H_{24}$
7	9.48	2.76	C_7H_{16}
8	10.50	16.22	C_6H_{12}
9	11.50	3.88	C_9H_{20}
10	12.66	1.63	$C_{12}H_{26}$
11	13.54	6.3	$C_{21}H_{40}O_2$
12	14.29	0.66	C_9H_{18}

4. CONCLUSIONS

Plastics present a major threat to today's society and environment. Over 14 million tons of plastics are dumped into the oceans annually, killing about 1,000,000 species of oceanic life. Though mankind has awoken to this threat and responded with developments in creating degradable bio-plastics ,there is still no conclusive effort done to repair the damage already caused. In this regard, the catalytic Pyrolysis studied here presents an efficient, clean and very effective means of removing the debris that we have left behind over the last several decades. By converting plastics to fuel, we solve two issues, one of the large plastic seas, and the other of the fuel shortage. This dual benefit, though will exist only as long as the waste plastics last, but will surely provide a strong platform for us to build on a sustainable, clean and green future. By taking into account the financial benefits of such a project, it would be a great boon to our economy. So, from the studies conducted we can conclude that the properties of the fuel obtained from plastics are similar to that of petrol and further studies on this field can yield better results. Hence plastic hydrocarbon fuel can be used as a fuel for the CI engine without modifications. Also Instead of considering a variety of plastics as raw material for extraction of HC fluid, if same type of waste plastic, without any dye is considered for extraction of HC fluid, harmful components can be eliminated.

5. FUTURE SCOPE OF WORK

For the successful implementation of a plastic HC oil as fuel for the IC engines, in- addition to the above, further analysis in the area of Combustion of fuel, Heat release during the combustion, Exhaust gas of the engine, tribological properties of engine components, engine vibration and noise need to do.

Table:2 Properties of the HC Fuel:

S. No	Parameter	Units	Plastic HC	Petro-diesel	Test Method
1	Kinematic Viscosity @400C	cSt	1.04	1.5-2.0	ASTM D 445
2	Iodine value		5.59	--	AOAC Ch.41
3	Carbon residue	%	0.061	0.03	ASTM D 189
4	Flash Point	0 C	30	55-60	ASTM D 93
5	Fire Point	0C	33	0.03	
6	Moisture content	%	0.02	57-63	ASTM D 4377
7	Density	gm/cc	0.7872	0.08	ASTM D 1298
8	Sediment	%	0.06	--	ASTM D 893
9	Gross Calorific value	kJ/Kg	37,867	43,700	ASTM D 240
10	Cetane Index		42	45-50	ASTM D 976
11	Saturated HC	%	18.6	--	GCMS Screening
12	Unsaturated HC	%	23.4	--	

6. ACKNOWLEDGEMENTS

Authors wish to thank Gandhi Institute Engineering & Technology, Gunupur, Orissa, India for the provided financial as well as infrastructure support.

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