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EXPERIMENTAL INVESTIGATION AND PRODUCTION OF PYRO-LIGNEOUS OIL FROM PLASTIC WASTE

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ABSTRACT

In this project the process of converting waste plastic in to the value added fuel. And it is explained as a viable solution for recycling of plastics. Here the plastic wastes from low density to high density is going to use for the pyrolysis process to get the plastic oil. The major benefits takes place in the conversion of plastics in to oil is used as a fuel for the domestic purpose like vehicle and industry. Secondly the plastic pollution is minimized. Here the pyrolysis process that converts waste plastic in to valuable liquid hydrocarbon products and the gases obtained from the process that can be used as a alternative fuel. The main aim of this project is to utilize the pyrolysis oil as an alternative fuel for a furnace.

KEYWORDS: Pyrolysisoil; Waste Plastics;Alternative Fuel; Furnace Oil

The plastic wastes are dumped in the oceans threatening the health and safety of marine life. The uncontrolled incineration of plastic produces polychlorinated dibEnzo-p-dioxins, a carcinogen. So, converting the waste plastic into crude oil will have two benefits. First of all, the hazards caused due to plastic waste can be reduced and secondly, we will be able to obtain some amount of oil from it, which can be further purified to be used as a fuel in different areas such as domestic fuel, fuel for automobiles and industries [Vijayakumar and Channa Shtty, 2016].

Diesel engines are the most efficient prime movers, from the point of view of protecting global environment and concerns for long-term energy security it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Unlike rest of the world, India's demand for diesel fuels is roughly six times that of gasoline hence seeking alternative to mineral diesel is a natural choice. Alternative fuels should be easily available at low cost, be environment friendly and fulfil energy security needs without sacrificing engine's operational performance. Waste to energy is the recent trend in the selection of alternate fuels1. Fuels like alcohol, biodiesel, liquid fuel from plastics etc. are some of the alternative fuels for the internal combustion engines [Lee, 2015]. Utilization of biomass as alternative fuel for compression ignition engine has a great scope especially in developing and undeveloped countries. Plastics have become an indispensable part in today's world, due to their lightweight, durability, energy efficiency, coupled with a faster rate of production and design flexibility. At the same time, waste plastics have created a very serious environmental challenge because of their huge quantities and their disposal problems [Saptoadi, 2015]. Waste plastics do not biodegrade in landfills, are not easily recycled, and degrade in quality during the recycling process. Instead of biodegradation, plastics waste goes through photo-degradation and turns into plastic dusts which can enter in the food chain and can cause complex health issues to earth habitants, through the thermal treatment on the waste plastic the fuel can be derive3, by adopting the chemical process such as Pyrolysis can be used to safely convert waste plastics into hydrocarbon fuels that can be used for transportation [Pawar, 2013].

Types of Plastics

Industry (SPI) defined a resin identification code system that divides plastics into the following seven groups based on the chemical structure and applications,

1. PET(Polyethylene Terephthalate),
2. HDPE (High Density Polyethylene),
3. PE(polyethylene),
4. LDPE(Low Density Polyethylene),
5. PP (Polypropylene).

Pyrolysis Oil

Feedstock material is the main factor to indicate the properties of the pyrolysis oil. Tire pyrolysis and plastic pyrolysis technologies are the available technologies on the market in Thailand. The feedstock pre-process is one of the main factors to assess the possibility of the technology. The waste tires are collected easily from the scavenger and garage as they are bulky and heavy but only shredding process is required to reduce the size. The waste plastics are collected from scavenger, MSW sorting plant, and landfill area. The weakness of the plastic is the character of the plastic, which is mainly from plastic bag, is small

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high impurity and bulky. However, as the purpose of the process is turning waste to energy, the pyrolysis process of tire and plastic is distinguished and compared in this research. Physical and chemical analysis properties of both oils are studied and compared in order to ensure to usage of the oil in diesel engine [Lee, 2015].

LITERRATRE REVIEW

In order to have a proper background study on technologies available for conversion of waste plastics to fuel, literature survey is carried out to know its various applied method throughout the globe, they are summarized below. From this crude oil various products petrol, diesel and kerosene etc. can be obtained by distillation. This process can convert all HDPE and LDPE waste plastic as an alternative fuel for furnaces. After reviewing these various literatures, we can see that different forms of Pyrolysis processes have been employed for the conversion of plastic wastes to efficient fuels and also successfully tested as well by both physical and chemical properties.

Impacts on Waste Plastics

Human hormones and therefore act to disrupt biochemical processes. These chemicals are “bio accumulative”, meaning that they build up in the body over time and can cause or contribute to a range of health problems partly as its uses are so widespread, and partly because it is treated with many plasticizers that enhance its feel which are thought to be bio-accumulative. There is still much debate over the validity and extent of such concerns, in general NGOs and some health organizations have raised concerns, whilst plastics manufacturers have sought to demonstrate the safety of their products. Due to its long life time, it is too difficult to recycle and so making huge hazard to our environment [Horshy, 2013].

Polymer Cracking

The first series of polymer cracking experiments was carried out in a glass reactor of 0.5dm3volume at atmospheric pressure and in a temperature range 350-420°C,the second one in autoclaves under hydrogen pressure (~3-5MPa) in temperature range 380-440°C.Process in the batch cycle in the presence of alkaline catalyst proceeds with similar temperature and rate as in the case of thermal cracking, temperature range 390-410°C,higher by 10-30°C in the relation to the process catalyzed by the acid catalysts.

Hydro Cracking

DSD plastic can be hydrocracked thermally to produce gaseous and Liquid products. Figure 3 shows the effect of reaction temperature on thermal hydrocracking of this plastic. The conversion was not a function of temperature in the temperature range of 450 to 480"C, although conversion increased markedly with temperature increasing from 370 to 450°C. Different from the APC plastic, this DSD plastic contained about 4.4% ash. Therefore, the maximum conversion should be about 95% and this value was reached at temperatures higher than 450OC.

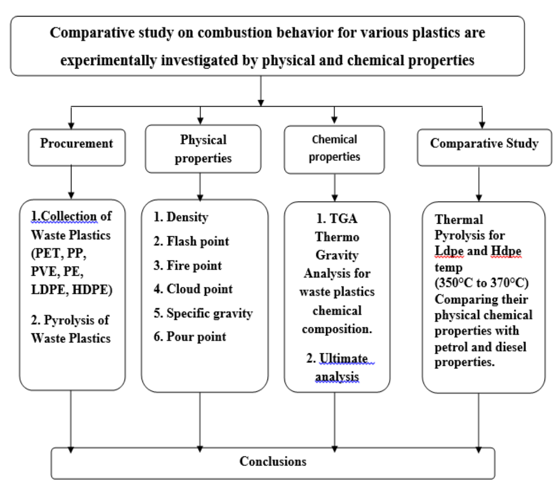
Comparison of Liquid Fuels

Described that Production of liquid fuel would be a better alternative as the calorific value of the plastics is comparable to that of fuels, around 40 MJ/kg. Each of these options potentially reduces waste and conserves natural resources. The temperature is 350-500˚C.The catalytic pyrolysis of plastic to fuel is gaining momentum and being adopted in different countries recently due to its efficiency over other process in all respects [Saptoadi, 2015].

Production of Plastics

The production of plastic begins with a distillation process in an oil refinery. The distillation process involves the separation of heavy crude oil into lighter groups called fractions. Each fraction is a mixture of hydrocarbon chains (chemical compounds made up of carbon and hydrogen), which differ in terms of the size and structure of their molecules. One of these fractions naphtha, is the crucial element for the production of plastics. Plastics are also produced from natural gas [Pawar, 2013].

METODOLOGY



EXPERIMENTAL SETUP AND DESCRIPTION

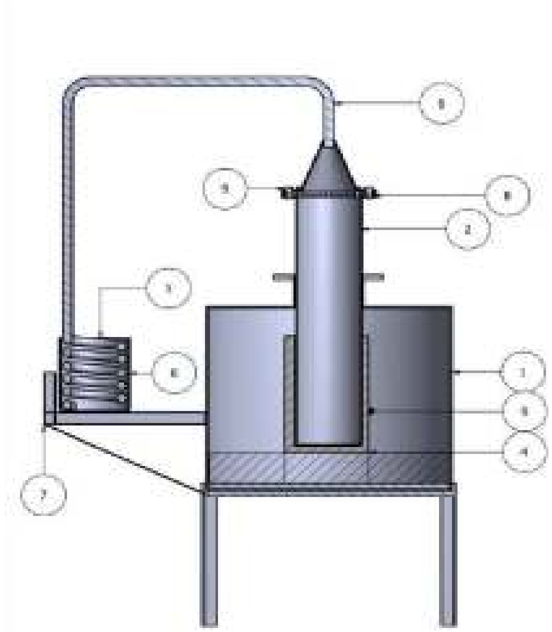


Figure 1: Experimental setup of pyroysis reactor with parts

Reactor parts: 1.Frame, 2.Heating chamber, 3.furnace, 4.Insulations, 5.Condensor, 6.Tank, 7.Bracket, 8.Nut and bold, 9.Gasket.

Experimental Procedure

Preparation of raw materials

Waste plastics are first collected, after the waste plastics were collected, it was washed to remove the impurities and then was dried to remove any water droplets. Then the washed plastic was sorted according to their categories. Finally, it was shredded and cut into pieces for ease of feeding the raw materials and for good heat transfer. 2 kilogram was weighed and feed to the reactor and the reactor was properly sealed to protect the gas from leaking. Adequate precautions were put in place to make sure there is no leakage before start of experiment.

Process Description

The reactor is placed in a heating furnace and maintained the temperature 330-450 Oc. Gases form the reactor is sent to a cyclone separator. The heavy ends from the separator are collected in a tank at the bottom as Wax and the light ends are sent to a condenser. From the condenser, two products condensable vapors and non-condensable gases are obtained Non-condensable gases are removed by using a gas scrubber. These gases are rich in methane, ethane, ethylene and can be used for power generation The condensable vapours are collected as oil in a tank. The entire time required for the process is 4 hours. The products obtained are Oil (60% to 70%), Gas (15% to 20%) and Black Carbon (20% to 30%).

RESULTS AND DISCUSSION

TGA Analysis

Analyzing Procedure

- Polymer samples such as polypropylene and polyvinyl chloride are taken 1 mg to 1.1 mg each for our experimentation on Thermo Gravimetric Analyzer.
- That polymer samples can be tested by increasing temperature on Thermo Gravimetric Analyzer machine and then the weight loss can be noted down at every temperature.
- Normally polymers losses most of its weights under 450 -500 c as per the result graph plotted.
- Plastic materials such as Polyethylene Terephthalate and Polyethylene are taken 1 mg to 1.5 mg each on Thermo Gravimetric Analyzer furnace for heating.
- Polyethylene Terephthalate losses its weight during 300-5000 c and Polyethylene can losses its weight during 500-600 0c.

TGA Sample Results

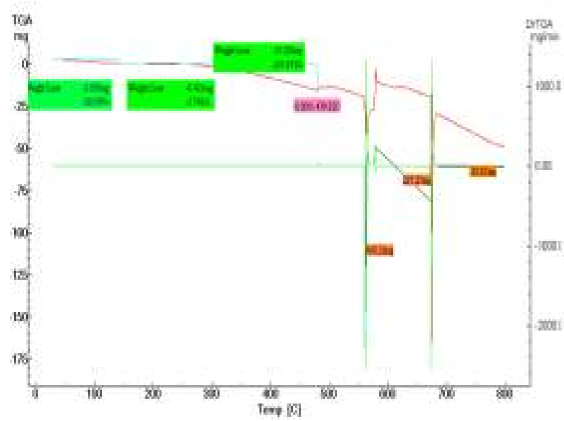


Figure 2: Polyethylene Terephthalate sample

From the above graph, TGA curve was indicating that, the weight was started from the temperature of 800c. The maximum weight was lost between temperature of 750c to 3250c. The two peak was found in this TGA curve at temperature of 5550c(aprox) and 6750c(aprox).

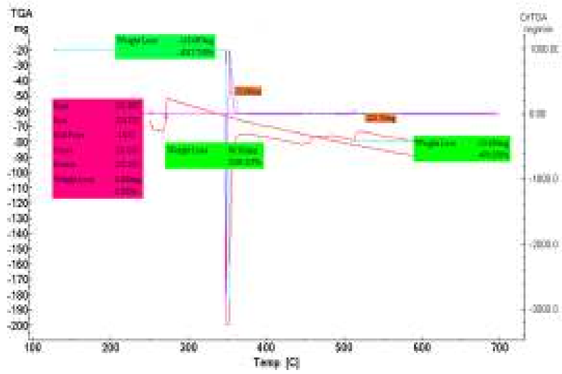


Figure 3: Polyethylene sample

In above graph, the maximum of weight was lost between the temperatures of 335^0c to 375^0c. So Polyethylene (PE) was lighter material then Polyethylene Terephthalate **(**PET). Because it was lost their maximum weight in current temperature then Polyethylene Terephthalate **(**PET).

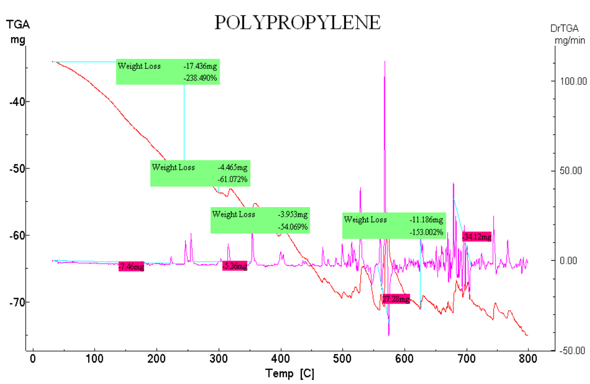


Figure 4: Polypropylene sample

The polymers are very difficult from wood samples. It starts from 0^0c to 800^0c. The weight loss curve was deep graduate when we compared both TGA of PET and PE. That PP had good alignment for oil extrusion then PE and PET. It because of their nuclear chain on the TGA.

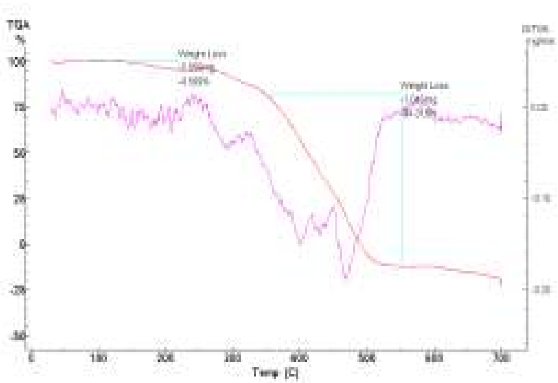


Figure 5:HDPE sample

The Hdpe sample weight loss curve is pointed from 200^0c to 300^0c. The weight loss curve was deep graduate when we compared with 400^0c to 600^0c. The overall oil extrusion is good when compared with PP,PS amd PET samples.

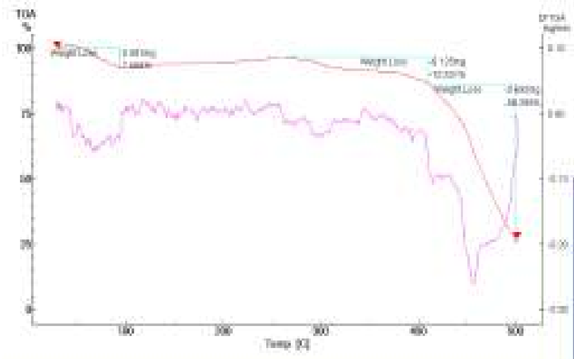


Figure 6: LDPE sample

The Hdpe sample weight loss curve is pointed from 50^0c to 100^0c. The weight loss curve was deep graduate when we compared with 300^0c to 400^0c. The overall oil extrusion is good when compared with all other samples.

Ultimate Analysis

- The ultimate analysis involves the determination of the elemental composition of the fuel such as carbon, hydrogen, Nitrogen, oxygen and sulphur. The determination of the total carbon and hydrogen and hence their ratio, provided idea on the type of volatile present in the biomass.

- The following table shows the results of ultimate analysis of selected biomass – carbon, hydrogen, oxygen, nitrogen and sulphur content in the dry biomass on a weight basis.

Table 1: Ultimate Analysis of Plastic Samples

Properties	PET	PE	PP	HDPE	LDPE
Carbon %	49	51	63	8.58	79.9
Hydrogen %	5.9	4.5	3.4	13.98	12.6
Nitrogen %	0.20	0.19	0.45	0.60	0.42
Oxygen %	44.5	43.2	32	5.19	5.3
Sulphur %	0.4	0.3	0.8	0.080	0.073
C.V (MJ/Kg)	24.7	40.4	41.6	43.8	46.3

Comparitive Study On Experimental Investigtion of plastics

In above comparing the TGA and Ultimate analysis we can select HDPE and LDPE plastics on the basis of their thermal behavior in TGA analysis and chemical composition in ultimate analysis . In ultimate analysis the carbon and hydrogen percentage is pointed as higher value in HDPE and LDPE when compare with other samples. So these two samples are introduced in to pyrolysis process and then the pyrolysis oil physical properties is tested and compared with diesel and petrol physical properties.

Table 2: Comparison of PLDE with Petrol and Diesel Physical Properties

Fuel Properties	HDPE	LPDE	Petrol	Diesel
Density	785.45 kg/m3	530.35 kg/m3	711 to 737 kg/m3	820 to 900 kg/m3
Viscosity	0.782 poise	0.652 poise	1.5 to 4 poise	1 to 3.97 poise
Specifc gravity	0.766	0.655	0.82	0.81 to 0.96
Flash point (^{o}c)	23	24	22	26
Fire point (^{o}c)	27	28	25	29
Cloud point (^{o}c)	Below 2	Below 0	1 to 3	2.5 to 4
Pour point (^{o}c)	-4.5 to -5	-2 o C	-4 to -20	-2 to-12

CONCLUSION

The Pyrolysis process was carried out in LPDE and HDPE type of plastic materials. The condensable gas is vaporized and the vapour is condensed and finally we got a plastic oil. The pyrolysis oil is introduced in to experimental investigation . Hence compared with petrol and diesel to verify its nature in physical properties. The value observed in LPDE and HDPE samples are acceptable when compared with the physical properties of petrol and diesel.

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