

Preliminary study on the conversion of different waste plastics into fuel oil

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Abstract
The objective of the work is the conversion of waste plastics into fuel oil. Plastic wastes such as, polypropylene, low density polyethylene, high density polyethylene, polystyrene are the most frequently used in everyday activities and disposed of to the environment after service. Plastic are those substances which can take long periods of time to decompose if disposed off simply to the environment. Therefore, waste plastic should be changed into usable resources. The different waste plastics were thermally cracked at different temperature and then it was tried to measure the oil produced, the residue left after the reaction is completed, and the gas produced. Then it is compared that which types of plastics can yield higher amount of oil. There are a number of methods by which plastic wastes can be managed such as incineration, recycling, land filling, and thermal cracking. But this work focuses on thermal cracking of waste plastic to change them into usable resources, because in this method the emission of hazardous gases to the environment insignificant. This means we can change all the waste in to useful resources.
Keywords: liquid oil, thermal cracking, and waste management system

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1. INTRODUCTION

Plastic waste is regarded as a potentially cheap source of chemicals and energy. Lots of us have encountered a variety of products that use plastic materials today. As a result of the increasing level of private consumption of these plastic materials huge amount of wastes are discharged to the environment. Plastic materials are a type of material that cannot be decomposed easily in a short period of time. Substantial quantities of plastic have accumulated in the natural environment and in landfills. Those wastes can be classified as industrial and municipal according to their origins; these groups have different qualities and properties and are subjected to different management strategies [1]. The continuous increase of waste plastic disposal is generating environmental problems worldwide. The present rate of economic growth is unimaginable without saving of fossil energy like crude oil, natural gas or coal. Suitable waste management is another important aspect of sustainable development. Plastic wastes represent a considerable part of municipal wastes; furthermore huge amounts of plastic waste arise as a by-product or defective product in industry and agriculture [2]. Some structure of waste plastic is shown in figure1.

1.1 Plastic Waste management systems

Plastic waste management is a collective term for various approaches and strategies used to recycle plastic materials that would otherwise be dumped into bodies of water, land fill or otherwise contaminate the environment. There are a number of methods by which waste plastics are changed into useful resources such as: Recycling is a method of reducing the quantity of net discards of municipal solid waste by recapturing selected items for additional productive uses [3]. Incineration has become an increasingly attractive disposal option for many communities, especially those facing dwindling landfill capacity and rapidly increasing tipping fees, but incineration at present limits the potential of waste plastic to energy technologies as it produce green house gases and some highly toxic pollutants such as polychlorinated dibenzo para dioxins and polychlorinated dibenzo furans [4]. Thermal cracking as a waste management option implies the decomposition of waste plastics by using some sort of heat sources. Because, plastics are composed of hydrocarbon originally, up on pyrolysis they are converted into fuel oil and some other important gases and this is the best method of utilizing waste plastics [5].

1.2 Liquid Fuel Production

Liquid fuel is defined as plastic-derived liquid hydrocarbons at a normal temperature and pressure. Only several types of thermoplastics undergo thermal decomposition to yield liquid hydrocarbons used as liquid fuel. PE, PP, and PS, are preferred for the feedstock of the production of liquid hydrocarbons. The production method for the conversion of plastics to liquid fuel is based on the pyrolysis of the plastics and the condensation of the resulting hydrocarbons [6].

2. MATERIAL AND METHODS

2.1 Materials and chemicals needed

The following materials and chemicals are used for the thesis work for producing fuel oil from waste plastics. Waste plastics are the main raw material for the thesis work, wood, water, Metal sheet for the construction of the reactor, gate valve, flask, cold water at 25^{o}c, L-shaped metal tube, half inch bolt, metal stucco, rectangular metal box with the rug of metal over the surface, and pyrometer, separatory funnel, balance, clipper, stove, vesco-meter, hydrometer, and knife.

2.2 Experimental set up and description

The reactor is constructed in the work shop from metal sheet in mechanical work shop. First the metal sheet is rolled, and then welded. The dimensions of the reactor are 1 meter long and 80centimeters diameter. In the thesis work batch reactor was used because it is simple to operate. Metal tube is connected by welding to the reactor through which the gases pass. It should be air tight by using screw bolt which holds the metal tube tight with the reactor so that the yield of the oil is maximized. The experimental setup is shown in fig 2.

Waste plastics are first collected from Bahir Dar university engineering faculty campus. 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. 1000g of it 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. Then the fire was started and the pyrolysis continued, until the last drop of oil was noticed in the measuring cylinder. The solid waste plastic was first melted and then cracked in the same reactor (converted to smaller units or gases) at different temperatures. Finally, the gas was allowed to pass through the metal tube. The gas from the tube was directly immersed into the water at 25^{o}C. As the gas and water are in direct contact there will definitely be heat exchanging between the gas and water. As the crude oil water are immiscible there will be two layers formed and can be separated using separatory funnel. The volume of fuel oil produced was monitored with time and temperature.

3 RESULTS AND DISSCUSION

3.1 **Effect of temperature on LDPE:**

Effect of temperature on the yield of fuel oil from LDPE: 1000g low density polyethylene was cracked at the different temperatures and reaction time is shown in figure 3. The initial temperature before the start of heating was found to be 31^{o}C.

This graph represents the production of gases at different temperatures and residue obtained at that temperature. Here, it was found that at the 180^{o}C, they are just started to separate from each other and after that at 205^{o}C the residue is reduced to 48.5% and gaseous product is increased to 50.5%. At 210^{o}C residue is 46.8% and gaseous product is about 52%. Finally at the temperature 250 we find the residue 44.9% and gaseous product is 53%.

Figure 4 shows that the amount of crude oil produced with respect to temperature. With increases of the temperature the amount of oil produced is increasing up to 15ml. Finally it remains constant even if temperature is increasing.

3.2 Effect of temperature on fuel oil from HDPE: 1000g of high density polyethylene was measured and cracked at different temperatures .At the different temperature the amount of oil produced and residue left after the reaction is completed was collected .The initial temperature before cracking was found to be 31°C.

Figure 5 shows the effect of temperature on the amount of oil produced from HDPE. First the amount of oil is increasing as the temperature is increasing up to 185ml. Finally, the amount of oil produced is remaining constant which indicates the consumption of the raw materials (plastics).

At a temperature of 137°C the percentage of gas produced and residue left were measured to be 35% and 62% respectively. As temperature is increasing, the value of the gas produced is increasing because the plastic is cracked more at higher temperature while the residue left was decreasing. As the temperature is increasing the amount of residue is close to zero.

3.3 Effect of temperature on fuel oil from polystyrene: 1000g of polystyrene was measured and cracked for the different temperatures.

In figure 7 it is shown that as temperature increases the amount of oil is increasing to 185ml and finally stops increasing because at this temperature almost all of the fed plastic materials are converted to fuel and some other gases.

At a temperature of 178°C the gas produced was 62% and continue with significant increment up to 250°C at which the percentage of the gas produced is 62.72%. At a temperature of 300°C the percentage of the gas produced is 56.2%.

4 CONCULSION

Thermal cracking was performed at the different temperature to obtain oil from the different waste plastic. It was also done measurement of residue, oil, and gas produced for the purpose of comparison which type of waste plastic can produce higher amount of oil. The resident time also has the effect on the yield of the oil. At the start of reaction the time required to get the first droplets of oil is higher. The yield of the different waste plastics are 1.17% for the pyrolysis of low density polyethylene ,15% from the pyrolysis of polystyrene ,and 13.88% from the pyrolysis of high density polyethylene. The reduction in the yield of the oil is due to the effectiveness of the reactor seal which means the gases which is going to be condensed is leaking out. This difference is brought about by the different in the structure of the polymer of the waste plastic. Because, the bond at the C-C is weaker than the bond between the C-H. Therefore, for plastic which has more number of C-C combinations the yield is higher than those which has C-H yield. From the work it has been tried to concluded that the major parameter which affect the yield of the oil from the waste plastic such as, the structure of the polymer, the operating temperature and the hold time. As it is seen from the results of the different experiments the temperature at which the first droplet of oil obtained is determined for the respective plastic type being cracked.

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References:

1. Murtha NH., patel M. premnath V. plastic materials flow analysis for India, resources, conservation and recycling 2006.
2. Buekens AG, Huang H. catalytic plastics cracking for recovery of gasoline- range hydrocarbons from municipal plastic wastes, Resources conservation and recycling 1998.

3. Garforth AA Ali S, MartineszJH, AKah A. Feed stock recycling of polymer wastes. Current opinion in solid state and material science 2004, page 419
4. http://www.environmetn.gov.au/setttelmens/publication/
5. Onu P. Vasile C. Ciocilteu S. Iojoiu S. Darie H. thermal and catalytic decomposition of polyethylene and polypropylene. Journal of analytic and applied pyrolysis 1999.
6. Lee KH. Shin DH. Thermal degradation of waste polyolefin polymers using spent FCC catalysts with various experimental variables. Korean journal of chemical engineering 2003.

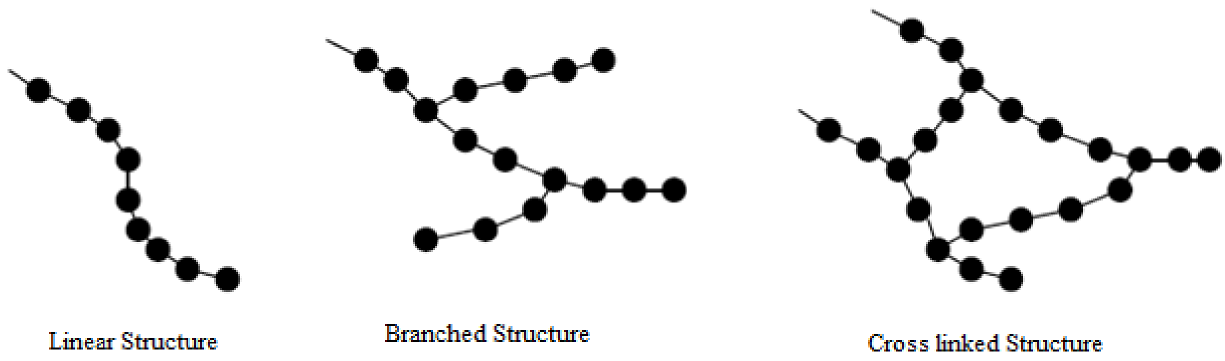

Fig. 1 Structure of polymer material

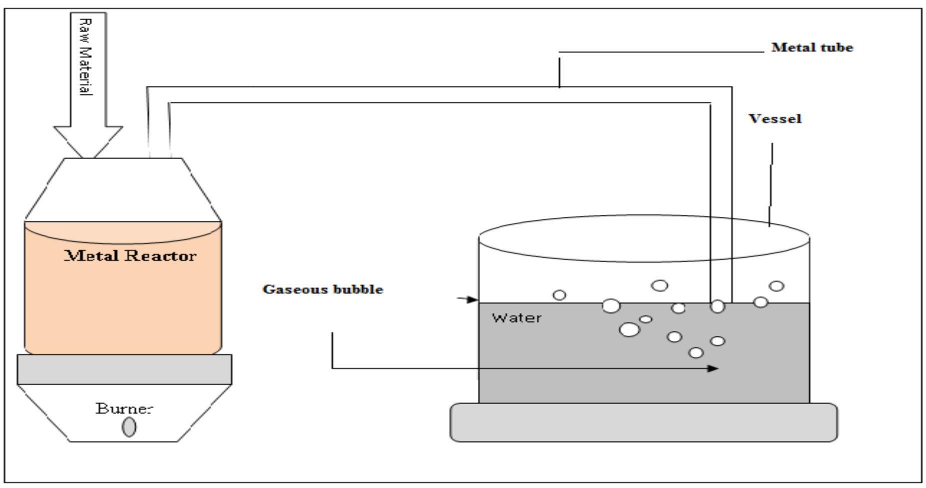

Fig.2 Experimental Setup to collect the plastic product

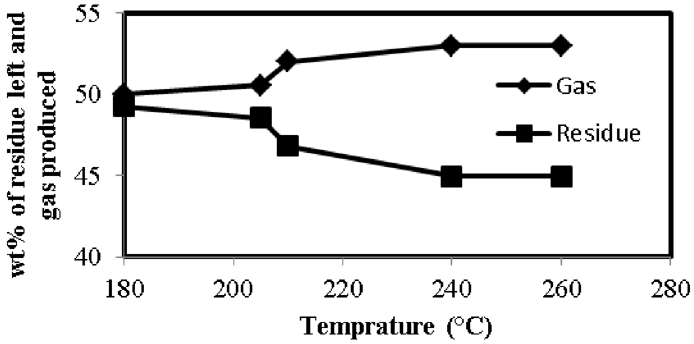

Fig 3: Effect of temperature on the residue left and gas produced for LDPE

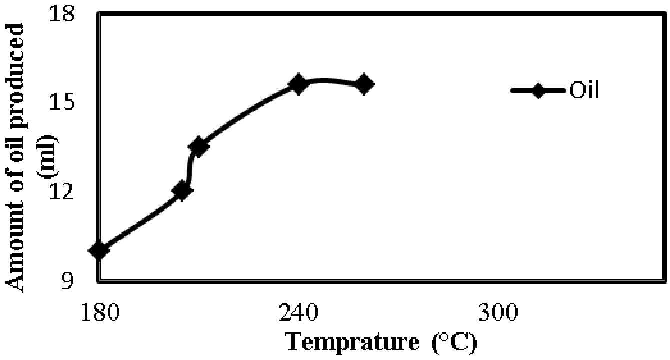

Fig 4: Effect of temperature on the amount of oil produced from LDPE

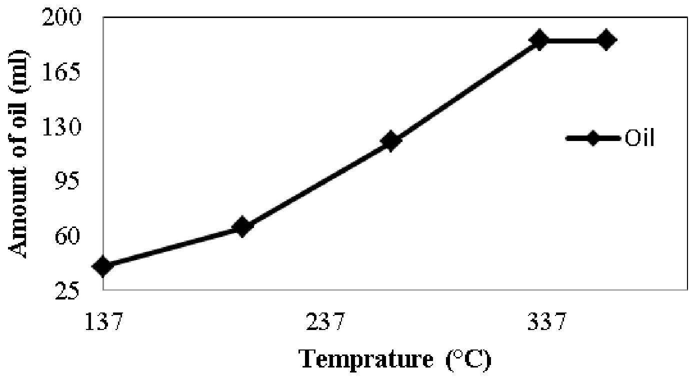

Fig 5: Effect of temperature on the production of crude oil from HDPE

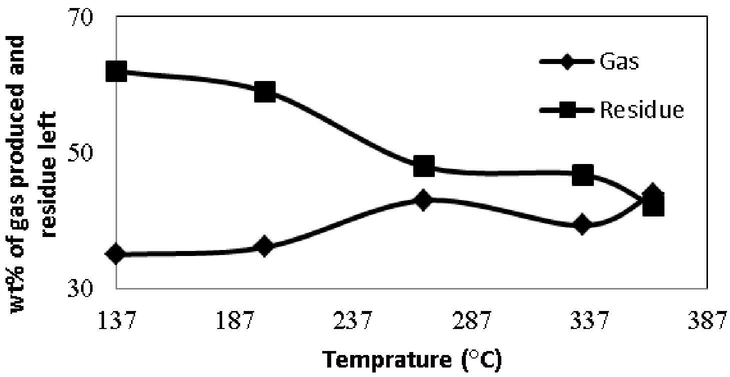

Fig 6: Effect of Temperature on the distribution of residue left and gas produced

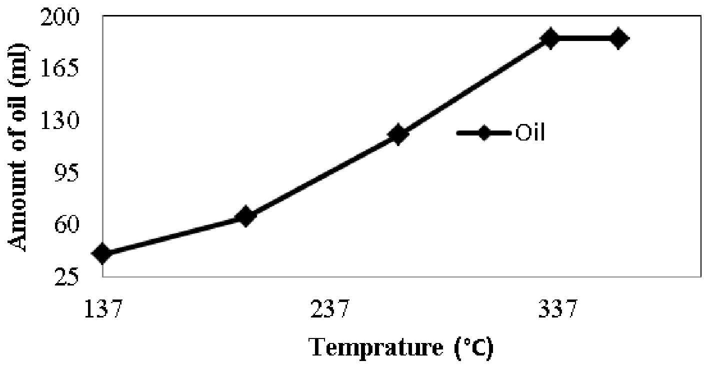

Fig 7: Effect of temperature on fuel oil production from polystyrene

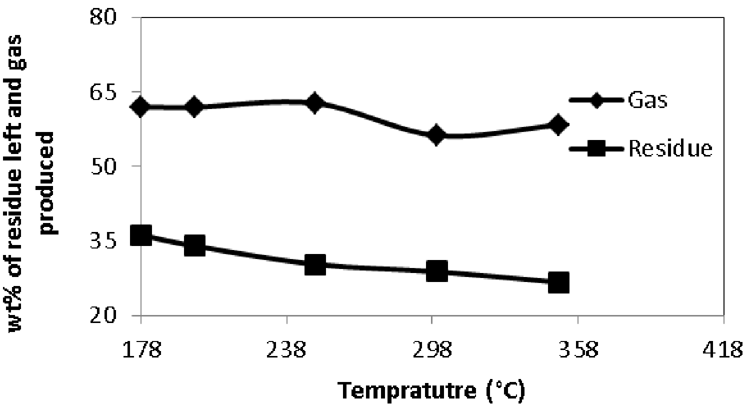

Fig 8: Temperature effect on the residue left and gas produce