A Study on the Pyrolysis Characteristics of Landfilled Plastic Wastes

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Abstract—Pyrolysis of landfilled plastic wastes has been carried out at 350°C under nitrogen. Plastics samples were supplied from the Thanyaburi municipal landfilled area, Pathumthani province. Municipal landfilled waste was separated by density different of plastics. Pyrolysis samples were packaging products comprised of PE, PP and PS. The pyrolysis reactor was design to prevent the radical combination reaction from decomposed oligomers. Pyrolysis products were gas, dark brown liquid and brown solid residue. Analysis of pyrolyzed liquid products showed similar quality to the oil products from pyrolysis of new plastics indicated that they can be used as fuel for agricultural machines such as lawn mowers, tractors, etc.

Keywords—Landfilled plastics waste, packaging plastics, pyrolysis process, hydrocarbon compounds, diesel oil

1. INTRODUCTION

Municipal solid waste (MSW) causes severe environmental problems due to its amount has been increased rapidly every year. Conventional treatments of MSW involve recycle, incineration, and landfill. Recycle of plastics involves many technical difficulties due to different rheological properties of plastics materials. Resins having high melt flow index are suitable for injection molding techniques while those having low melt flow index are more suitable for extrusion blow molding. Moreover, interaction of incompatible polymers results to low mechanical properties of the blends.

Incineration is easy and effective but needs high technology to protect the subsequence pollution generated from various kinds of waste. Landfill is the most popular method for waste treatment, but the limitation of land to be buried makes them less important in recent years.

MSW comprised of *ca.* 15 percent of plastics materials. In Thailand, plastic wastes comprised mainly of packaging materials made from polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), and polyvinyl chloride (PVC). These plastics are not degraded under environmental conditions.

Plastics are generally high calorific value products ranging approximately from 18,000 to 38,000 kcal/kg [1]. The utilization of waste plastics for energy is an alternative option for waste treatment. Plastic waste from landfilled waste cannot be used for recycle due to partial degradation and impurities. Pyrolysis may convert them to small molecular weight hydrocarbon, which may be utilized as fuel.

Pyrolysis is classified into low, medium and high temperature based on the range of the temperature used to decompose the plastic structure [2]. Temperature ranges less than or equal to 600°C, 600-800°C and greater than 800°C are used to define the pyrolysis states [3]. The products obtained from pyrolysis of plastics depend on the type of plastics, feeding arrangement, residence time, temperatures employed, reactor type and condensation arrangement.

In this study low temperature pyrolysis of landfilled plastic waste comprised of PE, PP and PS were carried out in a newly designed glass reactor to produce gas, oil and wax residues. Liquid product was subjected to analytical methods to compare with pyrolysis products of new plastics and tested with agricultural testing engine.

2. METHODOLOGY

2.1 Materials preparation

Plastic wastes collected from landfill were used in this study. They were washed in a pond and the floating materials comprised of polyethylene (PE), polypropylene (PP) and polystyrene (PS) were shredded into 5-mm size and subjected to pyrolysis. Products from pyrolysis comprised of gas, liquid and residue solid. The liquid products and residues were analyzed compared with standard for biodiesel. The experimental reactor was designed for the decomposed materials to leave the reactor before radical combination reaction and condense in the condenser. The reaction temperature was measure at the upper part of the liquid mixture in the reactor.

2.2 Experimental

Pyrolysis reactions of plastics were carried out at 300-350°C under nitrogen atmosphere for 3 h. Landfilled plastics were pyrolyzed compared with new packaging materials produced from PE, PP and PS. Pyrolysis products contained gas, liquid and wax residue.

2.3 Product analysis

The liquid products from new plastic bags and landfilled wastes were subjected to physical property analysis and compared with the standard for diesel oil.

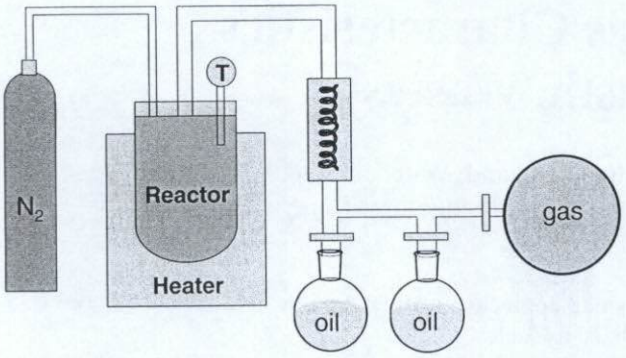

Fig. 1 Experimental apparatus

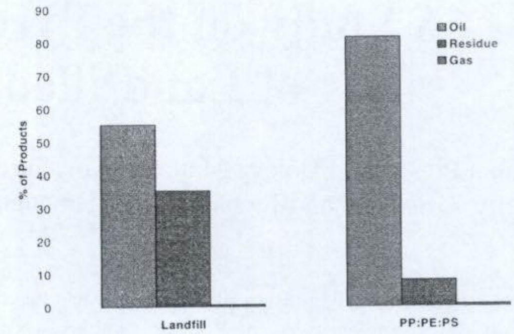

Fig. 2 Percent of products from pyrolysis of landfilled plastic waste and newly produced plastic bags (ratio PE:PP:PS=1:1:0.5).

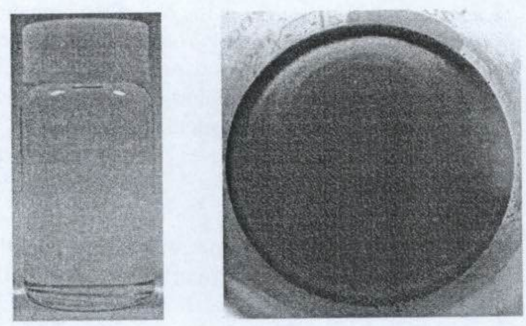

Fig. 3 Oil and residue from pyrolysis of newly produced plastic bags (ratio PE:PP:PS=1:1:0.5).

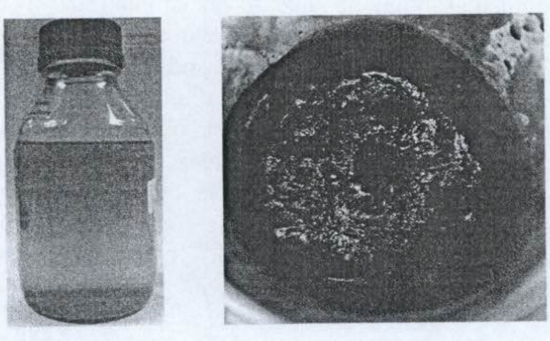

Fig. 4 Oil and residue products of landfilled waste.

3. RESULTS AND DISCUSSION

3.1 Pyrolysis of new plastic packaging materials and landfilled plastic wastes

The pyrolysis results of new plastic packaging materials (PE:PP:PS=1:1:0.5) and landfilled plastic wastes are shown in Table 1, 2 and Fig. 2. It was found that the new plastics produced more liquid products that those of landfilled samples. The amount of gas produced from the landfilled wastes was also found in similar results. This may be due to degradation of plastics to lower molecular weight of the landfilled samples which results in the feasibility to decomposed under the pyrolysis conditions.

Table 1 Products from pyrolysis of landfilled plastic waste and newly produced plastic bags (ratio PE:PP:PS=1:1:0.5).

Sample	Plastics	Sample weight (g)	Products (g)		
			Oil	Gas	Residue
1	plastic waste	50.17	27.74	0.39	17.73
2	PE:PP:PS (1:1:0.5)	125.03	102.3	1.16	10.32

Table 2 Percent of products from pyrolysis of landfilled plastic waste and newly produced plastic bags (ratio PE:PP:PS=1:1:0.5).

Sample	Plastics	Products (% by weight)		
		Oil	Gas	Residue
1	Landfilled plastic waste	55.29	0.78	35.34
2	PE:PP:PS (1:1:0.5)	81.84	0.93	8.25

Liquid products from new plastic bags exhibited clear color liquid than those from landfilled waste as shown in Fig.3 and 4, respectively. However, residues from both samples were dark brown paste.

3.2 Product analysis

The liquid products from new plastic bags and landfilled wastes were subjected to physical property analysis and compared with the standard for diesel oil. The results are shown in Table 3.

Table 3 Physical properties evaluation of liquid products

Physical property	New plastics bags	Landfilled plastics
Flash Point	<11.5	<19
Sulphur Content (% by weight)	0.0009	0.0248
Lead Content (g/L)	0.0085	0.0068
Reid Vapor Pressure (kPa)	7.2	7.8
Copper Strip Corrosions	No. 3a	No. 3a
Calculated Cetane Index	62.0	58.0
Specific Gravity (at 15.6 °C)	0.7771	0.7871

The oil products analysis from Table 3 that the flash point of landfilled wastes and the new bags were less than 19 and 11.5, respectively. They were too much lower than the standard for diesel oil (less than 52). The results indicated that the oil produced from pyrolysis should be modified prior to use as fuel since the low flash point oil will have much effect to engine. The Sulphur content, Lead content, Reid vapor pressure and calculated Cetane Index are in the range acceptable for diesel fuel. However, the oil from plastic pyrolysis exhibited high Copper strip corrosions. The Specific Gravity of the product liquid also lower that those of the standard diesel oil.

4. CONCLUSION

Pyrolysis of newly produced plastic bags of ratio PE:PP:PS=1:1:0.5 and the landfilled plastic wastes were pyrolyzed under nitrogen at 300-350^oC for 2 h. The pyrolysis reactor was design to prevent the radical combination. Pyrolysis of landfilled plastics exhibited more gas and liquid than the new polymers. Analysis of pyrolyzed products compared with standard diesel fuel indicated that modification of product oil prior to utilization as fuel is necessary. Fuel bleaching led to significant reduction of color.

5. ACKNOWLEDGMENTS

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