PRODUCTION OF FUEL BY LOW TEMPERATURE PYROLYSIS FROM WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT PLASTICS

A. Asueta, I. Robertson, M. Arieta-Araunabeña, D. Iribarnegaray, I. Acillona, S. Arnaiz

GAIKER Technology Centre, Parque Tecnológico, Edificio 202, 48170 Zamudio, Spain
e-mail: asueta@gaiker.es

Abstract

The huge increase in the generation of post-consumer plastic wastes has produced a growing interest about eco-efficient strategies and technologies for their appropriate management and recycling. In response to this, PROQUIPOL Project is working on developing, optimizing and adapting feedstock recycling technologies as an alternative of management for the treatment of complex plastic wastes. Among the different plastic wastes studied, the aim of PROQUIPOL Project is to provide a suitable treatment to a plastic fraction from commercial waste electrical and electronic equipment (WEEE) authorized treatment facility by pyrolysis. The collected residue is formed by a complex plastic mixture (ABS, PS, PP…) with the presence of metals. Initially, the composition of selected residues was determined using different analytical techniques. Pyrolysis test have been carried out using reference samples and the selected waste stream to study the distribution of liquid, solid and gas products. Pyrolysis liquids were analyzed with GC/MS and High Heating Value (HHV) test. Reasonably results, in terms of yield and composition of the liquid fraction, were obtained. The obtained pyrolysis liquids have a potential use fuel-like applications or as chemical source, the metal content may be recycled and the gas fraction can be use to cover the energy demand of the process.

Keywords: *pyrolysis, WEEE plastics, polyolefins, styrenics, feedstock recycling*

1. Introduction

The large increase in the generation of plastic wastes, due to the great success of these materials for numerous daily applications, has caused a growing interest about eco-efficient strategies for its appropriate management. The global concern on the compliance for the principles of Sustainable Development imposes severely penalty on traditional waste management procedures based on disposal and destruction by incineration without any resource recovery.

The European Commission WEEE Directive promotes the collection and recycling of such waste streams, proposing collection taxes in function of the amount of electrical and electronic equipment (EEE) for each member states. The aim is to increase the amount of WEEE that is appropriately treated and to reduce the volume that goes to disposal [1]. Once the WEEE is treated in an authorized facility, various complex rejected fractions formed by a dirty mixture of several types of plastics (ABS, PS, PP…) and metals are produced. Taking into account the cost and difficulty of these rejected streams separation, and the incompatibility between the different types of polymers when mixed for mechanical recycling, currently the only economically feasible management option is the incineration or landfill [2]. In accordance with this, PROQUIPOL project is assessing the pyrolysis process as an alternative of management for these non-mechanically recoverable WEEE plastics streams, with the aim of transform the waste into products suitable to be used as fuel or in petrochemical feedstock.

Pyrolysis is a promising process that can potentially be used to transform complex plastic waste streams to more valuable products [3]. Only a few studies have been carried out about the pyrolysis of real WEEE, and the interactions between components of different nature.

2. Materials and Methods

2.1. Materials

The waste stream aim of this study is a plastic fraction from a commercial WEEE authorized treatment facility. The waste is a mixture formed mainly by plastics, above 91%, metals (5.3%), wood (2.1%) and other solids (see Figure 1). In plastic fraction, the styrenics and polyolefins are the predominant polymers (57.4% and 22.9% respectively) while the rest of fractions correspond to rubbers, films, thermosets and others (see Figure 1).

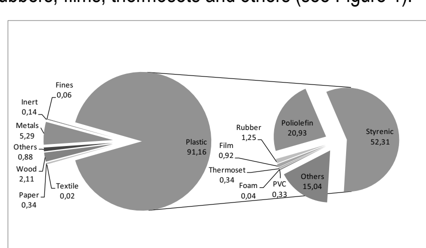

Figure 1. Type of materials and polymers present in the WEEE

Also virgin polymers of PP, HDPE, ABS and PS were used in the pyrolysis test, as reference materials to study the interactions between them.

2.2. Pyrolysis process

The pyrolysis lab-scale experiments were carried out in a 0.5 L stainless steel fixed bed batch reactor. Low temperature pyrolysis is aimed at the production of liquid fractions. Previous studies carried out by the authors indicated that 430°C and 1 h are adequate operation conditions for treating polymeric wastes by pyrolysis.
In a typical run 50 g of the material to be tested are placed into the reactor and sealed, then nitrogen is passed and the system is heated to the operation temperature, 430°C, and maintained there during 60 min. The WEEE particle size was reduced from 5-15 mm to feed in the reaction system.

3. Results and Discussion

3.1 Characteristics of the pyrolysed WEEE sample

For the moment, the selected WEEE stream is a polymer rich e-waste without a clear recycling strategy. The sample was provided by a Spanish WEEE recycling facility, mainly centred in the recovery of metals. Table 1 shows the elemental composition of the pyrolysed sample.

Figure 2. WEEE sample

Table 1. Elemental composition of WEEE

Elemental analysis (wt.%)	
C	35.0
H	7.9
N	1.5
S	<0.02
O	3
Cl	1.36
Br	0.71
F	<0.025
Ash	16.2

Complementary physico-chemical parameters were determined: High heating value (HHV) 33.6 MJ/kg, bulk density 496 kg/m^3 and the metal content analysis indicated the presence of Al, Cu, Ca and Sb.

3.2 Pyrolysis experiments

The liquid, solid, and gas yields wt% obtained in the pyrolysis experiments are presented in Table 2. The liquid and solid yields were determined by weighting the amount of each obtained, while the gas yield was determined by difference.

Table 2. Pyrolysis liquid, solid and gas yields (wt%)

Material	Polymer's nature	Liquid yield, %	Solid yield, %	Gas yield, %
PP		81.0	0.0	19.0
HDPE	Polyolefins	78.9	0.0	21.1
50%PP+50%PE		80.0	0.0	20.0
PS		85.2	0.1	14.7
60%ABS+40%SB	Styrenics	50.4	20.7	28.9
40%ABS+60%SB		59.8	17.1	23.1
WEEE waste	Mixture	44.3	37.3	18.5

Table 2 shows high liquid yields in the case of polyolefins materials, while for the styrenics the liquid yield decreases more with ABS addition; as a consequent the formation of solid product (*char*) increases. Taking into account the ash content of the WEEE waste, it organic content is 83.8 wt%, so the real liquid yield is similar to the obtained for the pyrolysed styrenic mixtures.

3.3 Pyrolysis liquids analysis

The characterization of pyrolysis liquids was made by the study of the HHV and GC/MS analysis. Figure 3 shows the HHV results. The HHV of all the liquids is above the HHV of a common fuel oil of refinery (42.6 MJ/kg).

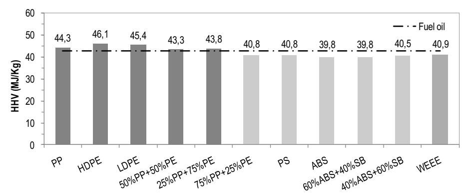

Figure 3. HHV comparison between obtained pyrolysis products and reference fuels

In addition, GC/MS was applied to characterise the reaction liquid products by determining their composition and distribution of hydrocarbons. The liquid products are complex mixtures of organic compounds. Liquids derived from polyolefins content mainly linear hydrocarbons, while liquids derived from styrenics content aromatic ones. Compared with the results after processing WEEE sample it is observed that the composition of liquid products is related with the main polymer contained in the waste.

4. Conclusions

The results have shown that the pyrolysis process is an attractive recycling alternative for waste complex plastic mixtures recovering liquid products and liberating valuable solids like metals.

References

[1] Directive 2002/96/EC, on waste electrical and electronic equipment (WEEE), *OJ* L 37, 13.2.2003
[2] W.J. Hall, P.T. Williams, Analysis of products from pyrolysis of plastics recovered from the commercial scale recycling of waste electrical and electronic equipment, *J. Anal. Appl. Pyrolysis,* 79 (2007) 375-386
[3] N. Miskolczi, A. Angyal, L. Bartha, I. Valkai, Fuels by pyrolysis of waste plastics from agricultural and packaging sectors in a pilot scale reactor, *Fuel Processing Technology* 90 (2009) 1032-1040

Acknowledgments

The authors wish to acknowledge the confidence and economic support of the Spanish Ministry of Education and Science to this work by financing the PROQUIPOL Project “Reference PID-560620-2009-4” and the courtesy of INDUMETAL RECYCLING, S.A. for providing the WEEE plastics samples used in this study.