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## Reduction of Bromine Compounds in the Pyrolysis Oil of Computer Casing Plastics Using Shell, $\text{Ca}(\text{OH})_2$ and $\text{NaOH}$

Z. Z. Hlaing<sup>a,\*</sup>, T. Wajima<sup>a</sup>, S. Uchiyama<sup>b</sup> and H. Nakagome<sup>a</sup>

<sup>a</sup>Graduate School of Engineering, Chiba University, 1-33, Yayoi, Inage, Chiba, 236-8522, Japan

<sup>b</sup>National Institute of Public Health, 2-3-6, Minami, Wako city, Saitama, 351-0197, Japan

### Abstract

The acrylonitrile butadiene styrene “ABS” resin is used in a variety of exterior and chassis electrical products, it have been contained brominated flame retardants to prevent fire accidents. If the resin (ABS) was thermally decomposed, the bromine compound was mixed in the pyrolysis oil. In this work, the fraction of acrylonitrile butadiene styrene “ABS” containing brominated flame retardants was pyrolyzed by using a reflux-condenser apparatus installation at 450°C. And we used additives of sodium hydroxide “NaOH”, calcium hydroxide “ $\text{Ca}(\text{OH})_2$ ” and scallop shell. The total bromine compounds in product oil could be reduced from 296 mg/L to 27 mg/L by NaOH.

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### 1. Introduction

The management and treatment of waste electrical and electronic equipment (WEEE), of which about 50 million tons are annually generated worldwide, is becoming a major concern [1]. The production of WEEE, such as TV housings, computer casings, refrigerator casings and washing machines, consequently results in environmental problems due to the use of harmful materials (e.g. plastic additives, metals). According to the WEEE EU directive, the fraction of major plastics associated with WEEE demands their recovery [2]. WEEE mainly consists of metals and plastic materials. The plastic fraction includes high impact polystyrene (HIPS)

\* Corresponding author. Tel.: +81-43-290-3466; fax: +81-43-290-3466.

E-mail address: [zarzarhlaing.mm@graduate.chiba-u.jp](mailto:zarzarhlaing.mm@graduate.chiba-u.jp).

and acrylonitrile-butadiene-styrene copolymer (ABS), and more than half of computer housings are made of HIPS, with the next biggest fraction being ABS [3]. Various pyrolysis processes have been tested for processing plastics which contain brominated flame retardants (BFRs) including fluidized bed pyrolysis [4], two-stage pyrolysis [5], long residence time pyrolysis [6], and pyrolysis in the presence of iron and calcium based catalysts [7]. Recently, William et al. [8] reported that the removal of bromine content of Br-ABS by using zeolite ZSM-5 and zeolite Y-Zeolite was carried out in a fixed bed reactor at 440°C. The concentration of bromine in oil was 2.7 wt% without zeolites, and the contents of bromine in oil contained 2.6 wt% with zeolites. Joo-Sik Kim et al. [9] also reported that the removal of bromine content of HIPS by using various Ca-based additives (CaO, Ca(OH)<sub>2</sub>, Oyster Shell) was carried out in a bench-scale system equipped with a fluidized bed reactor at 460°C. It was found that the concentration of bromine in oil was 5 wt% without catalyst, and the contents of bromine in oil contained 1.6, 1.3, and 2.7 wt% with various Ca-based additives. The present study, Br-ABS are pyrolyzed with or without NaOH, Ca(OH)<sub>2</sub> and scallop shell using a reflux-condenser at 450°C. It is demonstrated that using a reflux-condenser in combination with additives are expected for reducing to trace amounts of bromine compound in product oil.

## 2. Experimental

### 2.1. Materials

Brominated flame retardant of acrylonitrile-butadiene-styrene resin (ABS) used in this study was obtained from Asahi Kasei Chemicals Co. Ltd. (Tokyo, Japan). Raw material contains ABS 65%, flame retardant 30% and others 5%. The elemental composition of ABS was shown in Table 1. The additives of NaOH and Ca(OH)<sub>2</sub> were obtained from Wako Pure Chemical Industries, Ltd. The shell powder was used scallop shell.

Table 1. Elemental analysis of raw material Br-ABS used in this study.

Elemental composition (wt. %)						
Carbon	Hydrogen	Nitrogen	Oxygen	Bromine	Antimony	Chlorine
71.9	6.6	3.9	2.4	10.7	3.5	1.0

### 2.2. Experimental Apparatus and procedure

The experimental apparatus used in this study was shown in Figure 1. The glass reactor (length: 130 mm; i.d. 50 mm) and the glass reflux condenser (length: 350 mm; i.d. 12 mm) were used. The pyrolysis of Br-ABS plastic was performed in a glass reactor under atmospheric pressure in nitrogen gas with a reflux condenser. Approximately, 60 g of Br-ABS were added into the reactor for thermal decomposition. The additives are used to select the amount of each most effective additives (3 g of NaOH, 12 g of Ca(OH)<sub>2</sub> and 12 g of shell). In a typical run, the reactor was purged with nitrogen gas at a flow rate of 50 mL/min and held for 60 min to remove oxygen from the reactor. After nitrogen substitution, nitrogen gas flow stopped and the pyrolysis experiment was performed. The temperature of the plastic bed was measured as the decomposition temperature, and the reactor temperature was increased to the decomposition temperature (450°C) at a heating rate of 5°C/min and held for 30 min. During the experiment, the reflux-condenser (200°C) was heated to the desired temperature. A portion of the hydrocarbon gases condense in reflux condenser and falls back into the reactor. The uncondensed fractions passed through the reflux-condenser, and product oil is collected with cold water condensers. Moreover, the non-condensable gases, which pass through cold water condenser, were collected in an aluminum bag via bubbling in the alkaline water solution. After pyrolysis, the residue was

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