# Effect of polyolefins in pyrolysis of brominated high impact polystyrene

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## 1. Introduction

High impact polystyrene (HIPS) is the most widely used of thermoplastic especially for electronic application. Brominated additives such as polybrominated diphenyl ethers (PBDEs) are used in HIPS to reduce the flammability. The evidence appeared that some PBDEs were persistent organic pollutan in a decade of their introduction [1]. Recycling of bromine containing plastics by pyrolysis has more advantage than incineration process, as the volume of harmful gas produced is much lower. Many research have been conducted on pyrolysis of bromine containing plastics [2-3]. However, there is no work investigating the effect of polyolefins on pyrolysis of brominated high impact polystyrene (HIPS-Br) in presence of antimony trioxide. In this present study, we carried out the effect of polyethylene and polypropylene on pyrolysis of HIPS-Br.

## 2. Experimental

### A. Materials

High density polyethylene (PE) was obtained from Mitsui Chemical Co. Ltd., Japan; polypropylene (PP) was obtained from Ube Chemical Industries Co. Ltd., Japan. HIPS-Br containing decabromo diphenyl ether (DDO) flame retardant with $Sb_2O_3$ 5 wt% [DDO-Sb(5)] and without $Sb_2O_3$ [DDO-Sb(0)] was commercially available.

### B. Pyrolysis procedure

Pyrolysis of HIPS-Br samples with DDO type of flame retardants mixed with PE or PP were performed in a glass reactor under atmospheric pressure by batch operation. Briefly, 10 g of plastics [weight ratio (HIPS-Br/PE or PP = 8/2)] were loaded into the reactor and the temperature program was as follows; from ambient temperature to 120 $^{o}$C with heating rate of 5 $^{o}$C/min and hold for 1 hour to remove any moisture with $N_2$ carrier gas flow of 30 mL/min to 430 $^{o}$C at a rate of 5 $^{o}$C/min and hold at 430 $^{o}$C till the end of the experiment. The vapor products were condensed to liquid products using a cold water condenser and trapped in a measuring cylinder. The hydrogen bromide evolved during pyrolysis was trapped in a flask containing ion-exchanged water. The hydrocarbon gas products were trapped in the teflon bag and analyzed at the end of the pyrolysis experiment.

### C. Analysis of pyrolysis products

The hydrocarbon gas products were analyzed by gas chromatograph equipped with TCD. The liquids were analyzed by GC equipped with FID, MSD and ECD.

## 3. Results and discussions

The pyrolysis products were classified as liquid, gas and residue. The mass balance of the pyrolysis products and the properties of the pyrolysis liquid are given in Table 1. The majority of the pyrolysis products from the pyrolysis of mixture of HIPS-Br with PE and PP were liquid in the range of 77-80 wt%. Many of the aliphatic products from polyolefins are masked by the aromatic products of HIPS-Br pyrolysis. When mixtures of HIPS-Br with PE and PP were pyrolysed, the presence of $Sb_2O_3$ led to the absence of styrene and alpha-methylstyrene in the liquid. Analysis liquid by GC-ECD shown that either PE or PP shown that the presence of $Sb_2O_3$ led to the formation of a large number of brominated compounds but the absence of $Sb_2O_3$ led to an even greater number of heavier brominated compounds. The detailed investigation results of polyolefins effect on pyrolysis of brominated high impact polystyrene will be discussed during the conference and can be found elsewhere [4].

Table 1

Material balance from pyrolysis of polyolefins andHIPS-Br

| Sample plastics (10 g) | Yield of degradation products (wt%) | | | Liquid properties | |
|---|---|---|---|---|---|
| | Liquid (L) | Gas (G) | Residue (R) | Cnp | Density (g/mL) |
| DDO-Sb(5) | 78.9 | 5.1 | 16 | 14.3 | 1.07 |
| DDO-Sb(0) | 77.3 | 10.8 | 11.9 | 15.9 | 0.95 |
| PE/DDO-Sb(5) | 77.6 | 8.5 | 13.9 | 14.2 | 1.01 |
| PE/DDO-Sb(0) | 77.4 | 13.2 | 9.4 | 14 | 0.93 |
| PP/DDO-Sb(5) | 80.2 | 8.2 | 11.6 | 14.1 | 0.98 |
| PP/DDO-Sb(0) | 81.4 | 9.6 | 9 | 14.3 | 0.91 |

## 4. Conclusions

The presence of PE on pyrolysis of HIPS-Br showed that there are differences in the yield and composition of pyrolysis products. In case of PP, the interaction occurred between HIPS-Br and PP was found in the materials mass balance which showed differences from pyrolysis of HIPS-Br. Antimony trioxide has shown the absence of styrene and alpha-methyl styrene in liquid products from pyrolysis of PE and PP with HIPS-Br.

## 5. References


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