Instructions for abstract preparation for the HERAKLION 2019 Conference

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Abstract

Single step and two-step pyrolysis of waste computer casing plastic were conducted to optimize product distribution and characteristics of liquids separately. The single step pyrolysis was performed under different final temperatures from 350 to 600 °C. The two-step pyrolysis proceeded by initially increasing temperatures to 350~380 °C and keeping for 15 min, then reached the final temperatures at 500 °C. For the single step pyrolysis, the final pyrolysis temperature showed great influence on pyrolysis yield. The highest yield of 45.3 wt% oil was obtained at 500 °C. The produced oils mainly consisted of aromatic compounds, phenolic compounds and nitrogen-containing compounds. Meanwhile, approximately 11.3-15.9 wt% of bromine was detected in the oils. For the two-step pyrolysis, the impurities of O-, N- and Br-containing compounds were enriched in the pyrolytic oils from the first step (step 1 oil). Comparatively, more than 57 % of single aromatic compounds was obtained in the pyrolytic oils from the second step (step 2 oil), especially for the high content of styrene. The bromine content in the step 2 oils was less than 2.0 wt%. The intense interactions between the brominated flame retardant additives and the plastic matrix were also found to occur at 350-400 °C. The results suggested through two stage pyrolysis, most bromine can be transferred into liquid phase at low temperature stage, thus producing bromine containing compounds deficient oil.

Results

The product distribution from the two-step pyrolysis of computer casing plastic is shown in Table 1. It can be seen that the total amount of two step oils was lower than that in the single step pyrolysis at 500 °C, while the gas yields increased to 13.6-14.0 wt% for the two-step pyrolysis. Also, when the first step temperature increased from 350 to 380 °C, the yield of step 1 oil increased from 10.3 wt% to 16.8 wt% accordingly, but accompanied by a slight decrease of the step 2 oil. This indicated the intense effect of first pyrolysis stage on the oil and gas formation. Especially, the maximum yield of 38.7 wt% wax was also obtained at 350 °C, at which temperature the intense decomposition of BFR additives occurred. As mentioned previously, the released Br from BFR additives decomposition at low temperatures promoted the H-abstraction and cyclization reactions of vapor products, resulting in the formation of condensed products

Table 1 Product yield from the pyrolysis of computer casing plastic under different heating conditions

		Product Yields (wt%)				
	Run #		Oil	Wax	Solid	Gas
Single step pyrolysis	Run-1		14.0±0.8	24.4±1.3	58.8±1.7	2.8±0.9
	Run-2		31.2±1.1	39.1±1.1	22.9±1.1	6.8±0.7
	Run-3		38.5±0.9	38.5±0.9	15.7±0.8	7.3±0.7
	Run-4		45.3±0.9	31.3±0.8	14.1±0.5	9.3±0.5
	Run-5		44.8±0.8	31.3±0.9	13.2±0.7	10.7±0.6
		Step1 oil	Step 2 oil	Wax	Solid	Gas
Two-step pyrolysis	Run-6	10.3±0.8	22.0±0.8	38.7±1.2	15.4±0.7	13.6±0.5
	Run-7	12.5±1.0	19.9±1.1	37.2±0.9	16.6±0.8	13.8±0.7
	Run-8	14.6±0.9	20.0±0.9	35.1±0.8	16.5±0.6	13.8±0.6
	Run-9	16.8±0.7	19.5±0.8	33.3±0.9	16.5±0.5	14.0±0.7

From Table 2, it can be seen that most bromine existed in liquid products. For the single step pyrolysis, although the decomposition of the plastic matrix was incomplete at 350 °C, more than 25 % and 55 % of bromine were transferred into oil and wax, respectively. However, 15.9 % of bromine was remained in the solid residues. This suggested that the intense degradation of BFR additives ~~at the first stage~~ could not ~~complete the release of~~release all brominated products from the plastic matrix, which might be partly encased in the molten plastic matrix or reacted with the plastic matrix. At 500 °C, only 0.8 % of bromine was remained in the solid residues, which meant that ~~The increasing~~~~H~~higher temperature favored the degradation of ~~the~~plastic matrix and the release of brominated products, transferring most of ~~the~~ bromine in the wax and ~~char~~ solid residues ~~being transferred~~ into oils. However, regardless of the final pyrolysis temperature, nearly 11.3-15.9 wt% of bromine was found in oils from the single step pyrolysis.

Table 2 Bromine distribution in pyrolysis products from the pyrolysis of computer casing plastics under different conditions

		Bromine distribution (%)				
	Run #		Oil	Wax	Solid	Gas
Single step pyrolysis	Run-1		25.1±0.8	55.1±1.7	15.9±1.0	0.1±0.1
	Run-2		42.5±1.1	50.4±1.5	1.8±0.2	0.1±0.1
	Run-3		51.9±1.2	38.5±1.2	0.8±0.1	0.1±0.0
	Run-4		58.2±0.9	36.4±1.3	0.6±0.2	0.1±0.0
	Run-5		61.3±1.0	34.2±1.0	0.6±0.1	0.1±0.0
		Step 1 oil	Step 2 oil	Wax	Solid	Gas
Two-step pyrolysis	Run-6	32.4±1.0	6.3±0.5	54.5±1.5	1.2±0.3	0±0.0
	Run-7	37.9±1.1	4.9±0.4	52.4±1.6	1.6±0.2	0±0.1
	Run-8	38.7±1.2	4.7±0.6	52.7±1.7	1.5±0.2	0±0.0
	Run-9	39.0±1.2	4.4±0.5	52.6±1.5	2.0±0.1	0±0.0

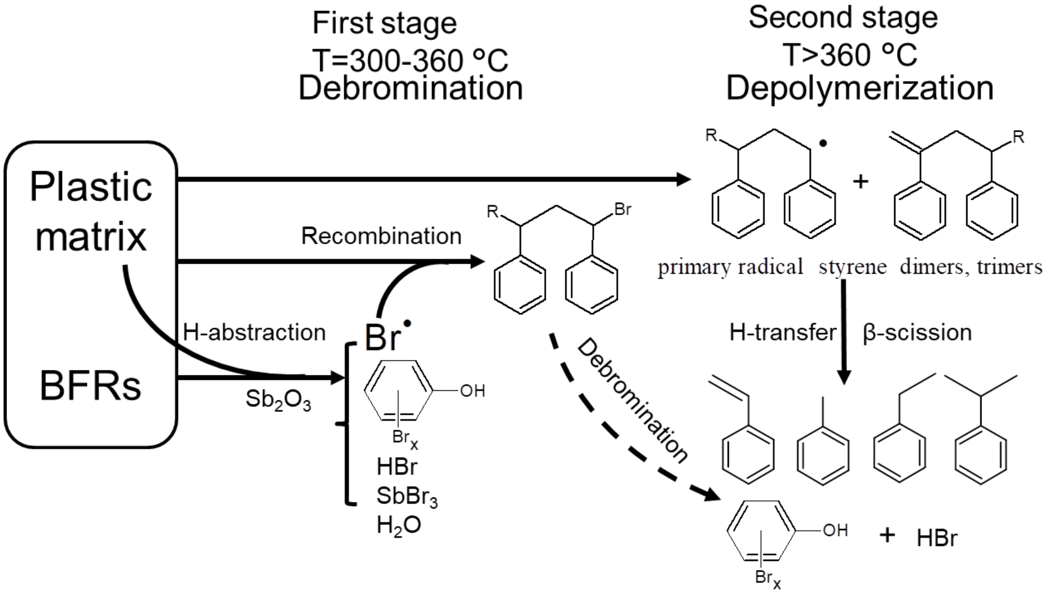

Figure 1 Possible degradation scheme of BFR-plastic

The single step pyrolysis of the plastics produced a variety of aromatic compounds, phenolic compounds, N-containing and Br-containing compounds. However, the produced brominated compounds from the decomposition of BFR additives at the first stage could not completely be released . This suggested that the interactions of BFR additives and plastic matrix could also encase some of brominated compounds in the plastic matrix. The two-step pyrolysis of the plastics showed that most impurities of O-, N- and Br-containing compounds were transferred into step 1 oils at the first stage temperature from 350 to 380 °C, whereas there were small amounts of phenolic compounds and Br-containing compounds in step 2 oils. Apart from the degradation acceleration of plastic matrix promoted by the decomposition of BFR additives, the inhibition effect of the release of BFR additives was achieved by the undecomposed plastic matrix at low temperatures. Meanwhile, the two-step pyrolysis promoted the depolymerization of plastic matrix for the formation of monomeric compounds due to the intense decomposition of BFR additives. The possible degradation scheme of BFR-plastic is proposed in Fig. 1.