Brominated Flame Retardants in Recycled Plastic Products

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Introduction

The demand for polybrominated diphenyl ethers (PBDEs) have decreased in the past few years. For example domestic demand for decabromodiphenylether (DeBDEther) in Japan has decreased from 10,000 ton in 1990 to 2,200 ton in 2003. From the viewpoint of the lifecycle risk management of PBDE products (Sakai et al. 2005), the use and disposal/recycling stage become relatively more important than the production stage. As to the disposal/recycling stage of PBDE products, Miyanaga and Motegi 2004 suggested that waste TV casings were recycled as raw materials for video cassette tape. They performed an elemental analysis on four video cassette tapes and detected bromine in two samples and antimony in one samples. However the types of brominated flame retardants were not determined in their study.

In this study, we measured the concentrations of brominated flame retardants in plastic parts from video cassette tapes to examine the possibility of material recycling of PBDE products.

Materials and Methods

Five video cassette tapes (VHS) were purchased at a discount store and an electrical store in Japan. The video cassette tapes were made in Korea, China or Japan. Several plastic parts (tape cover, upper half, upper half window and bottom half) were collected from each video cassette case (Table 1).

The target substances in samples were extracted by dissolution/precipitation method. The crude extracts were cleaned up by using multilayer silica gel column chromatography for PBDE analysis (followed by additional activated carbon chromatography for PBDD/DF analysis). For analyzing TBBPA, the crude extracts were derivatized (ethylated) and cleaned up by florisil column chromatography. The final extracts were concentrated and analyzed for PBDEs, TBBP-A, HBCD and PBDDs/DFs by HRGC/HRMS.

Table 1 Concentrations of brominated flame retardants in plastic parts of video cassette tapes.

ID	Country	Parts	Colour	PBDEs (mg/kg)	TBBP-A (mg/kg)	HBCD (mg/kg)	DeBDEthane (mg/kg)	T-Br (mg/kg)	Sb (mg/kg)
1c	Korea	Tape cover	Black	1300	46	1.6	260	1600	780
1u	Korea	Upper half	Black	1000	47	13	83	1200	500
2c	China	Tape cover	Black	2400	280	30	190	2500	1100
2u	China	Upper half	Black	5200	380	20	220	4500	2000
3c	Japan	Tape cover	Black	0.54	0.003	<0.03	<0.07	<10	<10
3u	Japan	Upper half	Black	170	24	27	64	120	150
4c	Korea	Tape cover	Black	1600	34	1.1	N.A.	1500	650
4b	Korea	Bottom half	Black	6	0.3	<0.03	N.A.	<100	2
5c	China	Tape cover	Black	6700	340	15	N.A.	4400	1700
5u	China	Upper half	Black	4600	250	13	N.A.	3100	1000
5w	China	Upper half window	Transparent	<0.05	0.0011	<0.03	N.A.	N.A.	N.A.
5c	Korea	Tape cover	Black	1000	9.5	0.31	N.A.	610	270
5b	Korea	Bottom half	Black	590	22	17	N.A.	370	220

N.A.: Not Analyzed DeBDEthane: Decabromodiphenylethane

Results and Discussion

The concentrations of brominated flame retardants in the plastic parts samples are presented in Table 1. Brominated flame retardants were detected in most of the video cassette samples. Among the four brominated flame retardants (PBDEs, TBBP-A, HBCD and DeBDethane), the concentration of PBDEs was the highest and HBCD was the lowest. DeBDE dominated the pattern of PBDEs in all samples (Figure 1). The concentrations of PBDEs ranged from <0.05 mg/kg to 6700 mg/kg (average 2000 mg/kg = 0.2%). These concentrations were lower than those of the plastics to which DBDEs were intentionally added (10%).

These results suggest that the BFRs in the video cassette tape samples were not intentionally added. One possible explanation to the BFRs contamination in the video cassette tapes is the use of recycled plastic compounds. The recycled plastic compounds can be obtained as industrial waste from manufacturing process or post consumer waste from households. In the former case, the plastic waste is “fresh”, while in the latter case, the plastic waste is “old.”

We believe that the plastic waste recycled to the video cassette tape is “old” (post consumer waste). This is supported by Miyanaga and Motegi 2004. They reported that the waste plastics from casing of waste TVs in Japan were exported as raw materials for video cassette tapes.

This idea is also supported by the ratio between DeBDEther and DeBDEthane in the plastic samples.

DeBDEthane is used as an alternative to DeBDEther. The demand for DeBDEthane increased sharply in 1990's while that for DeBDEther decreased drastically in the same period. In 1997, the demand for DeBDEthane surpassed that for DeBDEther. Recent demand for DeBDEthane is more than twice that of DeBDEther (Figure 2). If the BFRs source in the video cassette tape were "fresh" (industrial waste), the DeBDEthane concentrations in video cassette samples would have been higher than the DeBDEther concentrations. However, the actual DeBDEthane concentrations in video cassette samples were 2.7 to 24 times lower than the DeBDEther (Table 1). This ratio is close to the ratio of domestic demands in early 1990's. This suggests that the recycled plastic in the video cassette tapes are "old" (post consumer products such as waste TVs).

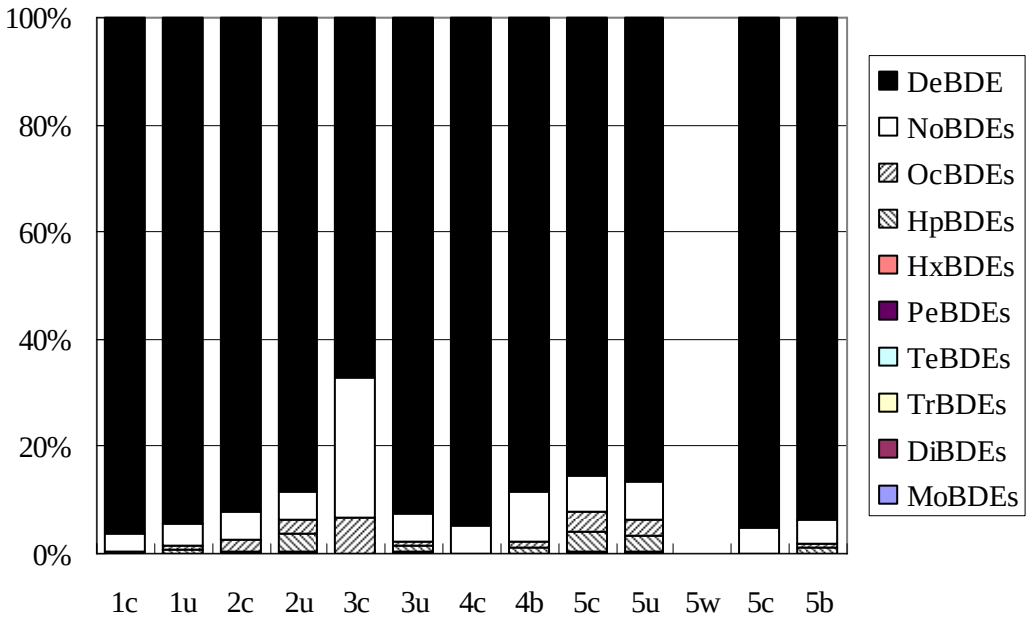

Figure 1 Homologue profile of PBDEs in the plastic parts from video cassette tape.

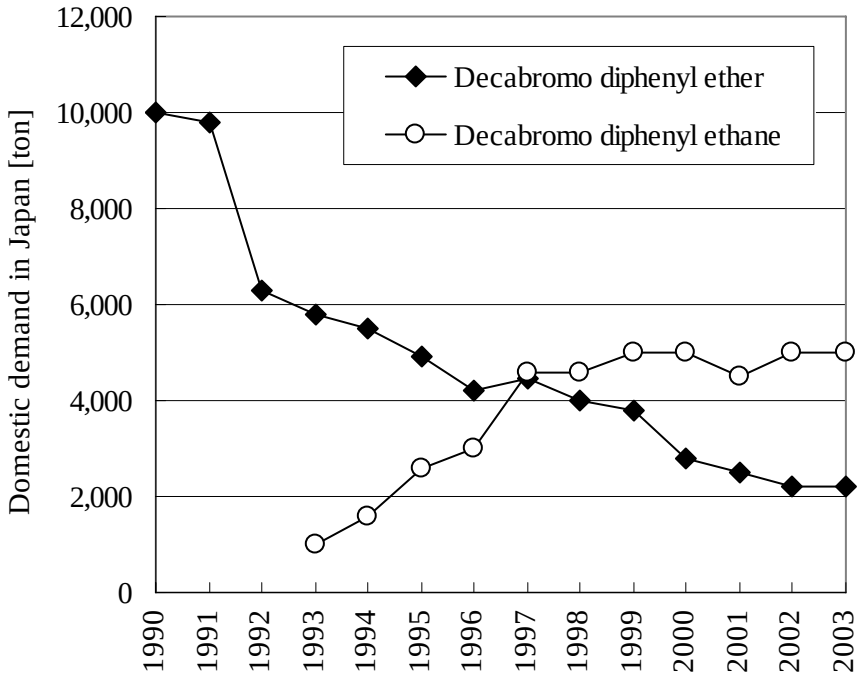

Figure 2 Domestic demand of Decabromo diphenyl ether (DBDE) and Decabromo diphenyl ethane in Japan from 1990 to 2003.

References

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