CONCENTRATION AND CHARACTERISTICS OF POLYBROMINATED DIPHENYL ETHERS IN WEEE OF KOREA

Jong-Eun Park[1*], Sun-Kyoung Shin[2], Woo-Il Kim[2], Young-Yeul Kang[2], Jong-Guk Kim[1]

[1]Environmental Engineering, Chonbuk National University, 664-14, Duckjin-dong, Chonju, 561-756, Republic of Korea; [2]Resource Recirculation Research Division, Environmental Resources Research Department, NIER, Environmental Research Complex, Kyungseo-dong, Seo-Gu, Incheon, 404-170, Republic of Korea

Introduction

Polybrominated Diphenyl Ethers (PBDEs) are used globally as flame retardants. Flame retardants are used to protect the public from accidental fires, by reducing the flammability of combustible materials such as plastic. Commercial PBDE preparations are commonly categorized according to the bromine contents as penta-BDE, octa-BDE and deca-BDE. The penta-BDE is primarily used in polyurethane for application such as carpet padding and furniture upholstery and octa-BDE and deca-BDE are used in hard plastic that electric and electronic equipment such as TV sets. They are highly toxic, persistent; endocrine-disrupting chemicals, with potential for long-range transport. Recently, environmental problems relating to PBDEs have become a matter of great concern. Especially, electronic equipments such as television sets containing PBDEs may be source of emissions of PBDEs into the environment. Other studies shows the BFRs such as PBDEs could be released from products to surrounding environments. Therefore the objectives of this study were to conduct analysis of PBDEs in WEEE (Waste electric and electronic equipment) and compared the pattern with indoor dust and sediments to examine the characteristics.

Material and Methods

For the target components, we chose rear covers, which is constitute a relatively large weight fraction of the plastics of TV. Collected waste TV sets with an identifiable manufacturing year (from 1983 to 1997) were used for analysis.

The samples were grinded to a size of 1.0 mm by the combination of cutting and mills under cooling with liquid nitrogen. After adding the $^{13}C_{12}$-Labeled PBDEs as recovery standard, the samples were dissolved with toluene and sonicate for 1hour. After extraction, the extracted was filtrated and concentrated for GC/MS. The GC conditions used for the PBDEs analysis were: 15 m DB5-HT x 0.25 mm ID x 0.1μm film thickness column and the temperature programmed to 110℃ (held for 2 min) followed by ramp at 40℃/min to 200℃, at 10℃/min to 260℃, at 20℃/min to 340℃ (held for 2 min). The temperatures for the GC injector, GC/MS interface and the MS ion source were 280℃, 300℃, and 250℃, respectively.

Results and Discussion

There are three commercial PBDE products, each composed of congener mixtures. The commercial Penta-BDE product is predominantly a combination of congeners BDE-47, BDE-99 and BDE-100; the commercial Octa-BDE product is predominantly composed of BDE-153 and BDE-183[1)]. The Deca-BDE is almost exclusively BDE-209 congener with minor nona-BDE impurities Deca-BDE[1)] is one of the most widely used PBDE flame retardants in high impact polystyrene (HIPS) which used mainly rear cover. Both Penta-BDE and Octa-BDE commercial formulations have been phased out of electronic items. However, Deca-BDE is still widely used in

diverse electronic products. Table 1 presents the concentrations of PBDEs in rear cover of TV. ∑PBDE concentrations in rear cover of TV (from 1983~1997) were 118,196 ~143,812 mg/kg. Compared to other TV sets made in other countries, the concentration level of the rear covers of American TV sets were verified to be 17,395 mg/kg[2], and Japanese TV sets 36,000 mg/kg, 84,000 mg/kg in 1980s and 1990s respectively[3].

Table 1. Contents of PBDEs in rear cover of TV

	1983-TV	1988-TV	1989-TV	1990-TV	1991-TV	1995-TV	1997-TV
47-TeBDE	ND	ND	ND	ND	ND	ND	ND
66-TeBDE	ND	ND	ND	ND	ND	ND	ND
100-PeBDE	ND	ND	ND	ND	ND	ND	ND
99-PeBDE	ND	ND	ND	ND	ND	ND	ND
85-PeBDE	ND	ND	ND	ND	ND	ND	ND
154-HxBDE	ND	ND	ND	ND	ND	ND	ND
153-HxBDE	ND	ND	12,324	ND	ND	ND	ND
183-HpBDE	ND	ND	ND	ND	ND	ND	ND
209-DeBDE	121,834	142,293	120,128	118,196	143,229	143,812	124,861
total	121,834	142,293	132,452	118,196	143,229	143,812	124,861

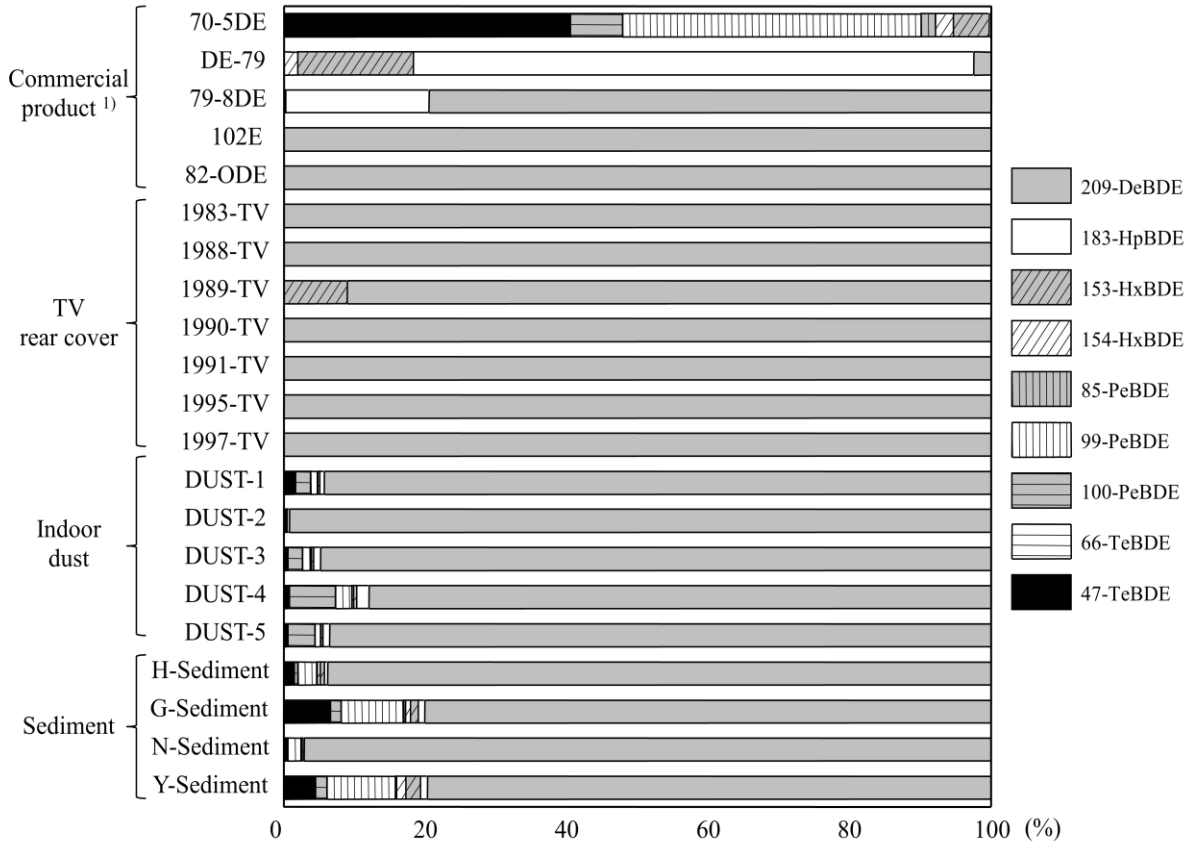

Fig. 1. Percentage contributions of PBDEs

To examine the characteristics of PBDEs of TV rear cover, we compared the pattern of PBDEs in dust collected from indoor and sediments collected from 4 main rivers in Korea. Fig. 1 presents that the pattern of PBDEs in rear cover of TV is similar to those in indoor dust and river sediments of Korea. From the isomer pattern, it was obvious that the PBDE in product affect on surrounding environment. Especially, the finding of relatively high level of 209-DeBDE compared with other PBDEs in indoor dust show that this electric and electronic equipment such as TV is an important indoor contaminant. In addition, The researchers have shown that Deca-BDE rapidly breaks down to lower brominated BDE, more bioavailable and more toxic PBDEs such as 47, 99, 100, 153, 183.[4)] As a result, because PBDEs are not permanently bound to the plastic, they can be released as volatiles or dust.

Acknowledgements
This study was supported by the National Institute of Environmental Research in R.O.K

Reference

1. MARK J. LA GUARDIA , ROBERT C . HALE, ELLEN HARVEY. (2006) *Environ. Sci. Technol*. 40: 6247-6254
2. An Exposure Assessment of Polybrominated Diphenyl Ethers, EPA/600/R-08/086F (2004)
3. Surveys of hazardous chemicals at life-cycle stages of articles/products, Hidetaka takigami (NIES) (2010)
4. Juan Bezares-Cruz, Chadt. Jafvert, Inezhua. (2004) *Environ. Sci. Technol.* 38: 4149-4156