Analytical method of polychlorinated biphenyls(PCBs) in transformer oil

Sun Kyoung Shin[1], HYE-Jin Kim[0], David Chung[0], Kyoung Sim Kim[0], Jin Kyoung Kim [0], Young Hee Chung[0], Il Rok Chung[0]

[1]National Institute of Environmental Research, Incheon

Introduction

Polychlorinated biphenyls (PCBs) is a chlorinated biphenyl compound with the general formula $C_{12}H_{10-n}Cl_n$. PCBs generally occur as mixtures, where *n* can vary from 1 to 10. The 10 sites available for possible chlorine substitution result in 209 possible PCB congeners[1-3]. There is now considerable concern regarding ; the presence of PCB congeners in insulating oils used within large-scale electrical supply systems. Due to its outstanding chemical and thermal stabilities and electrical insulation properties, the commercial and industrial products of polychlorinated biphenyls (PCBs), such as Aroclors, Kaneclors, Clophens, Phenaclors etc., had been widely used as thermal oil and transformer oil from 1930s until the 1970s. PCBs from a group of persistent organic pollutants of the environment, especially dangerous to living organisms due to high toxicity, persistency, and bio-concentration in adipose tissue[3-6]. Despite of this fact, PCB-contaminated oils are still commonly encountered partly because PCBs used as dielecric liquids in transformer and condenser. The source of PCBs in environments can range from used transformer oils or dielectric liquids to liquid wastes, and some PCBs contamination is occurred due to the re-use of incompletely reconditioned oil. The current action plan of Republic of Korea dictates that organizations with electrical equipment contaminated with more than 2 mg/L PCBs will need to treat as PCBs-containing wastes [7], and 50mg/L of PCBs or PCBs equivalent to be treated as a pure PCB preparation [8]. In this study, transformer oils analyzed based on guideline for PCBs analytical method of transformer oil in Korea[9].

Methods and materials

Aroclor® 1242, 1248, 1254 and 1260 (Supelco) were used to make quantification of the waste samples by peak matching method. The main instrumentation was a HP 5890 equipped with electron capture detectors (ECD). A capillary column (HP-5, 30 m × 0.32 mm, film thickness 0.25 um) was installed. The injector temperature was held at 200°C. The detector temperature 250°C with nitrogen make-up gas at a flow rate 17 psi. The temperature program of the column of the column was started at 140°C; 2.5°C/min. until 200°C, 0.5°C/min. until 220°C and 10°C/min. until 270°C. PCB-209 was used as an surrogate standard. A 1μL of extract was injected under splitless condition. An initial multi-point calibration was constructed up to 10 ppm. Daily calibration of GC was performed using a minimum of two standards of 0.5 and 1 ppm. The analytical procedure used is based on the guideline for PCBs analytical method of transformer oil in Korea. About 0.2-10.5 mL of transformer oil was dissolved in hexane and pretreatment processes such as alkali treatment, acid treatment, column cleanup etc. as shown in Fig. 1.

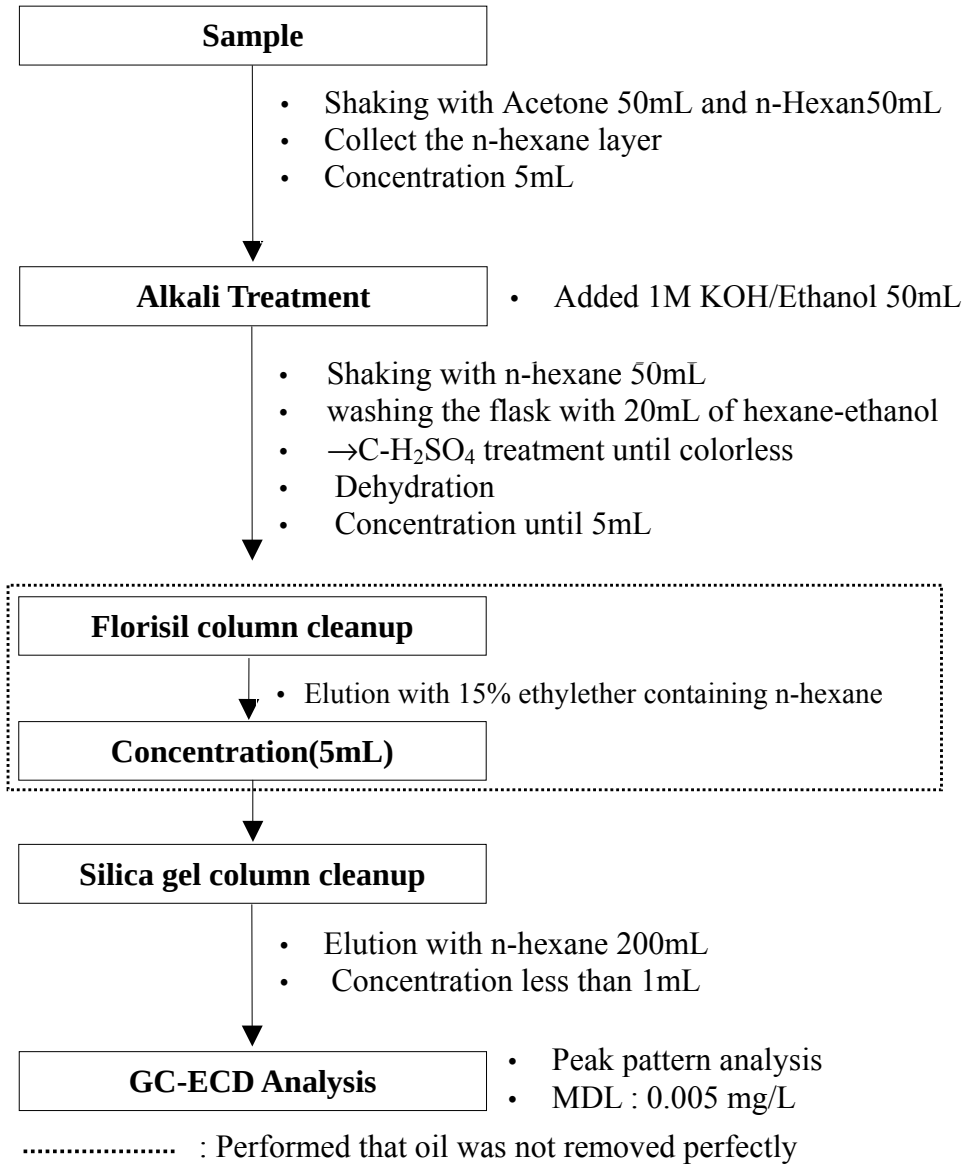


Fig. 1. PCBs analytical method of the transformer oil in Korea

RESULTS AND DISCUSSION

The recovery was determined 82~97% using decachlorobiphenyls (IUPAC No. 209). The presence of PCBs is indicated when the pattern of peaks resembles that observed in a standard material. Retention time was existed within ±0.1 min. and relative peak heights showed similarly. Record the peak area (or height) for each characteristic Aroclor® peak to be used for quantification in the initial calibration solution. The collected samples were analyzed using the quantification methods of Korean waste test methods. This method is quantified the chosen total peaks in each Aroclor standards that are at least 25% of the height of the largest peak as shown in Fig. 2.

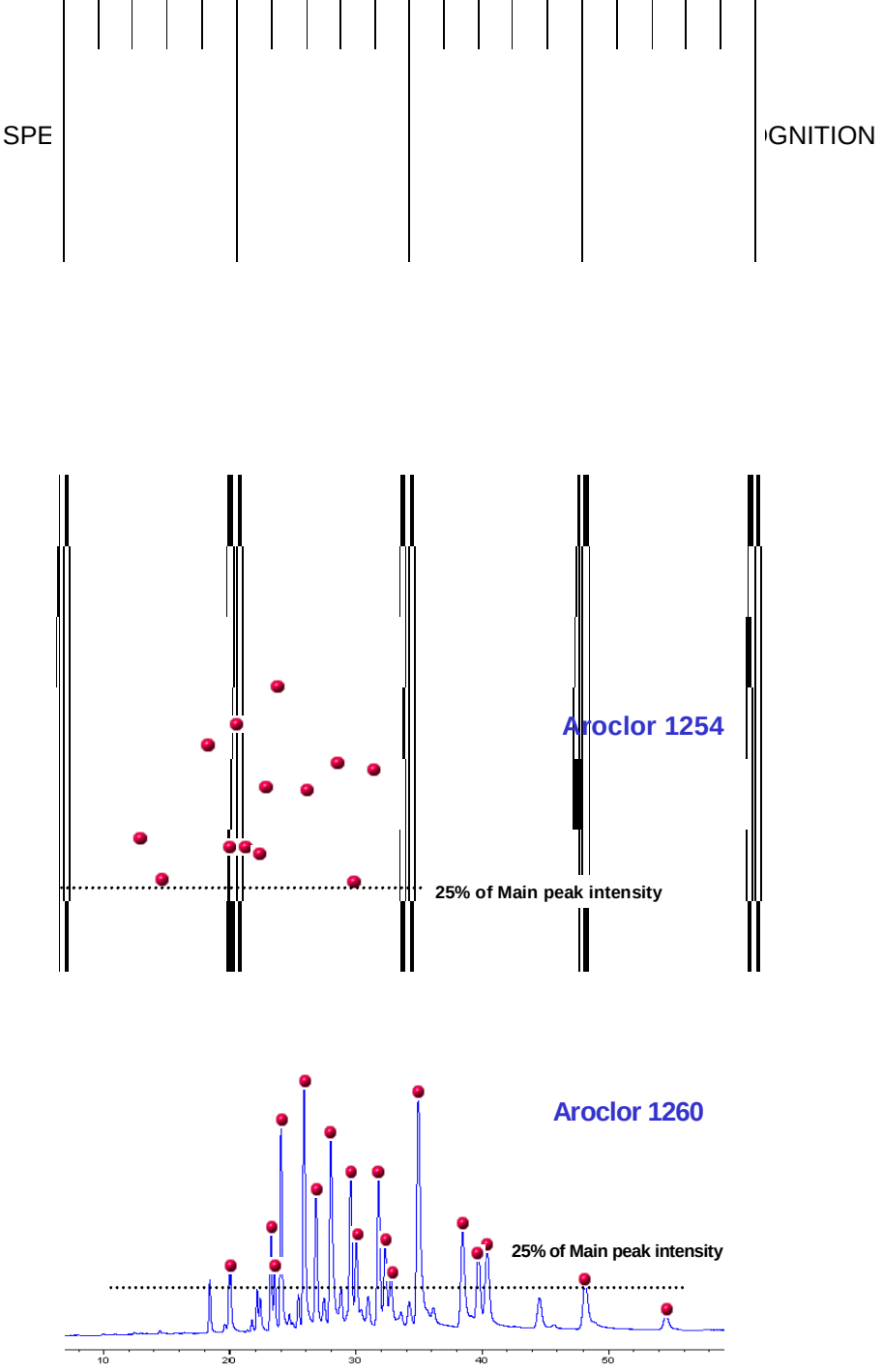
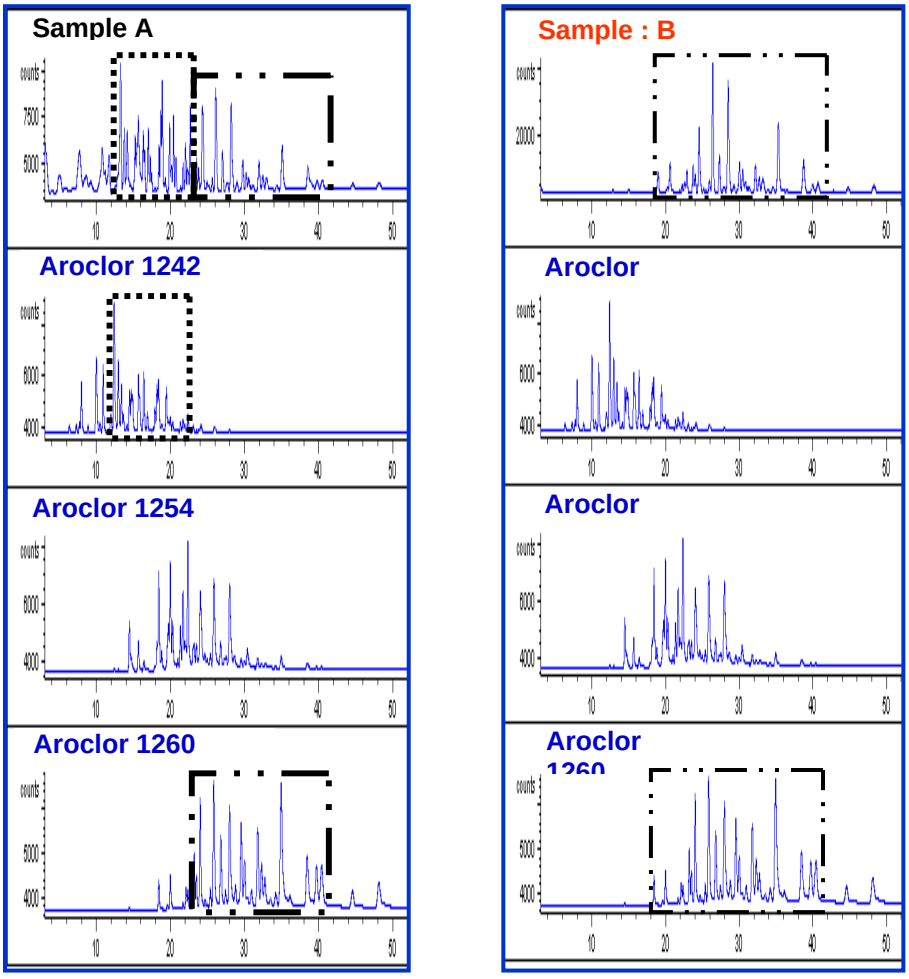


Fig. 2. Quantification peaks of Korea analytical method

The total PCBs concentration was determined by a visual pattern matching and summing selected peaks to obtain a total amount in the sample containing the pure PCBs products as shown in Fig. 3 (b). However, the mixed ratio was calculated using the individual products peaks as shown in Fig. 3 (a). The peaks selected except for the overlapping region to evaluate the each product ratio. The calibration curve was prepared using this mixed PCBs standards, and then sample concentrations were calculated. The sample contained the Aroclor 1242 and 1260 with 3:2 ratio in Fig. 3.



(a) Aroclor 1242 and 1260 mixture (b) Aroclor 1260

Fig. 3. Gas chromatogram of transformer samples

REFERENCES

1. 1.Dobson, S. and Van Esch, G. J., 1993. PCBs & PCTs (2nd Eds), WHO, Geneva.
2. Erickon. M. D., 1997. Analytical Chemistry of PCBs, Lewis Publishers, New York.
3. Basel Convention., 2003. Preparation of a National Environmentally Sound Management Plan for PCBs and PCB-Comtaminated Equipement, Geneva .
4. Sulkowski, W., and Rosinska, A., 1999. Comparison of the efficiency of extraction methods for PCBs from environmental wastes, Journal of Chromatography, 845, 349-355.
5. Lulek, J., 1998. Levels of PCBs in Some Waste Motor and Transformer Oils from Poland. Chemosphere. 37, 2021-2030.
6. Breivik. K., Sweetman. A., Pacyna. J. M., and Jones. K. C., 2002. Toward a global historical emission inventory for selected PCB congeners : a mass balance approach 1. Global production and consumption. The Science of the Total Environment. 290, 181-198.
7. Ministry of Environments in Korea., 2002. Management of Waste Act.
8. Ministry of Environments in Korea., 2002. Management of Hazardous Chemistry Act.
9. Shin, S.K., Kim, H.J., Chung, D., Kim, J. K., Kim, K.S., Chung, Y.H., Chung, I.R., 2003. A Study on the Appropriate Management of PCBs-Containing Wastes, NIER, Republic of Korea.