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Electron Beam Treatment of Toxic Chemicals

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1. Introduction

Polychlorinated biphenyls (PCBs) were commercially produced from 1920s as complex mixtures containing multiple isomers for a variety of applications. They are very toxic, chemically stable and resist microbial, photochemical, chemical, and thermal degradation.

The public, legal, and scientific concerns about PCBs arose from research indicating they were environmental contaminants that had a potential to adversely impact the environment, and, therefore, were undesirable as commercial products. Eventually, most producers reduced or stopped production of PCBs in the 1970s.

Stockholm convention on POPs (Persistent Organic Pollutants), which was effective on May 2004 and 151 nations including Korea were joined on June 2005, asked to dispose of PCBs by 2028 with environmental friendly methods. Korean government also has declared to perform by 2015. According to the Environmental law of Korea, over 2 ppm of PCBs has to be decomposed by legal methods of incineration and thermal destruction. But those are inapplicable owing to the environmental groups.

KAERI(Korea Atomic Energy Research Institute) has recently developed a remarkable technology for radiation treatment of toxic chemicals including chlorides using an electron beam accelerator.

2. Methods and Results

Electron beam accelerator of 2.5 MeV energy and 100 kW power capacity was used to decompose of PCBs having been used as a commercial transformer oil for more than 30 years. Concentrations of PCBs ranged between 5 ~ 900 ppm. The oil were irradiated with ~0.1% of TEA(Triethyl Amin) to make chloride ion parted off from the PCBs into precipitate at normal temperature and pressure.

The equipment for irradiating the transformer oil in this study was used in a pilot plant scale of 25 tons a day capacity. It was established following hundreds times of batch tests.

The concentrations of PCBs were measured by GC (Gas Chromatography) with ECD (Electron Capture Detector) following the KS (Korean Standard) test procedure.

2.1 Pilot test results of transformer oil

After electron beam irradiation with the absorption dose range of 10 ~ 650 kGy, oil samples containing 10 ~ 900 ppm of PCBs initially were to be undetectable(<0.5 ppm) as shown in Table 1.

Figures 1 and 2 show the pilot test equipment for decomposing the PCBs and reactor for irradiation of transformer oil in this experiments.

Table I: Pilot test results of transformer oil by electron beam accelerator.

No. of runs	Conc. of PCBs before irradiation, ppm	Dose. kGy	Conc. of PCBs after irradiation, ppm
1	111.5	250	〈0.5

2	13.39	150	〈0.5
3	10.85	150	〈0.5
4	27.3	150	〈0.5
5	98.91	300	〈0.5
6	853	650	〈0.5
7	853	650	〈0.5
8	27	150	〈0.5
9	49	200	〈0.5
10	98	250	〈0.5
11	73	200	〈0.5
12	373	400	〈0.5
13	498	600	〈0.5
14	82	200	〈0.5
15	20	150	〈0.5
16	47	150	〈0.5
17	5	90	〈0.5
18	37	180	〈0.5
19	80	200	〈0.5
20	16	150	〈0.5

Fig.1. Pilot test equipment for decomposing the PCBs.

Fig. 2. Reactor for irradiation of transformer oil.

3. Conclusions

Electron beam should be a useful tool for environmental conservation. Residual concentrations of PCBs after irradiation were depended on the absorption dose of electron beam energy. Advantages comparing to other methods such as chemical destruction, biodegradation, IR, UV, and so on for decomposition of PCBs in transformer oil are economic, massive, no additive, simple process owing to the normal temperature and pressure operation.

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