LEVELS OF PCDD/Fs IN A FIRE ACCIDENT OF PRIVATE RESIDENCE IN HSINCHU, TAIWAN

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Introduction

The formation of thermally produced Polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) has been extensively studied. The reduction and elimination of PCDD/Fs can be achieved by optimizing the incinerating parameters and using air pollution control devices [(1)]. However, certain thermal process such as fire accident, which is not controllable and releases unknown amount of PCDD/Fs. The study of PCDD/Fs in fire accidents is prevalent among researches, for example PVC-fire [(2)], house fire [(3-5)], vehicle fire [(6)], open-door incineration [(7)] and municipal waste landfill fire [(8)]. In November 2001, a fire accident occurred in a private residence and spread to the neighboring pesticide factory in Hsinchu city, Taiwan. A building next to the pesticide factory was heavily smoked during the fire. In this study, we collected and analyzed PCDD/Fs levels in wipe and ash samples from the scene of the fire. Principal component analysis (PCA) was used to compare the PCDD/Fs distribution and to investigate the characteristic of the fire.

Methods and Materials

Twenty-four hours after the fire extinguished, a total of 11 wipe samples and 2 ash samples were collected and analyzed. Figure 1 depicts the sampling regions in the corresponding buildings of the fire accident. The details of each sampling points were listed in Table 1. We collected 4 wipe samples (A-1 to A-4) and 1 ash sample (A-5) from the private residence (2F of building A, A-2F), 3 wipe samples (B-1 to B-3) and 1 ash sample (B-4) from the pesticide factory (2F of building B, B-2F), 4 wipe samples (C-1 to C-4) from the smoked building (3F of building C, C-3F). For the sake of comparison, 3 wipe samples (D-1 to D-3) were also collected form a normal residence. US EPA Method 1613B was used for sample analyses. Glass fiber filters damped in toluene were used to wipe the burned stuff left on the surface. Each surface ranged from 110-240 cm^2 was wiped for 3 times with a fresh glass fiber filters each time. The ash sample was approximately 5 g. The samples were kept in pre-cleaned glass bottles before subjected to Soxhlet extraction, which used 250 ml toluene and lasted for 18 to 24 hours followed by rotary evaporation. The concentrates were then treated with sulfuric acid, acid silicon gel, acid alumina and carbon column for clean up. A VG AutoSpec Ultima HRGC-HRMS with a dynamic mass resolution of 10,000 coupled to a HP 5890 GC system using a 60-m DB5-MS column were used for instrumental analyses.

Results and Discussion

The PCDD/Fs levels in the wipe samples and ash samples expressed in concentration and international toxic equivalent quantity (I-TEQ) are listed in Table 1, respectively. The concentration of PCDD/Fs in wipe samples ranges from 1.06 to 605 ng/m^2, and the TEQ ranges from 0.027 to 18.6 ng-TEQ/m^2. The PCDD/Fs levels in surface samples from the fire scene are much higher than those from

Table 1. PCDD/Fs levels in wipe and ash samples at each sampling point

Sampling points	No.		PCDD		PCDF		PCDD/PCDF Ratio		Total PCDD/Fs	
			Con.	TEQ	Con.	TEQ	Con.	TEQ	Con.	TEQ
Wipe samples (Con. expressed in ng/m^2, TEQ expressed in ng-TEQ/m^2)										
Normal residence	Window pane	D-1	0.446	0.001	0.138	0.0001	3.24	5.83	0.583	0.001
	Aluminum frame	D-2	0.753	0.014	0.603	0.058	1.25	0.250	1.36	0.072
	Ceiling	D-3	5.14	0.006	0.177	0.006	29.1	0.899	5.31	0.012
	Window pane	A-1	4.10	0.232	10.7	1.15	0.383	0.202	14.8	1.38
Fire source (A)	Ceiling[1]	A-2	2.53	0.024	3.79	0.529	0.667	0.045	6.32	0.553
	Ceiling[2]	A-3	7.25	0.096	7.25	0.884	1.00	0.109	14.5	0.980
	Ceiling[3]	A-4	12.9	0.382	19.7	2.70	0.654	0.141	32.6	3.08
Pesticide factory (B)	Window pane	B-1	1.75	0.005	0.332	0.022	5.26	0.225	2.08	0.027
	Wall	B-2	0.711	0.040	0.345	0.037	2.06	1.08	1.06	0.077
	Ceiling	B-3	2.92	0.170	1.68	0.218	1.74	0.780	4.60	0.389
Smoked building (C)	Window pane	C-1	48.6	2.03	84.3	9.90	0.576	0.205	133	11.9
	Aluminum frame	C-2	50.9	2.88	160	15.8	0.319	0.183	211	18.6
	Wall	C-3	570	1.49	34.8	3.43	16.4	0.436	605	4.92
	Ceiling	C-4	38.1	0.806	26.7	2.54	1.43	0.317	64.8	3.35
Ash samples (Con. expressed in ng/kg, TEQ expressed in ng-TEQ/kg)										
			Con.	TEQ	Con.	TEQ	Con.	TEQ	Con.	TEQ
	Fire Source	A-5	656	7.73	62.4	8.20	10.5	0.943	719	15.9
	Pesticide Factory	B-4	90.9	3.31	110	12.8	0.824	0.258	201	16.1

[1] fireproofing material, [2] above fire source, [3] non-fireproofing material

the normal residence. Wobst [3] presented that PCDD/Fs ranged between 4.15 and 1,300 ng/m^2 in surface samples from two private residences after real fire accidents. Ruokojärvi [4] has reported PCDD/Fs in simulated house fires. The PCDD/Fs concentrations in the wipe samples were 60-240 ng/m^2, and the presence of additional PVC during the fires increased the concentration to 270 ng/m^2. The PCDD/Fs concentrations found in this study are at the same level in comparison to Wobst and Ruokojärvi's reports, but relatively lower than the concentrations in the combustion of high molecular weight PVC, low molecular weight PVC and PVC-cable which are 5320, 1260 and 2620 ng/m^2, respectively [2]. The concentrations of PCDD/Fs in 2 ash samples are 719 and 201 ng/kg, and the TEQ are 15.9 and 16.1 ng-TEQ/kg. The PCDD/Fs levels in fire ash samples vary frequently and depend on the conditions (temperature, time and burning materials…etc.) during the fire. Our limited results of ash sample concentration are lower than previously reported ones, such as PVC combustion [2], PVC fire accident [5], open-air incineration of waste wood, house fire [7], and municipal waste landfill fires [8]. Nevertheless, our results clearly indicate that house fire produces PCDD/Fs and contaminates the fire scene.

The 17 PCDD/Fs congener TEQ profiles of each sample are not similar. Nevertheless, 2,3,4,7,8-PeCDF contributes the most in TEQ ranging from 26 to 65 %, and the second abundant congener is 2,3,7,8-TeCDF. The comparison of 10 PCDD/Fs homologue profiles shows that the concentration contribution of PCDD homologue is proportional to its chlorine number, i.e. the higher the chlorine numbers the higher the PCDD/Fs content in the ash sample. No distinct relation in the concentration

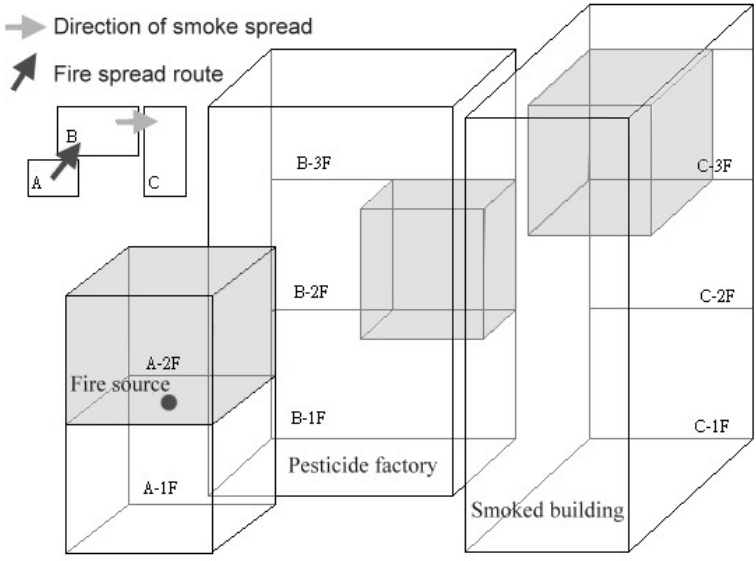

Figure 1. The sampling regions in the corresponding buildings of the fire accident

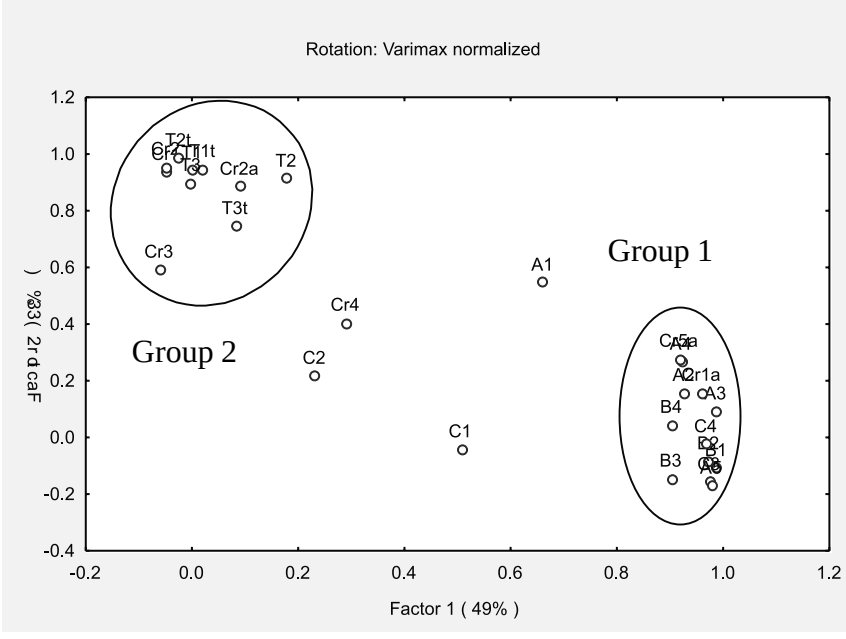

Figure 2. PCA analysis of 17 PCDD/F 2,3,7,8 congeners from wipe and ash samples

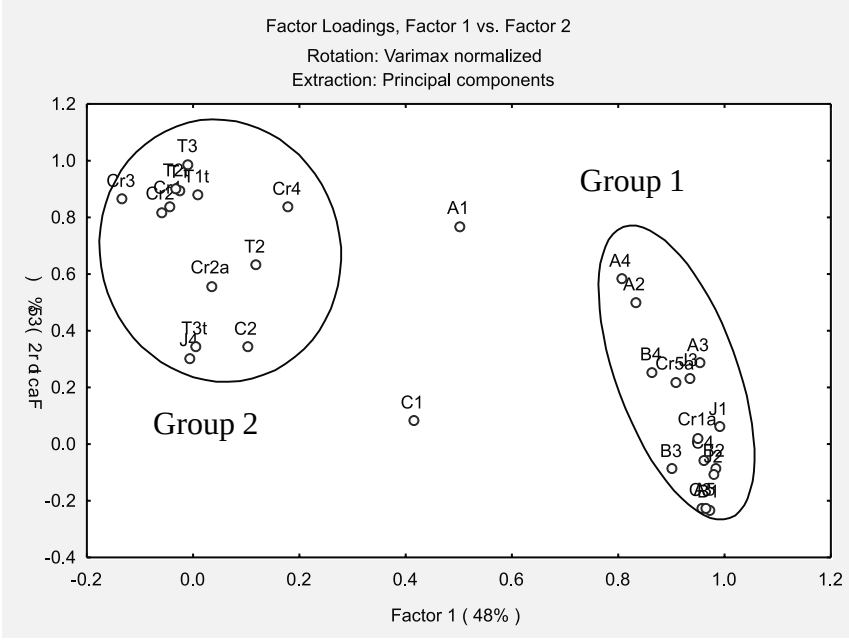

Figure 3. PCA analysis of 10 PCDD/F 2,3,7,8 homologues from wipe and ash samples

ratio of PCDDs to PCDFs was observed. We used PCA to compare the PCDD/Fs distribution and to investigate the characteristics of the fire, using additional 17 reference data from the literature [5-7]. The PCA results of 17 congeners and 10 homologues are shown in Fig. 2 and Fig. 3, respectively. Both results are similar and cluster together into 2 groups as marked on the plots. Group 1 (no PVC materials during the fire) contains the wipe samples and ash samples in this study except A1, C1 and C2. Moreover, samples with PVC materials during the fire assemble into group 2.

Acknowledgements

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